

EPIDEMIOLOGICAL STUDIES ON OVINE
PARASITIC GASTROENTERITIS AT EASTER BUSH

By

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SUMMARY

Two flocks of Suffolk ewes with lambs and one flock of Cheviot ewes with lambs, and their four pastures were monitored for gastrointestinal nematode infestations from October 1973 until July, 1974. Faecal examinations included egg counting and the identification of third stage strongyle type larvae. Herbage was also examined for infective larval contamination.

It was shown that the epidemiology of ovine parasitic gastroenteritis is complex and variable even on this single farm. Only the Cheviot ewes illustrated a typical peri-parturient rise and they maintained, on average, egg counts which were fifty percent lower than the Suffolk breed.

Haemonchus contortus dominated the egg and larval counts, including the larvae from herbage. Ostertagia spp. and Trichostrongylus spp. larvae were found to be much less numerous. Haemonchus contortus was the main contributor to the peri-parturient rise. Strongyloides papillosus egg counts were high in both the lambs and the ewes during the eight weeks following lambing.

The overall pasture contamination rate was found to be surprisingly low. Parasitic findings correlated well with management practices and recent changes in the local climate.

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D. J. M.
Easter Bush, Scotland
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TABLE OF CONTENTS

| | |
|-------------------------------|-----|
| SUMMARY..... | ii |
| ACKNOWLEDGEMENTS..... | iii |
| INTRODUCTION..... | I |
| REVIEW OF THE LITERATURE..... | 2 |
| MATERIALS AND METHODS..... | 9 |
| RESULTS..... | 28 |
| DISCUSSION..... | 39 |
| CONCLUSIONS..... | 58 |
| REFERENCES..... | 60 |

Introduction

Parasitic gastroenteritis of sheep is of great economic importance in Scotland, and indeed the world. A complex of factors is involved. These factors may be classified as parasitic, host or environment related.

This dissertation describes a nine month survey in which groups of sheep were monitored for helminth infection from October 1973 until July 1974, by means of coprological examination. Infective parasitic larvae present on the pastures grazed by these sheep were also monitored.

The results obtained were then examined together with the available climatic data on the immediate area with the aim of showing any correlations. This is the first helminth survey to be carried out on this farm and flock.

REVIEW OF THE LITERATURE

Epidemiology has been described as the how, why, when and where of any disease (Gordon, 1973). Parasitic gastroenteritis (PGE) is probably the world's most costly disease. In the U.S.A. losses due to worm parasites in 1954 amounted to twice the losses from all other diseases put together (Parnell, 1954).

In Scotland, as elsewhere, agriculture is becoming more intensified as farming margins of profit dwindle. Parasitic gastroenteritis is a problem which increases in importance with intensive management, especially that of sheep on pasture. In the past, Scotland has been largely a country for extensive hill sheep farming (Cameron, 1923; Parnell, 1954), but now is rapidly becoming intensified, as is the rest of the United Kingdom (Michel, 1971). Parasitic gastroenteritis is, therefore, an important problem (Boag and Thomas, 1971).

Several excellent reviews concerning numerous aspects of the epidemiology of PGE are available in the literature (Gordon, 1957; Levine, 1963; Crofton, 1963; Michel, 1969; Gordon, 1973). No single article covers all the recorded literature but Gordon (1973) is the most recent and comprehensive review, with an excellent list of most of the recent, relevant detailed references.

The first parasitic nematode survey in Scotland revealed that Bunostomum spp. (syn. Monodontus) and Nematodirus spp. were the most common species (Cameron, 1923).

Goats and sheep from the Pentland Hills were reported to be carrying Bunostomum spp., Chabertia spp., and Haemonchus contortus (Cameron, 1923). Ostertagia spp. were found in low numbers and often associated with H. contortus. H. contortus, however, was considered to be commonly found in the lowlands and only in small numbers. Trichostrongylus axei was also commonly found in small numbers, except during the winter (Parnell, et al, 1954). Most of the work was based on hill sheep with very few studies on lowland sheep, but was considered representative at the time. Strongyloides papillosus was not an important species according to Parnell (1954), but Nematodirus spp. was occasionally important.

Seasonal variations in Scottish hill sheep showed that increased worm egg counts in the spring were mainly due to increased numbers of Ostertagia spp. and Trichostrongylus axei. The increased number of worms was considered to have arisen from overwintered larvae (Morgan, et al, 1951). Lambs became infected initially with Ostertagia spp. and Trichostrongylus spp., but haemonchosis was the main contributor to an increased egg count in May and June. T. axei always outnumbered Ostertagia spp., and infestations with Bunostomum spp. was a serious problem with a high incidence especially in the south-west and west coast areas of Scotland (Morgan, et al, 1951; Parnell, et al, 1954). Haemonchosis became a problem only in a bad year following poor

weather and lack of herding.

More recently Nematodirus battus became a problem in Eastern Scotland (Crofton, 1963) especially in the wet year of 1967 (Annual Reports of the Veterinary Investigation Service, 1967-72). These reports state that high numbers of Ostertagia spp. and Trichostrongylus spp. are commonly seen in PGE diagnosed post mortems, and large outbreaks of clinical haemonchosis are often diagnosed. One hill farm near Edinburgh lost five percent of 8,000 Blackface sheep with H. contortus while in another case, twenty-one lambs were found to be infested with nearly 100 percent Nematodirus spp. nematodes. Reid and Armour (1974) report that 90 percent of the total worm burden in the spring in western Scotland is Ostertagia spp. Reports from Northern Ireland show similar findings to Scotland with the exception of extremely low numbers of H. contortus (Taylor and Cawthorn, 1972).

The most extensive epidemiological surveys on gastro-intestinal nematodes, however, are being carried out in north-east England by Thomas and Boag (1971, 1972, 1973). In their studies Ostertagia circumcincta was the predominant species and caused the major parasite problem in the lambs. Cooperia curticei and T. vitrinus were present also, in considerable numbers. Infective larvae were not always observed to overwinter. In one study, it was considered that the steep

increase in larvae counts on pasture in July resulted from the peri-parturient rise of April lambing ewes. The lambs ingested these infective larvae on pasture and showed a marked increase in egg counts four or five weeks later. Nematodirus filicollis and N. battus were observed to survive ploughing and reseeded.

In another study, however, two patterns of infestation in the lambs were noted, one related to the ingestion of overwintered infective larvae and the second arising from the ewe "spring rise" or peri-parturient rise. Pasture larval counts peaked to 800 larvae per kilogram of herbage in July (Thomas and Boag, 1972).

Faecal egg counts of the lambs were closely correlated with faecal egg counts of the ewes and pasture larval levels. Their exhaustive work under conditions similar to those in eastern Scotland is very detailed, continuous and relevant. Heath (1969) studied the epidemiology of PGE in a commercial flock in Cumberland. Crofton (1963) presents an excellent account of parasite relations on pasture and in sheep for all nematodes, except S. papillosus in the United Kingdom. Michel (1969) and Oller^{er}shaw and Smith (1969) wrote complimentary reviews of the relationship of weather, climate nematode bionomics and helminthic disease in grazing animals, in Britain. Studies in neighbouring countries provide similar and possibly

relevant information, for instance, from Norway (Helle, 1964) and Belgium (Pandey, 1974). Such European information is probably more relevant to Scotland than data from such areas as New Zealand (Brunsdon, 1964), Australia (Seddon, 1967; Gordon, 1957, 1973) and the United States (Levine, 1963). Nevertheless, this latter information can not be ignored as the epidemiology of parasitic nematodes has been studied in great detail in all of these countries, including the use of climatographs and bioclimatographs (Seddon, 1967; Levine, 1963).

The how, why and where of epidemiology of PGE as considered in this survey is largely contained in the period when the parasites are living free as a larva or an egg. Naturally, this cannot be separated from the other parasitic stages. Complete life cycles are dealt with adequately in several good references on veterinary helminthology (Soulsby, 1968; Dunn, 1969). Control either by husbandry or anthelmintics is likewise dealt with in the standard texts (Blood and Henderson, 1968).

In general, all free-living nematode larvae prefer moderate warmth, moisture and oxygen. The latter is almost always readily available on pasture. In Scotland, however, the first two are variable from season to season and area to area. The requirements for these vary between species of nematode. It is not only a question of survival but also of development (Levine, 1963). Levine (1970) describes nematode transmission on pasture in seven stages and points out that the unembryonated egg of all nematodes

is the most susceptible stage and the third stage larva the least susceptible to adverse conditions. All stages in between are moderately susceptible. Generally, high temperatures increase development rate but decrease survival time, while low temperatures, increase development time and above a critical limit which varies with the species of helminth, prolong survival (Michel, 1969). Moisture is less frequently a limiting factor in Scotland and therefore only the temperature factor will be considered further.

With Ostertagia spp. it is reported that total development, including hatching, is possible at less than 41°F (Crofton, 1963), with the optimum pasture transmission at a mean monthly temperature of 43° to 68°F and at least two inches of rainfall (Levine, 1963). This is a considerable advantage in Scottish hill areas, for Ostertagia spp. (Parnell, 1954).

H. contortus tends to favour much warmer temperatures and haemonchosis is reputed to require a minimum of 65°F, which is referred to as the "Dinaburg Line" (Kates, 1950), with the potential transmission temperature ranging from 59° to 99°F (Levine, 1963). Trichostrongylus spp. likewise prefer warmth but can withstand considerable cold, and have a similar optimal transmission requirement to Ostertagia spp. They have one of the most resistant larval forms (Crofton, 1963). Much controversy still surrounds most of these facts, especially with conflicting reports from the field and

the laboratory.

It is evident that there is a need for more accurate and detailed knowledge of the epidemiology of parasitic gastroenteritis before man is ever "master" in the world of parasites.

MATERIALS AND METHODS

Farm Location

The survey was carried out at the Veterinary Field Station of the Royal (Dick) School of Veterinary Studies, University of Edinburgh. The farm is located at Easter Bush, Midlothian, Scotland and lies immediately south-east of the Pentland Hills.

Pastures

Four separate pastures were grazed at different times by the various flocks, in no particular pattern. The sward consisted of a mixture of white clover, rye grass and timothy. The animals were set-stocked with stocking rates varying widely throughout the study period. On balance the stocking rates were relatively heavy, at about eight ewes plus their lambs per acre.

Housing

One group of ten Suffolk ewes was kept indoors in a five metre square concrete pen with free access to a similar outdoor concrete enclosure, with a density of 4.3 square metres per ewe. Straw bedding was provided indoors only. Hay was fed inside from an overhead manger, while turnips and grain concentrates were fed in

in troughs in the outdoor enclosure. A single water bowl was located inside.

Management

Interference with normal farm routine was kept to a minimum. The shepherd acted independently of the weekly survey findings, in carrying out normal management including any antihelmintic therapy.

Animals

The sheep under study consisted of mature Suffolk and Cheviot ewes. These were divided into three different flocks and their respective lambs were included from birth. No attempt was made to sample the same animals on each occasion. The animals were sampled at random, in order to minimise the demands on the farm staff.

The first group consisted of ten mature Suffolk ewes kept indoors from October 1973, until April 1974. This group lambed indoors between January 5 and January 15, 1974. The monitoring of this group was terminated when the lambs and the ewes returned to pasture in April, 1974.

The second flock comprised thirty-five mature Suffolk ewes, kept continually on pasture except for lambing indoors between January 1 and January 15, 1974. The ewes, with fifty-five lambs, returned to pasture within ten days of lambing. Creep feed was provided for the lambs and grain concentrates were fed to the ewes

following lambing. The lambs were weaned in May, 1974.

The third group contained seventy head of purebred, mature Cheviot ewes which were run with another thirty crossbred ewes, and were also kept continually outdoors. These ewes were allowed to lamb on pasture during the month of April, 1974. Creep feed was not provided for the one hundred lambs due to improved pasture conditions by this time. The lambs were not weaned before the end of the study period.

Meteorological Data

A weather station is located on the Bush Estate, Edinburgh School of Agriculture, approximately five hundred yards from the farm. The data obtained from this station includes (1) mean monthly dry bulb temperature, (2) mean monthly grass minimum temperature, (3) mean monthly soil temperature at a depth of four inches, and (4) total monthly rainfall.

Sampling

(a) Faeces

Ten rectal fecal samples were collected randomly from each group of ewes weekly or biweekly. In addition, ten similar samples were collected from their respective lambs. In the lambs, the samples were first obtained by observing and collecting naturally passed droppings, until they reached sufficient size to be sampled

manually. All samples were transported to the laboratory in sealed plastic containers.

(b) Herbage

Random grass sampling was carried out on each of the four pastures using the "Weybridge" system (Ministry of Agriculture, Fisheries and Food, 1971), with some modifications. When working unassisted, the author used "N" shaped collection routes (Lancaster, 1970), but used the "W" shaped pattern of collection (Taylor, 1939) when assistance was available. The grass samples were thoroughly mixed in a large plastic bag and were sometimes stored at 4°C for one or two days before being processed.

Faecal Egg Counting

Faecal egg counting was carried out according to the McMaster technique, with only minor modifications. Following identification, results were recorded as Eggs Per Gram under the headings (1) Strongyle-type, (2) Nematodirus spp., (3) Strongyloides papillosus, and (4) Others. Lamb and ewe results were recorded separately. A flock average was then calculated for each category of egg. Spot checks were made for the presence of fluke eggs using the Sellotape-Zinc Sulphate Flotation Technique (Sewell and Hammond, 1972).

Faecal Larval Cultures

Each week the remaining faeces from each group was pooled and stored at 4°C for variable periods of time in tightly closed plastic containers. Faecal cultures were prepared by a technique derived from that of Skerman (1966). Peatmoss and/or vermiculite were used as drying agents and cultures were incubated for eight days at 24°C. An adequate moisture level was maintained during this time. The larval suspension was collected by pipette and transferred to a clean universal bottle or medical flat bottle. Some larval samples were processed further and identified immediately, while others were stored for several weeks in slightly inclined medical flat bottles (Ministry of Agriculture, Fisheries and Food, 1971). Following storage the suspension of larvae was gently shaken to loosen those larvae adhering to the glass. The bottle was then set upright for an hour in order for the larvae to settle. Excess water was siphoned off to leave approximately five ml or less of suspension. This suspension was then transferred to a clean universal bottle for further processing.

Three drops of absolute methanol at room temperature were added to each ml of larvae suspension, to relax and straighten the larvae with a minimum of distortion. The universal bottle was inverted several times to mix and then allowed to stand for five minutes before adding five to ten drops of one percent

aqueous iodine solution. The larvae in the resulting suspension were then examined under low magnification (50X-100X) in an Eel worm counting chamber (Hawksley Gelman). When possible, at least one hundred third stage sheathed larvae were identified. Third stage larvae were identified according to the key on the following page, which was adapted, with minor modifications, from Skerman (1966).

Only generic differentiation of larvae was attempted in this survey. Strongyloides spp. and Nematodirus spp. larvae were not recorded due to the relative ease of identification of their eggs. No attempt was made to study the detailed morphology of the infective larvae. Only those major comparative characteristics useful for quick diagnosis at low magnification (X50), and which are essential in routine larvae generic differential counts, were used (Plate I). Higher magnification (X100) was used only occasionally when an identification was difficult.

The most useful characteristics used were (1) the total length of the larva, including the sheath, (2) the distance between the tip of the larval tail and the tip of the tail of the sheath, (3) the general width of the larva, and (4) the shape of the larval tail, including the larva and the sheath. Larval characteristics are under the influence of various factors, which can alter them slightly or drastically. Some of these factors are larval culturing technique and time, larval killing

/ Key To
Identification of Third Stage Larvae

| Total Length (General) | Tail Sheath (μ) | Genera, with Range of Total Lengths (μ) | Description | Plate |
|------------------------|-----------------------|---|---|-------|
| SHORT | LONG 85-115 | <u>Bunostomum</u> spp. 560-640 | Wide body, tapering into a long filamentous tail. | 2 |
| MEDIUM | SHORT 20-30 | <u>Trichostrongylus</u> spp. 560-720 | Very straight, rigid body. More slender than <u>Bunostomum</u> , but a little thicker than <u>Ostertagia</u> and <u>Haemonchus</u> . Intestinal cells few and prominent. (16) | 3 |
| | MEDIUM 30-40 | <u>Ostertagia</u> spp. 660-900 | Very gradually tapering, sharp, slender body. Looks needle-like. Larvae end sharply. | 4 |
| | 40-60 | <u>Haemonchus</u> spp. 650-750 | Larval body tapers later, faster and more unevenly than the above. (Tapers faster on one side than the other.) | 5 |
| LONG | LONG 60-80 | <u>Chabertia</u> spp. 710-790 | Stout body, numerous (24-32), prominent intestinal cells and long tail. | 6 |

Ref: Skerman, 1966; Dikmans and Andrews, 1931; Morgan, 1939

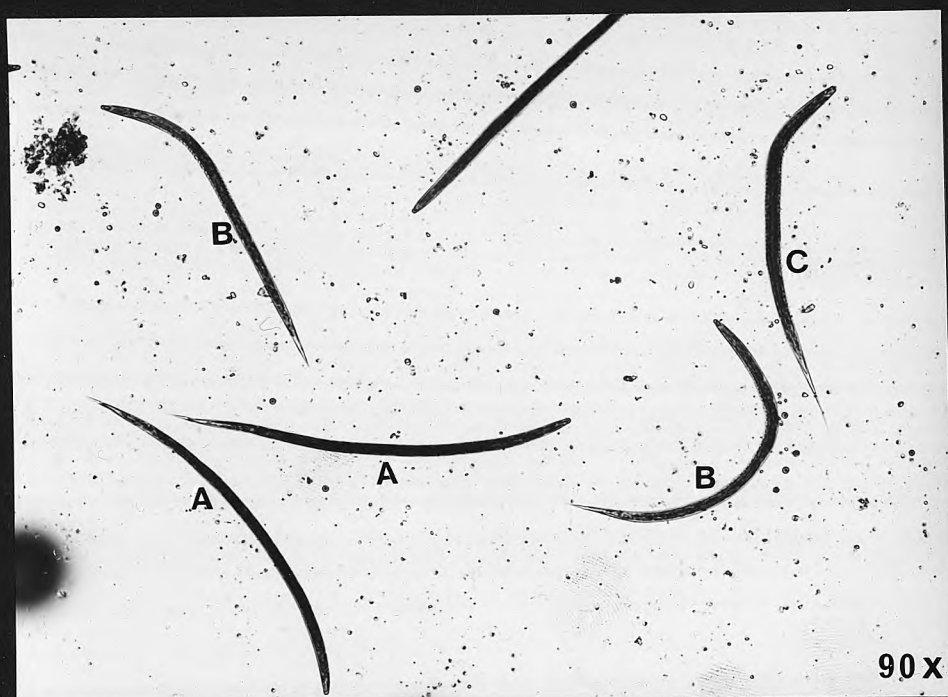
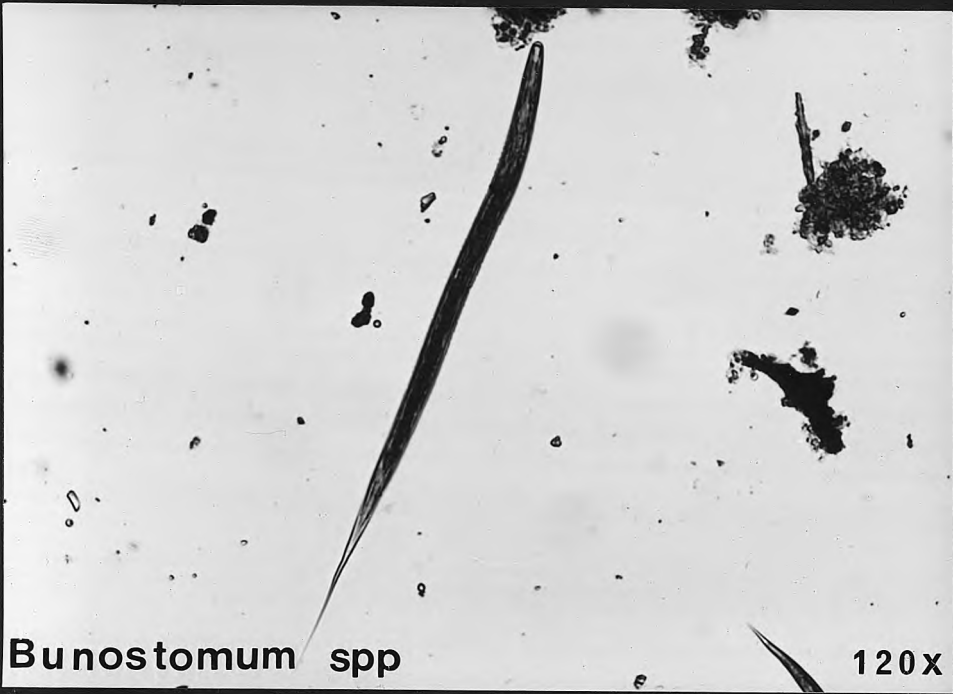


Plate 1

A--- *Ostertagia* spp

B--- *H. contortus*

C--- *Chabertia* spp



Bunostomum spp

120X

Plate 2



Trichostrongylus spp

120X

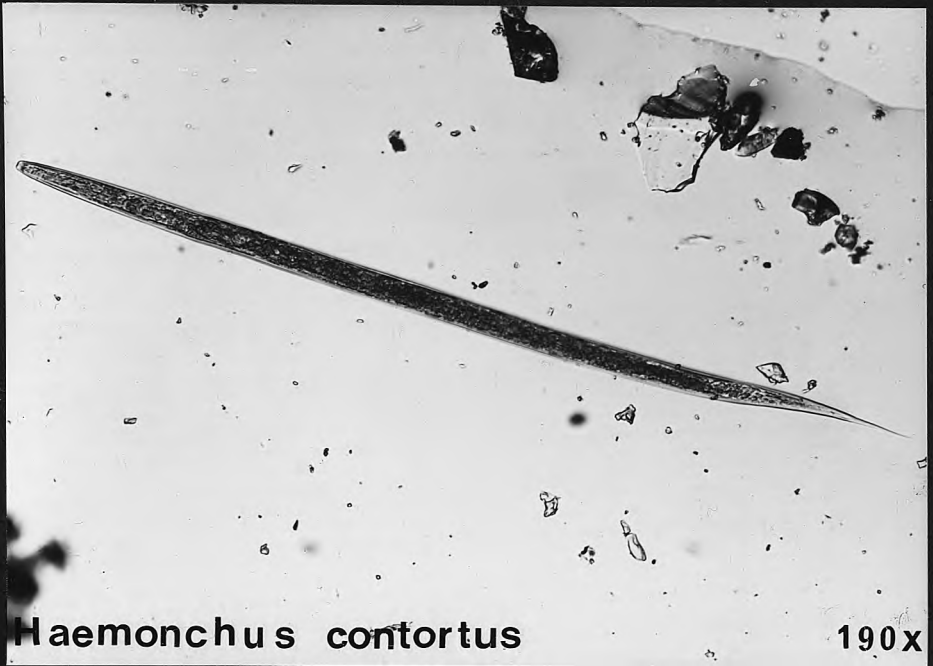
Plate 3



Ostertagia spp.^o

190x

Plate 4



Haemonchus contortus

190x

Plate 5



Plate 6



Plate 7

methods, larval staining methods, larval storage methods and time, as well as generic, species and strain differences (Soulsby, 1965).

Larvae cultured from faecal samples of animals with mixed natural infestations ensured a range of larvae measurements and observations of each species which was more variable and possibly representative than these larvae from a pure culture of a single species. A pure culture laboratory strain of Haemonchus contortus available in the department measured one hundred and sixty microns shorter, in total length, than those Haemonchus contortus cultured from a mixed natural infestation.

The literature on third stage larvae identification is very confusing, and often misleading. Some common difficulties were ill defined measurement limits, and superimposed ranges of measurements and characteristics over two or more genera. The former difficulty is exemplified in tail sheath measurements, when some authors appear to measure from the anus (Soulsby, 1968), while others measure from the tip of the ensheathed larvae (Dikmans and Andrews, 1933). Points of reference, such as the anus or larval tip, are often omitted altogether (Mönning, 1931). The overlapping and very close measurements of body and sheath, as well as other characteristics of Ostertagia spp. and H. contortus were difficult to distinguish, both in the literature (Dikmans and Andrews, 1933), and in practice. It was not uncommon

to see Figures in the literature without a scale as well (Ministry of Agriculture, Fisheries and Food, 1971). In practice, it is indeed unfortunate that some of the most pathogenic and the most common genera appear the least different in their third stage larval forms. For instance, Ostertagia spp. and Haemonchus spp. (Plates 4 and 5). Where this differentiation becomes very difficult alternatives should be sought, such as using adult nematode differential counts from post mortems of tracer lambs, or performing life history studies with known parasite-free sheep.

Identification of Bunostomum spp. larvae (Plate 2) was readily made because of their relatively small size, short, wide, and suddenly tapering body, and very long, filamentous tail (Skerman, 1966). The wide range of total lengths of the larvae, 510 to 670 μ , (Skerman, 1966) did not generally apply and a narrower range of 560 to 640 μ was most commonly observed (see Key on p. 15), which is similar to the findings of Mönning (1931) for Bunostomum trigoncephalum. Observations on the length of the tail sheath are those shown on the Key To Identification of Third Stage Larvae, (p. 15). Contrary to Keith (1953) the author found that the tail of the Bunostomum spp. sheath (Plate 2) did not closely resemble that of H. contortus (Plate 5) larva, but appeared very similar to the tail sheath of Chabertia spp. (Plate 6) instead.

The parasitic larvae of Trichostrongylus spp. (Plate 3), are reported to have a range of total length from 620 to 790 μ (Dikmans and Andrews, 1933) but a narrower range from 560 to 720 μ (Gordon, 1933) was more commonly observed in this study. The most common total larval length appeared to be 640 μ . Tail sheath measurements are reported to be from 20 to 40 μ (Dikmans and Andrews, 1933) but, again, the observations indicated a much narrower range of only 20 to 30 μ to be predominant. A large proportion of the specimens of this genera exhibited a very straight, rigid posture (Skerman, 1966), more so than larvae of different genera which had undergone similar treatment with methanol (Plate 3). Intestinal cells were usually very prominent as well (Skerman, 1966).

Ostertagia spp. infective larvae (Plate 4) are medium sized and very similar to H. contortus larvae (Plate 5), but span a much larger range than do the H. contortus (see Key on p. 15). Observations regarding the lower limit of 660 μ are consistent with findings by Gordon (1933), but contrary to the findings of Dikmans and Andrews (1933) with 790 μ as a lower limit. Such a wide range (660 to 900 μ) which overlaps with similar measurements for larvae of other genera leads to difficulties, especially with the genus Haemonchus and genus Trichostrongylus. A second major differential feature, such as tail sheath length, is, therefore, helpful.

It must be remembered, however, that there are conflicts in the findings of various workers in the literature, as well as between the literature and findings in this study. (Dikmans and Andrews, 1933; Soulsby, 1965).

Differences in conformation of total larval appearance between Ostertagia spp. and Haemonchus spp. (Plates 4 and 5) were useful in that the former is much more "needle-like", with a very gradual tapering of the body into the tail. Haemonchus spp. larvae tend to taper more quickly nearer the posterior end, often tapering on one side more than on the other. Haemonchus spp. larvae also appear slightly thicker than Ostertagia spp. larvae (Plates 4 and 5).

According to the literature H. contortus larvae have a characteristic "kink" in the tail (Monning, 1931) which can be used for identification. The "kink" is often said to produce a "finger-like" tail sheath (Skerman, 1966). Findings in this survey, however, were inconclusive in this respect since it was found that both Haemonchus and Ostertagia spp. larvae commonly exhibited this "kink". This is in agreement with the findings of Keith (1953). For this reason the "characteristic kink" (Skerman, 1966) was not relied upon in this survey.

The author found the tail sheath of Ostertagia spp. larvae to end in a sharp tip (Mönning, 1931; Dikmans and Andrews, 1933), and not in a blunt tip (Keith, 1953). It may be that, due to common pasturing of sheep and cattle

at Easter Bush, that the longer Ostertagia larvae may belong to the species O. ostertagi which normally infest cattle, while the shorter ones are O. circumcincta which prefer sheep as hosts (Keith, 1953).

Haemonchus spp. third stage larvae (Plate 5) were observed to conform to the moderate range in total length of from 650 to 750 μ (Skerman, 1966) but disagreement arose in the range of tail sheath measurements. The common range observed in this particular study was 40 to 60 μ , which differs from the 65 to 105 μ found by Dikmans and Andrews (1933), the 70 to 84 μ quoted by Morgan (1930), and the 142 μ of Mönning (1931). Keith (1953) has referred to the tail sheath as a "whip-like filament" similar to the Bunostomum larval tail sheath. Observations in this survey disagree with Keith (1953) and indicate a closer similarity between tail sheaths of Ostertagia and Haemonchus spp. larvae. Dikmans and Andrews (1933) indicate the larvae tip is pointed while the author observed blunt larval tips on the Haemonchus spp. larvae. In addition, the various strains of H. contortus also have varying body lengths and tail sheath measurements. (Poeschel and Todd, 1972).

The few Chabertia spp. larvae noted in this study conformed excellently to the species range of total body length, which is 710 to 790 μ , with typical tail sheath lengths ranging from 60 to 80 μ (Skerman, 1966). Their stout body and long tail is similar to Bunostomum but their greater total length differentiates them readily.

Extraction of Larvae from Grass

The extraction technique was essentially a modified Baermann technique. After thoroughly mixing the entire grass sample, five hundred grams of fresh grass was weighed out in three or four subsamples. Each subsample was placed in a gauze bag, which was closed with "Velcro" (Selectus Limited). The gauze had a pore size of 330 μ . Care was taken to distribute the grass within the bag to form an even layer. This layer was then loosely rolled into a cylindrical form leaving an open space in the centre of the roll, and immersed in three litres of tap water. The water was contained in a modified plastic Baermann-type funnel apparatus, called a "Herbatode Apparatus" (Figure I). The modifications made to the classical Baermann apparatus (Macy and Berntzen, 1971) consisted of (1) extending the funnel sides greatly to accommodate the large volume of water, (2) incorporating a second gauze sieve in addition to the gauze bag containing the grass, both being of equal pore size, thus retaining more debris, and (3) providing a double clamp system on the dependent transparent collecting tube to trap and tap the small volume of larvae suspension.

The cylinder or roll containing the grass was gently washed up and down, in and out of the water at irregular intervals. Care was taken to ensure that all of the water drained from the bag at least once during each washing and always on the last washing.

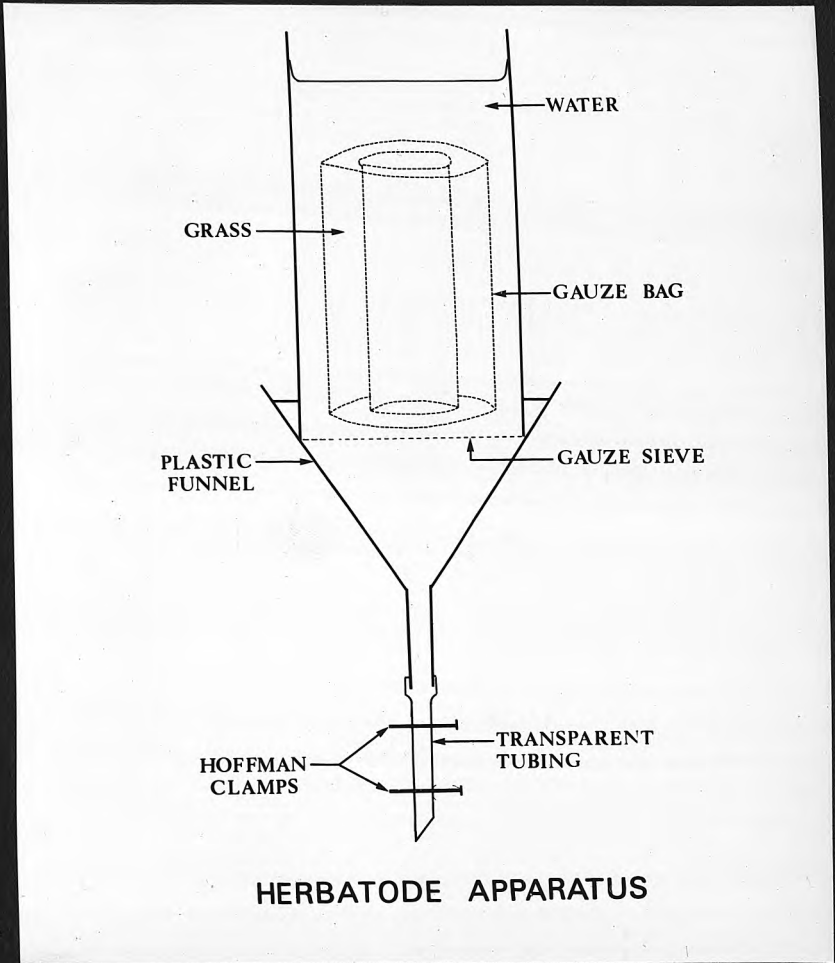


Figure 1

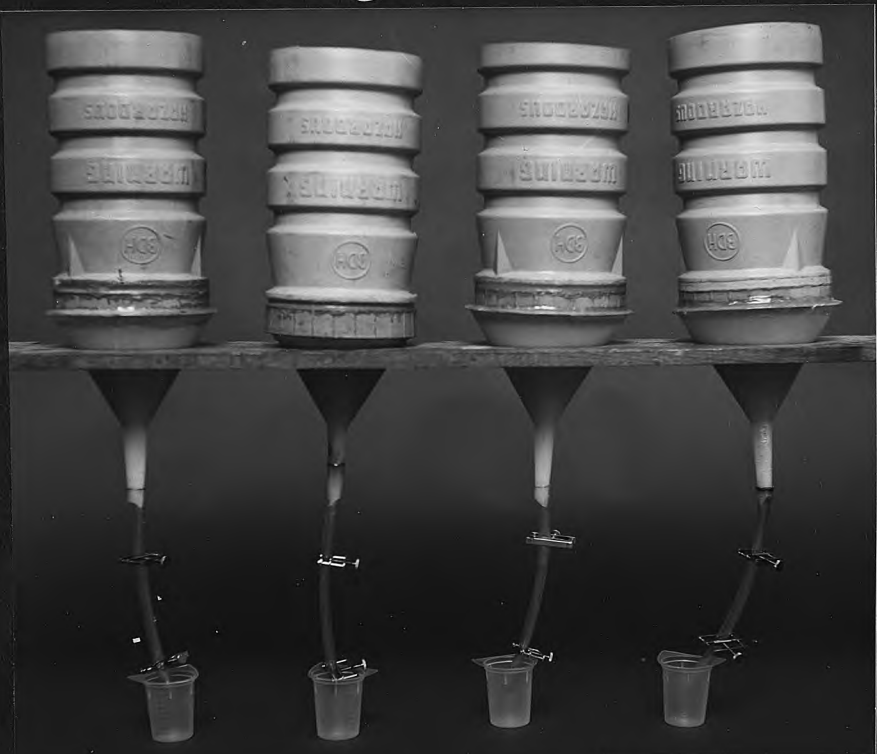


Plate 8

After six to eight hours the settled larvae were collected by closing the top clamp and opening the bottom clamp(Plate 8).The collected suspension was then cooled at 4°C for one hour and the supernatant removed.The residual larval suspension was then poured into an universal bottle or medical flat bottle and treated and identified in the same way as the third stage larvae from the faecal cultures.Any larvae without sheaths(Plate 7) were disregarded and only parasitic, infective larvae having sheaths were recorded.

RESULTS

The overall mean egg count figures for the three groups of ewes and similar figures during the period of the peri-parturient rise (PPR) are shown in Table I. The PPR covers the period of eight weeks following January 15, 1974 for the two Suffolk groups, and from April 15, 1974 for the Cheviot ewes.

TABLE I
The Comparison of Mature Ewe Egg Counts
(Eggs Per Gram)

| | <u>Strongyle type eggs</u> | | <u>Strongyloides eggs</u> | |
|------------------|----------------------------|----------------------|---------------------------|----------------------|
| | <u>Mean* Count</u> | <u>PPR Count</u> | <u>Mean Count</u> | <u>PPR Count</u> |
| Indoor Suffolks | 800 | 881 | 145 | 176 |
| Outdoor Suffolks | 779 | 1111 | 254 | 354 |
| Cheviots | 423 | 1120 | 159 | 383 |

*Mean Count is the average of the "flock average", during the survey period.

In Table I the small group of indoor Suffolk ewes show only a very slight increase in egg counts during the PPR in both strongyle type and Strongyloides papillosus eggs. In addition, the indoor group fails to illustrate a typical PPR (Figure 2). Nematodirus filicollis ova were noted in very low numbers in only one of the

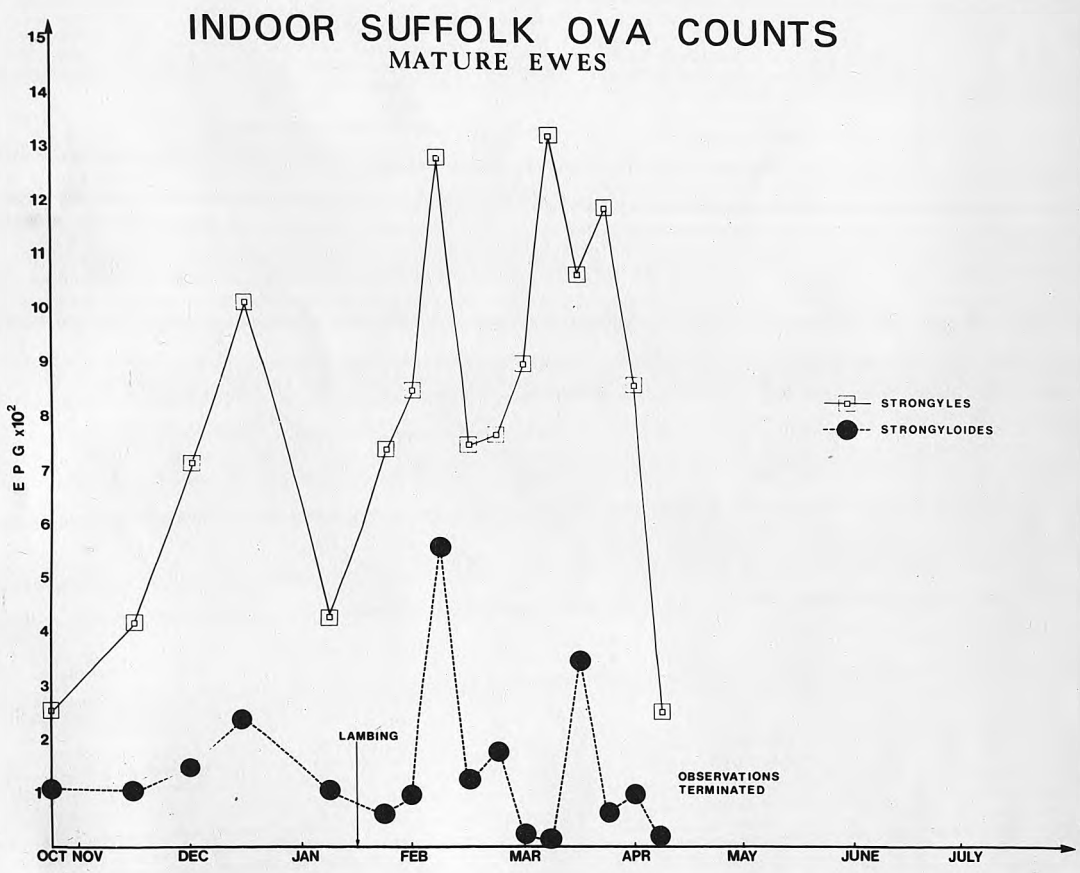


FIGURE 2

ten animals during the entire survey period.

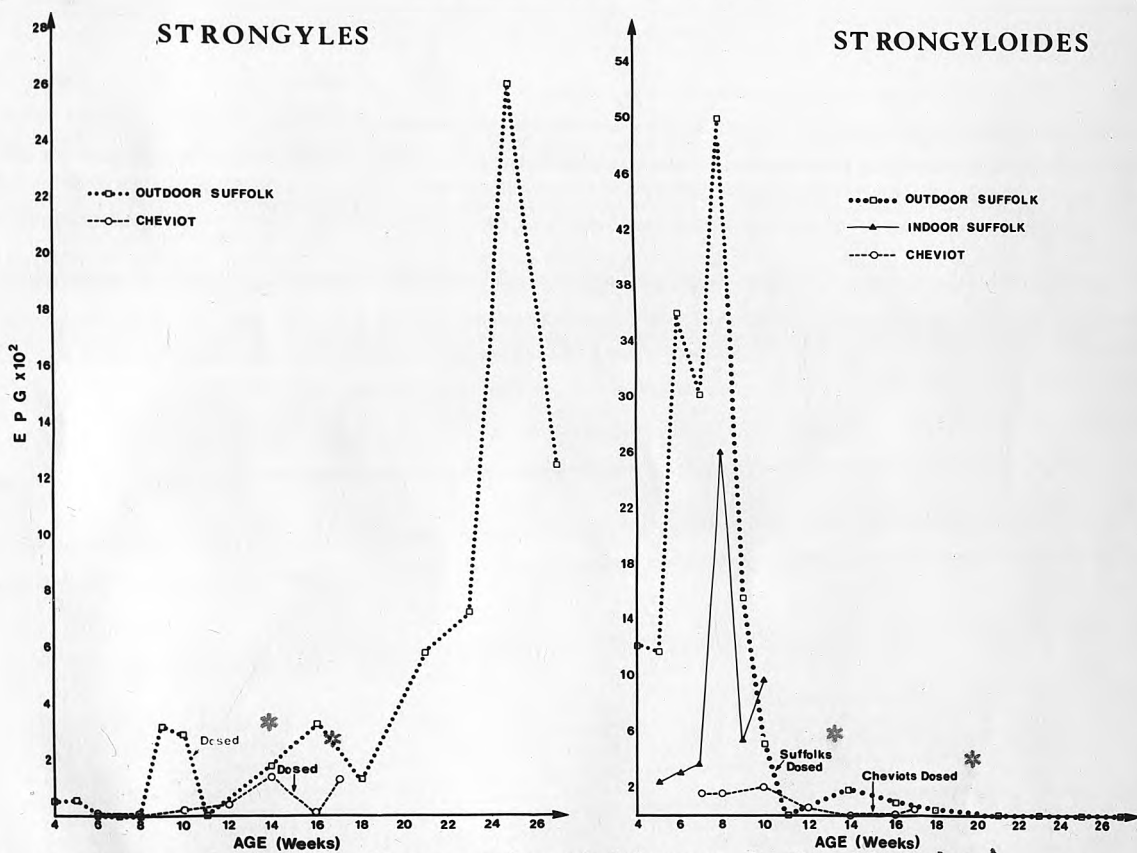
Only Strongyloides papillosus eggs were found in the Indoor Suffolk lambs, averaging 800 eggs per gram (epg)(Table II), but peaking at 2600 epg(Figure 3).

TABLE II
Comparative average Ova Counts in eggs per gram
for Lambs between 6-14 weeks of age

| | <u>Strongyle type</u> | <u>Strongyloides papillosus</u> | <u>Nematodirus</u> |
|------------------|---------------------------|-------------------------------------|--------------------|
| Indoor Suffolks | NIL | 800 | NIL |
| Outdoor Suffolks | IOI | 243I | 76 |
| Cheviots | 32 | 93 | I3 |

In addition, coccidial oocyst counts ranged from 100,000 to 255,000 per gram at the same age. The species of oocysts noted, in decreasing order of prevalence were Eimeria parva, E. ninakohlyakimovae and E. arloingi, with the latter occurring very infrequently compared to the other two. It is evident from Table III that there is very little change in generic larval composition between the January to April period and the eight weeks following lambing.

LAMB OVA COUNTS



* Haloxon (Loxon, Burroughs, Wellcome & Co., London)

* Thiabendazole (Thibenzole, Merck, Sharp & Dohme, Herts.)

FIGURE 3

TABLE III
 Comparison of Average Faecal Larval Culture
 Results, according to genus,
 from Indoor Suffolk Ewes (percent)

| | <u>During PPR</u> | <u>Jan-April</u> |
|------------------------------|-------------------|------------------|
| <u>H. contortus</u> | 64.5 | 68.5 |
| <u>Ostertagia</u> spp. | 21.0 | 14.0 |
| <u>Trichostrongylus</u> spp. | 12.5 | 10.0 |
| <u>Bunostomum</u> spp. | 2.0 | 7.5 |

The "Outdoor Suffolk" flock of ewes consistently showed a high average egg count very similar to the Indoor Suffolks but considerably higher than the Cheviot ewes (Table I). The PPR is not easily distinguishable (Figure 4). Nematodirus filicollis and N. battus ova were both recorded, but only during the period from mid-February to mid-May, 1974, and averaged a very low 12 epg.

The Suffolk lambs born outdoors showed a relatively high average of S. papillosus egg count of 2431 epg (Table II). N. filicollis and N. battus were also found in the lamb faeces but in quite low numbers on average. Strongyle type egg counts were similarly low (Table II). A heavy coccidial oocyst count was recorded, in the range from 100,000 to 152,000 per gram of faeces, during the same period. The same coccidia species occurred in this outdoor group as in the indoor group, and in the same proportions.

OUTDOOR SUFFOLK OVA COUNTS MATURE EWES

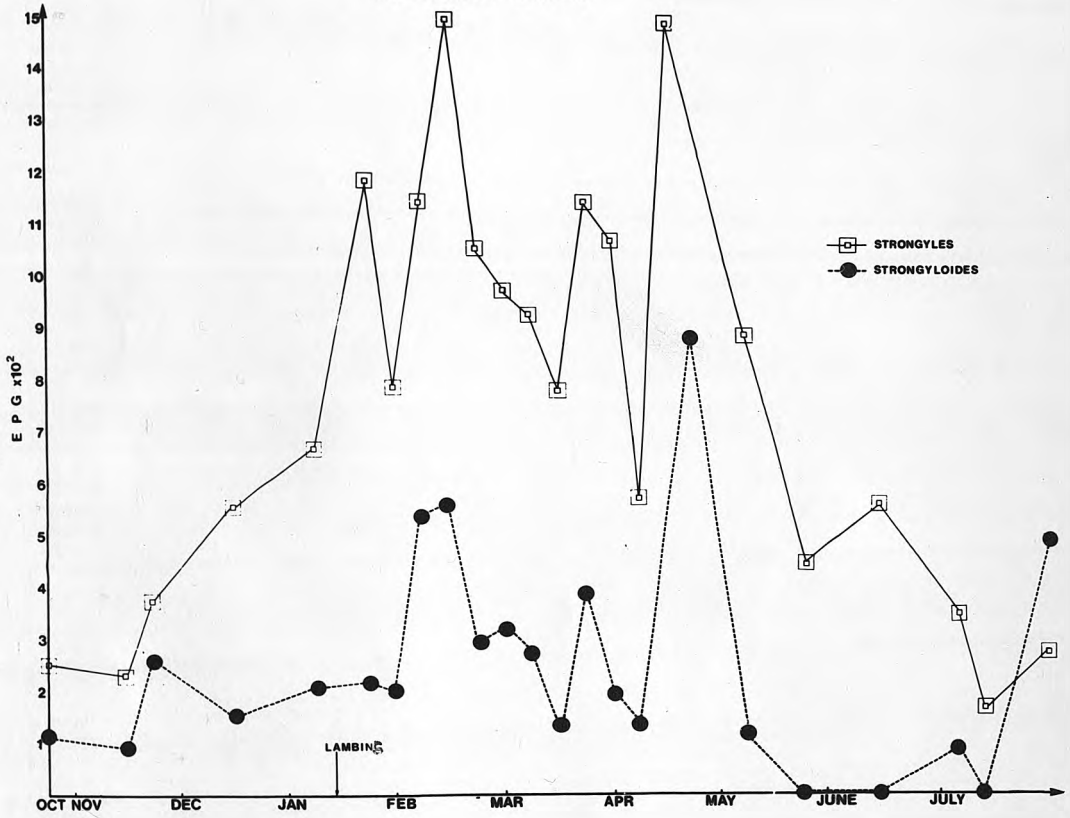


FIGURE 4

Table IV shows that, for the Outdoor Suffolk flock there is no evident change in generic larval composition between the January to July period and the PPR period. Also, the order of prevalence of the genera is identical to that of the Indoor Suffolks (Table III).

TABLE IV
Comparison of Average Faecal Culture
Results, according to Genus,
from Outdoor Suffolk Ewes (percent)

| | <u>During PPR</u> | <u>Jan-July</u> |
|------------------------------|-------------------|-----------------|
| <u>H. contortus</u> | 52.4 | 48.0 |
| <u>Ostertagia</u> spp. | 28.0 | 35.0 |
| <u>Trichostrongylus</u> spp. | 18.6 | 14.0 |
| <u>Bunostomum</u> spp. | 1.0 | 3.0 |

Two fecal cultures from the Outdoor Suffolk lambs during July, 1974 produced the following average results: H. contortus 79, Trichostrongylus spp. 17, and Ostertagia spp. 4.0 (figures are percent).

Finally, the April-lambing Cheviot ewes seem to carry the lowest average faecal egg counts consistently throughout the entire study period (Table I). They show, however, the highest average PPR strongyle type ova count (Table I), and also the highest peaks for the average of both strongyle type and S. papillosus eggs (Figure 5). In addition, the Cheviots illustrate a

CHEVIOT OVA COUNTS MATURE EWES

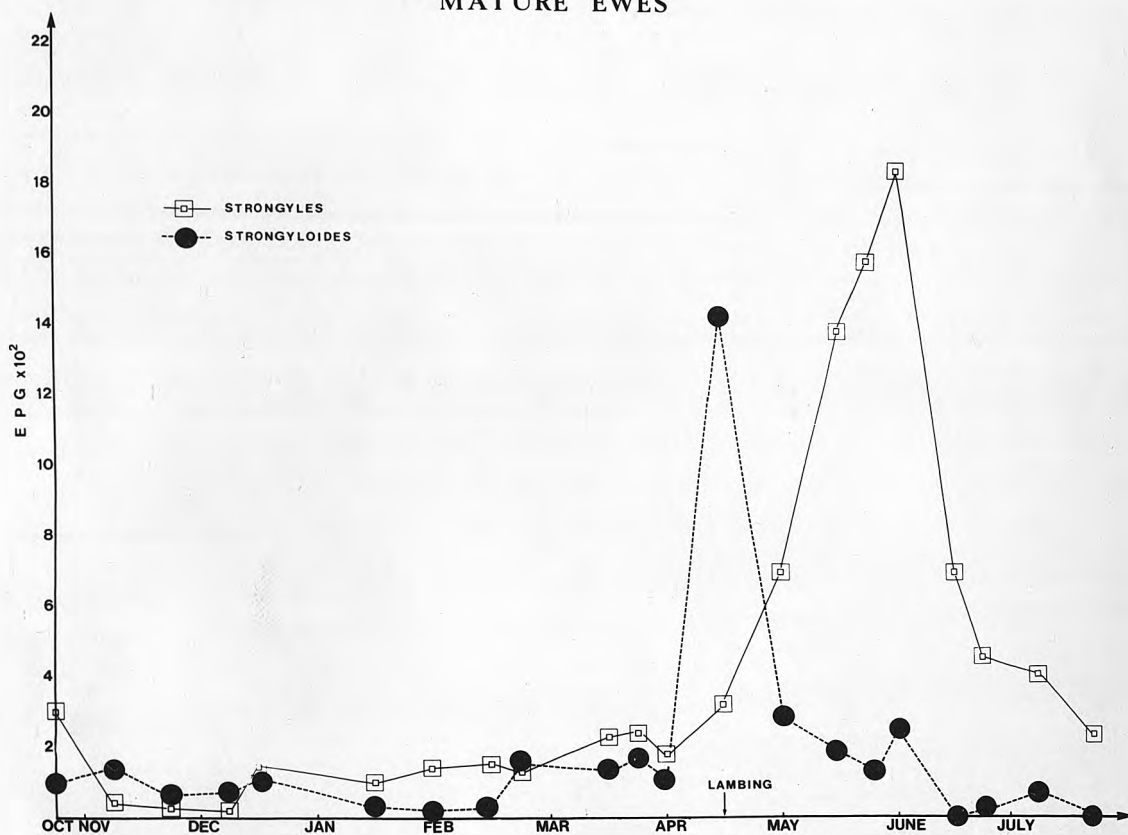


FIGURE 5

typical PPR (Figure 5). A single sharp peak in the S. papillosus count is evident during lambing (Figure 5). Table I, however, shows very little relative change in the average S. papillosus egg counts during the PPR compared to the mean count for the entire survey period. No Nematodirus spp. ova were found in the Cheviot faecal samples throughout the survey. It is evident from Table V that, during the PPR period, the increase in strongyle type egg counts in the Cheviot flock was largely due to a relative increase in the H. contortus egg count. The PPR period is included in the April to July figures below.

TABLE V
Mean Percent Recovery of Different Helminth
Genera as Larvae, from Cheviot Faeces

| | <u>Jan-July</u> | <u>Jan-Mar</u> | <u>April-July</u> |
|------------------------------|-----------------|----------------|-------------------|
| <u>H. contortus</u> | 33 | 13 | 56 |
| <u>Ostertagia</u> spp. | 21.5 | 23 | 71 |
| <u>Trichostrongylus</u> spp. | 34.5 | 57 | 27 |
| <u>Bunostomum</u> spp. | 6.2 | 8.2 | 4.6 |

The Cheviot lambs between six and fourteen weeks of age showed very low Strongyle type and S. papillosus egg counts, in addition to very low N. filicollis counts of 13 epg (Table II). Moderate levels of coccidial oocysts were also observed, but not counted. A Cheviot^{lamb} faecal culture taken and examined in late August, 1974 showed

the following larval results, expressed as percentages: H. contortus 70, Ostertagia spp. 20 and Trichostrongylus spp. 10.

Table VI illustrates the relative proportions, in percentages, of infective larvae found on the herbage from pastures grazed by the unweaned Cheviot lambs and their dams from May to July 1974, as well as for all four pastures used from February to July, 1974.

TABLE VI
Average Percent Recovery of Different
Helminth Genera as Larvae from Pasture

| | <u>Cheviot Pasture</u> <u>(May to July)</u> | <u>Four Pastures</u> <u>(February to July)</u> |
|------------------------------|--|---|
| <u>H. contortus</u> | 41 | 46 |
| <u>Ostertagia</u> spp. | 6 | 7 |
| <u>Trichostrongylus</u> spp. | 37 | 35 |
| <u>Bunostomum</u> spp. | 14 | 9 |
| Others* | 2 | 3 |

*Others includes Chabertia spp. and Nematodirus spp.

Parasitic larval counts from fresh herbage between February and July, 1974 ranged from eight to sixty-eight larvae per kilogram of fresh green grass. Counts tended to increase from winter to summer. The ratio of the different genera of larvae contaminating all the pastures sampled is illustrated in Table VI.

The only other nematode eggs counted during the survey were Trichuris spp., and they occurred only at very low levels. Moniezia expansa eggs were observed infrequently. All spot checks for Fasciola hepatica eggs were negative.

DISCUSSION

From the findings of this survey there appears to be a difference in ova counts according to the breed (Figures 6 and 7). The Cheviots egg counts almost always are below those of both groups of Suffolks. The same trend is suggested by the lamb ova counts, when these are compared, up to an age of 17 weeks. This latter trend, however, is less obvious, perhaps due to the short survey period, lambing dates, and differences in climate and anthelmintic therapy. The more obvious comparison is in the strongyle type egg counts of the mature ewes, as seen in Figure 6, and in Table I, in which the mean Suffolk counts over the entire period are almost twice that of the Cheviots. The differences in strongyle type egg counts, however, are much less, between all groups, during the peri-parturient rise (PPR). By comparison to this, the S. papillosus egg counts show much less difference among all groups and breeds. In Figure 7, however, it becomes apparent that very high peaks of S. papillosus are possible in both breeds. This breed comparison spills over into the PPR as previously mentioned, yet the difference of strongyle type egg counts during this period are not clear cut as those averaged for the entire study period. From Figure 6, however, it appears that only the Cheviot breed exhibit a typical PPR. The immediate reason, seen from the same figure is the very low, consistent egg counts

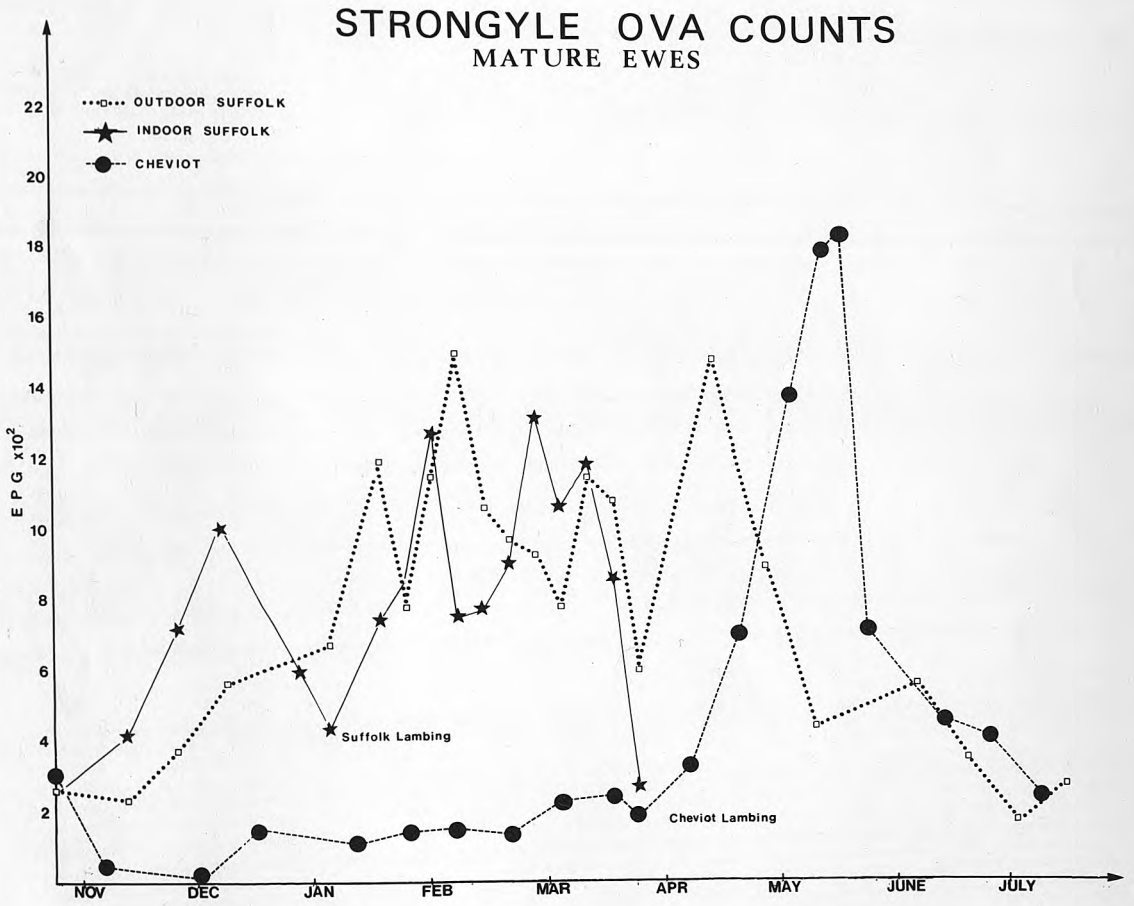


FIGURE 6

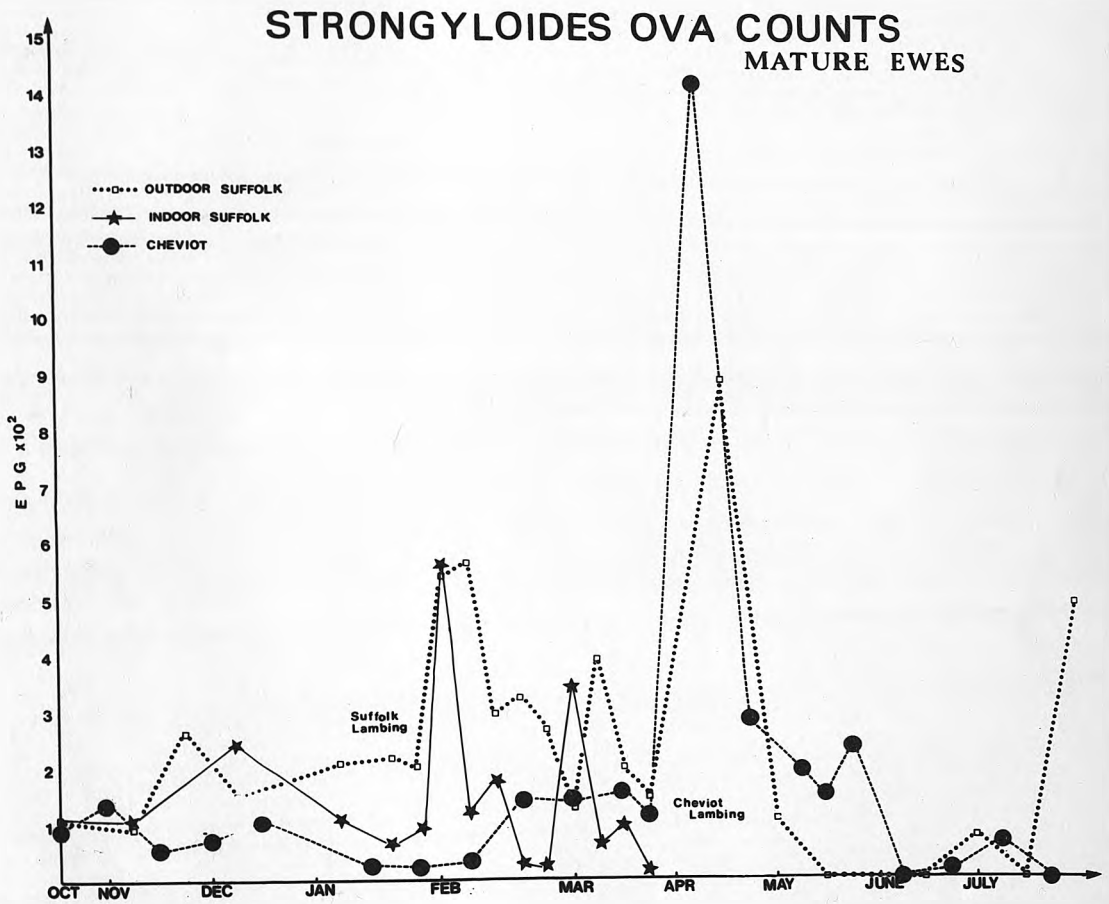


FIGURE 7

up to April, 1974, followed by the very sudden increase during lambing. In comparison, the Suffolk groups had a much higher and more erratic basic level of egg counts during late autumn, with a peak of similar size to the Cheviots after lambing, and accordingly the increase in the lambs is much less dramatic. The Indoor Suffolk group showed the lowest PPR average increase while the Outdoor Suffolk flock increased its average PPR egg count a mere seventy percent, compared to an increase of nearly three hundred percent in the Cheviot group (Table I).

Some of the differences between the egg counts results during the entire survey period and those of the PPR period may stem from a difference in certain extrinsic factors such as the weather, at the different lambing dates (Figure 8). These extrinsic factors will be discussed later. Intrinsic factors, however, must also be considered. The two main, interrelated intrinsic factors are (i) the parasite(s), and (ii) the host unit.

The parasite burden and the contamination of herbage in this study appear to be a mixed natural infection of Haemonchus contortus, Ostertagia spp., Trichostrongylus spp., Bunostomum spp., and Chabertia spp. Also noted in the results is the fact that H. contortus is the predominant nematode. All three flocks have at least fifty percent H. contortus content in their strongyle larval differentiations during PPR (Tables III, IV, V). Only the Cheviot flock changes considerably from

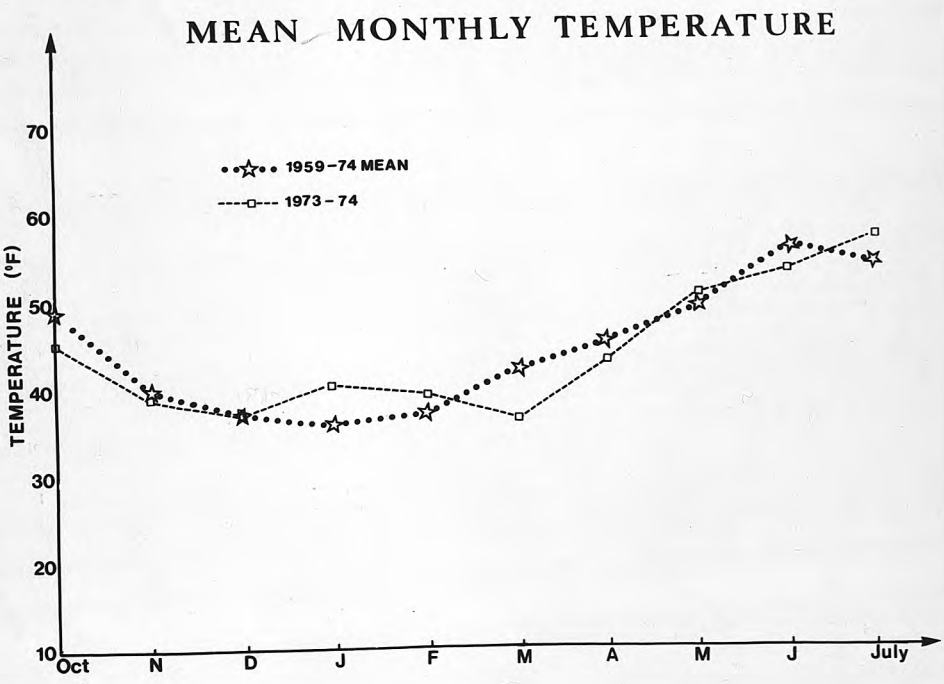
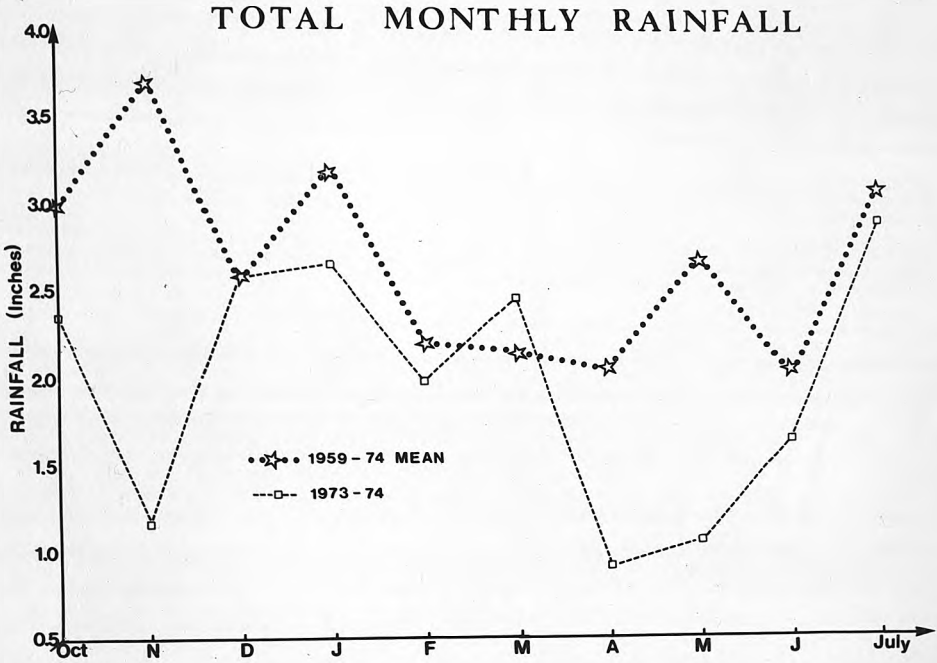


FIGURE 8

fifty-six to thirteen percent, outside of the PPR period (Table V). In addition, it is evident that H. contortus is responsible for most of the PPR in the Cheviot ewes, as the relative proportion of H. contortus larvae rose from thirteen percent before PPR to fifty-six percent during PPR (Table V). This is in agreement with observations in Norway (Helle, 1964) and in England (Connan, 1967) where H. contortus was also found responsible for increased egg counts during the PPR. The enormous fecundity alone of the adult H. contortus could easily increase average egg counts three hundred percent. In addition, endocrinological influences during the PPR could lower the hosts resistance through the process of parturient relaxation of resistance (PRR) (Gordon, 1973). The vast numbers of H. contortus ova excreted by the Outdoor ewes during the PPR (Table IV and V), and the relatively short generation potential leads to this species occurring predominantly in the contamination of the pastures with third stage larvae (Table IV). It, therefore, follows that the initial strongyle type infestation of the outdoor lambs would likely be haemonchosis (Gordon, 1973). This was observed in both outdoor groups of young lambs on this farm, under the present system of management, and agrees with the findings of Waller (1974) in north-east England.

When considering other intrinsic factors related to parasites, one can not ignore the importance of all

genera of gastrointestinal nematodes in a mixed infection (Gordon, 1973), due to their combined pathogenicities. In this survey it is, therefore, essential to consider the other four major genera found in these flocks. Trichostrongylus spp. and Ostertagia spp. appear to occur in nearly equal proportions, in all three flocks. The Suffolks have a slightly higher proportion of Ostertagia spp. larvae (Table III, IV), while the Cheviots have a slightly higher proportion of Trichostrongylus spp. (Table V). However, possibly due to biotic variation between the free-living stages of the two genera, results of pasture contamination with third stage larvae show Trichostrongylus spp. larvae proportions (35 percent) well above the Ostertagia spp. proportion (7 percent) (Table VI). In the same table, Bunostomum spp. larvae appear two percent higher than the Ostertagia spp.

Again, perhaps due to the bionomics (Gordon, 1973), first infestations in the two groups of lambs show Trichostrongylus spp. to be more common than Ostertagia spp., but much lower than H. contortus. It must be remembered, however, that larval differential counts from strongyle type eggs, as well as the faecal egg counts, are only a guide to an estimation of parasitic burden in the host unit (Crofton, 1963). The remaining two most common nematodes were Bunostomum spp. and Chabertia spp. The Bunostomum spp. numbers are possibly low due to the decreased rainfall in the area during the study period (Figure 8).

The intrinsic factors related to the host unit (i.e. the flocks of sheep in this case) are less numerous. The major observation appears to be a difference in average egg counts between the breeds of sheep. The shepherd has often commented that "Suffolks are wormy", and the egg counts suggest that he is correct. As seen by the results presented in Table I and in Figure 6, it appears that the Cheviots are, by far, the better breed from a helminthological point of view.

Possible reasons for the breed variations in this case could be directly associated with differences in body size, and weight of the mature sheep between the Suffolk and the Cheviot breeds. The author would like to suggest the following sequence; most Suffolk ewes are thirty^t to forty percent heavier in live weight than the Cheviot ewes in this particular flock. As a result, the larger Suffolk animal tends to eat more. Considering the flock as a host unit, the Suffolk host unit consumes more herbage than the Cheviot host unit, and, therefore, more infective larvae as well. If a large Suffolk ewe consumes more larvae, more larvae are offered the opportunity to infest the host and thereby develop into more adult worms (within limitations). As the larger animal ingests more herbage, then the same animal will most likely excrete more wastes. Therefore, it follows that the larger animal with greater numbers of adult nematodes in its gut will deposit higher potential ova counts

more widely about its pasture. This greater dispersion of contamination then can lead to another compounding life cycle within the same host unit. Further controlled studies are necessary to confirm this suggestion, but similar examples of breed variation in regard to haemonchosis in sheep are reported in the literature (Radhakrisnan, Bradley, and Loggins, 1972; Knight, Vegors, Glimp, 1973). Genetic differences were noted by Ross (1970) in the susceptibility of Scottish Blackface sheep and Dorset sheep to infections with Trichostrongylus axei. Jilik and Bradly (1969) and Radhakrishnan et al (1972) showed that haemoglobin type HbA of the Florida Native breed is the inherited factor of resistance against H. contortus in the lambs. Knight et al (1973) compares five breeds of sheep for resistance to haemonchosis and found the Navajo breed most resistant. Some similar factor may be involved in the breed differences found in this survey. Secondary host related factors such as flock size, flock grazing behaviour and average age of sheep in the flock could also be involved, in addition to this possible genetic tolerance or immunity (Gordon, 1973).

In dealing with epidemiology, it is very difficult to separate complex relationships between intrinsic and extrinsic factors. The extrinsic factors are those factors dealing mainly with the environment. In parasitic gastro-enteritis the environment mainly influences the survival and development of the egg and free-living stages of the parasite. At these stages the parasite has essentially

lost the protection provided by the host and is then subject to climatic variation. The climate can be roughly divided into the Macroclimate (Figure 8) and the Microclimate (Figures 9 and 10).

Some correlation can be illustrated between lambing dates and the egg counts during the PPR period (Figures 6 and 7), by examining the meteorological information. The rise (PPR) of strongyle type egg counts in the lambing Cheviots during April and May occurs very shortly after a secondary rise in the Outdoor Suffolk ewes which lambed three months earlier (Figure 6). Figure 7 illustrates the similar rises in the S. papillosus counts which are essentially superimposed. The influence of Gordon's (1973) parturient relaxation of resistance (PRR) reaction may cause the Cheviot count to extend beyond that of the shorter Suffolk peak (Figure 7). The "difference" may be due to the PRR but the "similarity" appears to be attributable to the changing climatic influences (Figure 8). The above average rainfall during March (Figure 8) did not show its most favorable effects on the bionomics of the adult parasite population until later due to (i) below normal temperature (Figure 8) at the time of increased rainfall, followed by a warming trend, and (ii) the natural time lag required for infective larvae to mature into adults and lay eggs. This prepatent period varies between genera of nematode as well as according to the bionomic conditions affecting

MEAN MONTHLY GRASS MINIMUM TEMPERATURE

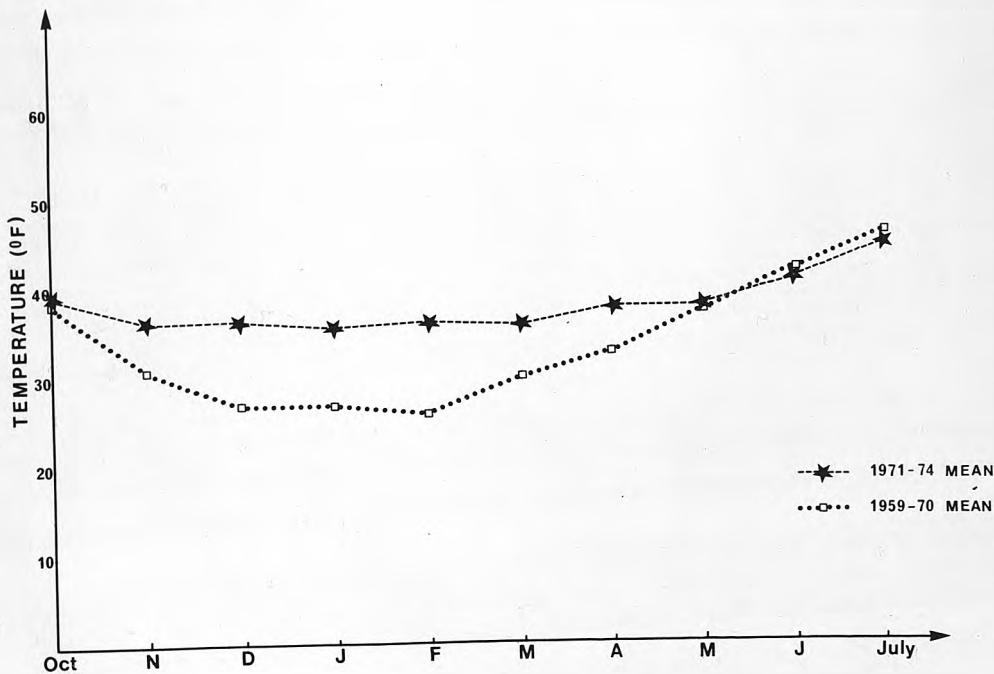
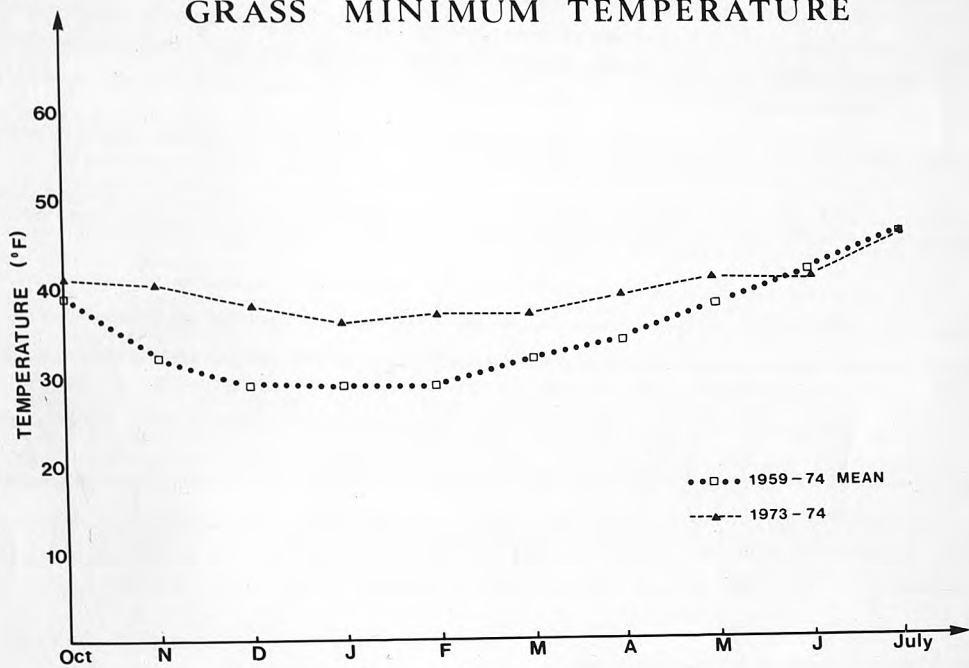


FIGURE 9

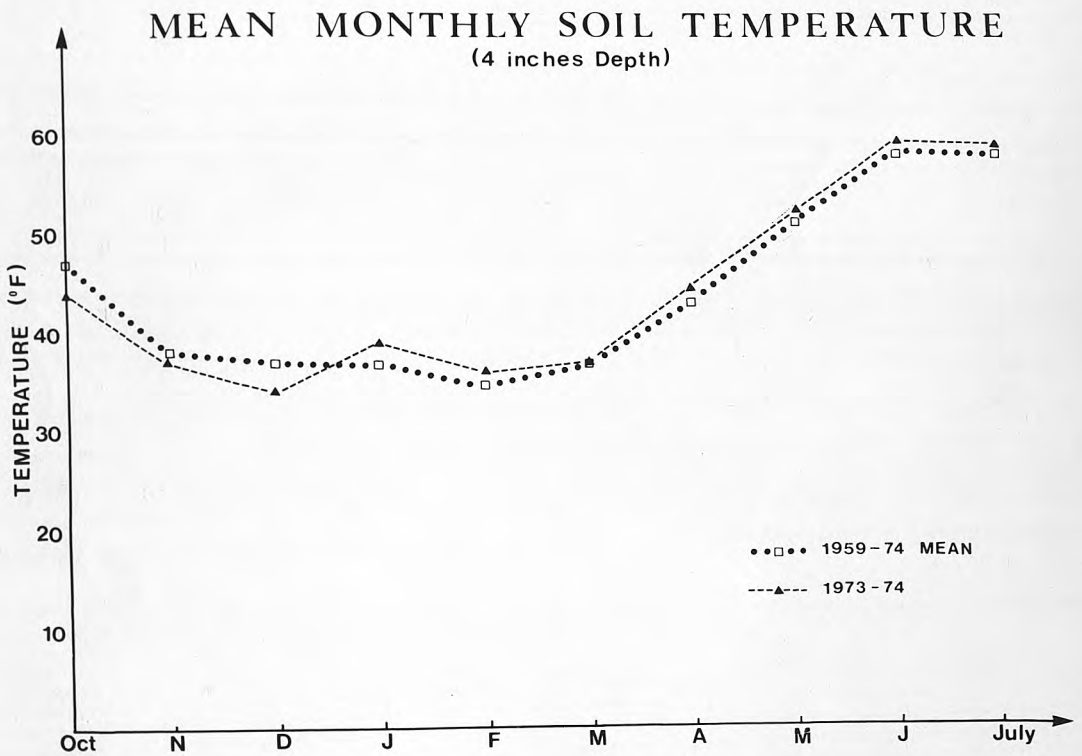


FIGURE 10

the free-living stages. S. papillosus has been reported to have a parasitic prepatent period of nine days or less (Dunn, 1969), while H. contortus takes about three weeks, followed by Trichostrongylus spp. and Ostertagia spp. at about four weeks prepatency, and finally Bunostomum spp. and Chabertia spp. in the range of seven to ten weeks (Crofton, 1963). One should, however, remember that a factor favouring one genus may not equally favour another genus. The short prepatent period of three to four weeks complies with the requirements of the genera in Table IV, mainly H. contortus, Ostertagia spp. and Trichostrongylus spp. However, the simultaneous increase in the S. papillosus count may be due to the free-living infective larvae of this nematode becoming parasitic due to the adverse temperature (below normal) and moisture (below normal) conditions at this time (Figure 8). In the period after the PPR in the Suffolk ewes there is a rise in strongyle type egg counts (during April and May in Figures 6 and 7), and it is possible that in the Suffolk ewes this rise is the product of overwintered infective larvae ingested earlier during February and March.

Management is another extrinsic factor. An illustration of the effect of this factor can be seen in Figure 3, in the high peak of strongyle type eggs for the Outdoor Suffolk lambs at twenty-five weeks of age, in mid-July. As Figure 3 indicates, the lambs were

dosed at eleven weeks of age, but clean pasture was not available. During the next fourteen weeks the lambs were weaned but not moved to a clean pasture, only to a different pasture which had been previously grazed by the flock before the lambs were weaned. With improving spring and summer climatic conditions (Figure 8) and the PPR contamination of eggs from the ewes the pasture became increasingly infested with third stage larvae, and, consequently, so did the susceptible lambs (Figure 3), mainly with H. contortus.

A second example of the influence of management factors is illustrated by comparing the Indoor and the Outdoor Suffolk lambs (Table II). The Indoor group had not shown any evidence whatsoever of strongyle type eggs in its faeces up to fourteen weeks of age, while their counterparts on pasture showed both strongyle type and Nematodirus spp. eggs.

An interesting situation is illustrated in Figures 3 and 7, in that the high S. papillosus ova counts of the Suffolk ewes during the PPR period are reflected in their lambs, most markedly at eight weeks of age. A very high single peak of the same eggs in the Cheviot ewes is not reflected in their respective lambs. However, the first sampling taken from the Cheviot lambs were collected at seven weeks of age and may have been too late, as the peak occurs about four weeks earlier in the Cheviot ewes lambing period than it does in the Suffolk lambing period.

These findings (Figure 3) show clearly that in lambs resistance to S. papillosus develops early in life (Dunn, 1969), in this case by about eight weeks. Transplacental, transcolostral or trans-milk infestations as well as skin penetration may be responsible for such early infestations (Figure 3). This is in agreement with the findings of Dunn (1969) and Lyons (1970). Under experimental laboratory conditions, using ultraviolet attenuated infective S. papillosus larvae, Stankiewicz (1974) immunized six month old lambs. Formation of immunity took six weeks.

In addition, from Figure 3, one can easily criticize ^{the} strategic anthelmintic chemotherapy routine used. The management based its action on an outbreak of clinical PGE in lambs during the summer of 1973. It is apparent, however, that both groups of lambs were dosed when strongyle type egg counts were low. The S. papillosus egg count had, in fact, just fallen from its very high peak. Therefore, dosing and development of natural resistance to this parasite coincided. As the Outdoor Suffolks grew older and received their higher challenge infestations no further dosing was carried out although this might have been valuable at about 20 to 24 weeks of age.

Other unusual management practices have been observed which will have had complex effects on the epidemiology. For instance, there is the mixed stocking

of cattle and sheep, and sometimes horses. The low larval contamination of the pasture, as shown by a maximum of 64 larvae/kilogram of herbage, is surprising when considering the high stocking rates, but may result from the mixed stocking. Thomas and Boag (1972) refer to heavy contamination of pasture by infective larvae as varying from 200 to 800 larvae/kilogram of herbage. It is not clear, however, whether or not S. papillosus free-living larvae are included.

Diet can influence the epidemiological picture through changes in egg counts as may be seen in Figure 6 with the Indoor Suffolk group. The first peak of the strongyle type eggs in December coincides with a change in diet from mainly hay to fresh turnips, which were not given to either of the outdoor groups. The count then appears to dip just in time to become suddenly reversed in the PPR (Figure 6).

In considering seasonal climatic patterns (Figures 8, 9, 10) it is their effects on the free-living stages of the parasite which are most significant (Levine, 1963; Michel, 1969). Figure 8 shows that generally below average rainfall fell during the survey period, with one exception in March, 1974. This factor in combination with the temperature changes also noted in Figure 8 may alter the proportion of the species of infective larvae by affecting the survival rate of eggs and larvae on pasture. A decreased amount of rainfall may favour the

survival of one genera (e.g. Trichostrongylus spp.) and harm that of another (e.g. Bunostomum spp.) on the same farm. Climatological limitations reported from Australia (Seddon, 1967) and America (Levine, 1963) for H. contortus may not be strictly applicable to the strain of H. contortus present in Scotland. On the other hand even seasonal variations found in the United Kingdom may not be generally applicable, due to local geography and meteorology (Michel, 1969; Boag and Thomas, 1971; Ollerenshaw and Smith, 1969).

There seems to be a definite tendency for the winters to have become warmer at Easter Bush, since 1971 (Figure 9), in addition to the recently decreased rainfall (Figure 8), both of which factors occurred during the winter months of this survey. This is contrary to the theory that the world is entering another glacial era. The free-living larvae community in their microenvironment appear to be enjoying a relatively "tropical" tendency compared to the fifteen year average (Figure 9). The warmer temperatures during the winter are not likely warm enough to increase egg and larval development, but are sufficiently warm to prolong larval survival (Levine, 1963; Michel, 1969) and provide the means for a greater proportion of contaminating larvae to overwinter, thus providing both ewes and lambs with a source of residual infestations in the following spring (Gibson and Everett, 1972). The grass minimum temperature and the mean soil

temperature (Figures 9 and 10 respectively) illustrate the vast difference that may exist between the micro-climate and the macroclimate, the latter being illustrated in Figure 8. The difference itself also illustrates the deficiencies in using macro-climatological data in forecasting the incidence of parasites.

It is not possible, in one short and relatively limited survey such as this, to describe and discover all the epidemiology and long term effects. This requires long term epidemiological studies similar to those used for meteorological recording. The author would like to suggest, however, that in light of the obvious changes in climate with time (Figures 8 and 9) and its close effect on the bionomics of PGE some changes in the parasite population (number and content) are likely. The results of this survey suggest that H. contortus may be of increasing importance in the south-east of Scotland, in contrast to the past when PGE in Scotland was caused by primarily (i) Ostertagia spp., (ii) Nematodirus spp., and (iii) Bunostomum spp., with H. contortus being found only occasionally, in small numbers or in isolated areas (Cameron, 1923; Morgan, et al, 1951; Parnell, et al, 1954; Parnell, 1954; Annual Veterinary Investigation Reports, 1967-72). The author would like to suggest that perhaps in the past the colder temperatures in Scotland favoured the development and survival of Ostertagia spp. Since 1971, however, the higher temperatures, and more recently

decreased rainfall, may be hindering the Ostertagia spp.
and Bunostomum spp. while relatively favouring the
H. contortus and Trichostrongylus spp.

CONCLUSIONS

The epidemiology of ovine parasitic gastroenteritis (PGE) on Easter Bush farm is particularly complex because of the presence of two flocks of sheep of different breeds, which lamb at different times and because of the unusual management routine.

The findings in this survey showed a variation in faecal egg counts between the two flocks, probably arising from the breed difference. Only the Cheviot breed experienced a "typical" peri-parturient rise (PPR). High Strongyloides papillosus egg counts appear in both lambs and ewes. Haemonchus contortus appears to be the dominant nematode involved on this farm and in these flocks, and is the major contributor to the PPR in the Cheviots. Ostertagia spp. and Trichostrongylus spp. appear to be secondarily involved. Bunostomum spp. and Chabertia spp. were also found.

Recent meteorological changes in which there has been a tendency for the winters to be relatively warm and dry may be of major importance to the incidence of parasitic gastroenteritis in south-east Scotland.

The management practices observed on the farm, including the heavy stocking rate, the resulting inability to avoid the contamination of all the pastures, and the way in which anthelmintics are used might have been expected to result in parasitic gastroenteritis being a major

problem. However, the contamination of the pastures with infective larvae seems to have been very light. The need for long range epidemiological studies on a local basis is suggested.

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