Seasonal Changes in the Prevalence of Gastrointestinal Nematodes in Sheep in Nova Scotia, Canada.

By

Rebecca A. Betts

A thesis submitted to Saint Mary's University, Halifax, Nova Scotia
in partial fulfilment of the requirements for the degree of
Bachelors of Science (Honours) in Biology.

April 22, 2014, Halifax, Nova Scotia, Canada.

Approved:	Dr. Gwyneth Jones Supervisor
Approved:	Dr. Ron Russell Reader
Date:	April 22, 2014

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SIGNATURES OF THE EXAMINERS

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ABSTRACT

Currently, there is a major lack of documentation regarding the seasonal changes in the prevalence of gastrointestinal nematodes (GINs) in sheep in Nova Scotia. Therefore, the objective of this study was to document the seasonal changes in the prevalence of GINs found in sheep in Nova Scotia so that farmers and researchers understand the trends in monthly and yearly infection. The primary focus was placed on the correlation between GIN levels and climate. It was predicted that the prevalence of GINs would increase in the early spring due to periparturient egg rise and cessation of winter larval hypobiosis, decrease during the late spring/early summer, remain low during a hot dry summer, increase in conjunction with the late summer/autumn rainfall and accumulated build-up of infective larvae (L3) and GIN ova on pasture, and decrease again as the GINs go into hypobiosis in the late autumn. For this study, particular attention was placed on the ova produced by *Haemonchus* spp., *Telodorsagia (Ostertagia)* spp., *Trichostrongylus* spp., *Cooperia* spp., *Bunostomum* spp., *Nematodirus* spp., and *Trichuris* spp. Faecal samples from a closed flock were taken in 2012 and 2013 that represented a typical flock encountered in Nova Scotia. Faecal egg counts (FEC) were used to monitor GIN prevalence, and were determined using the McMaster Technique. Larval cultures were used to identify certain GIN species. It was determined that the prediction was supported. However, prevalence increased from 2012 to 2013, which was not expected. This was likely caused by proliferative GINs dominating other GIN species, ova build up on pasture from month to month and year to year, or increasing anthelmintic resistance in GINs.

Date: April 22, 2014

ACKNOWLEGMENTS

I would like to give my sincerest gratitude to Dr. G. Jones, K. Hipwell, D. Thibault, Dr. S. Meek, N. Osborne, Dr. D. Strongman, C. Cranley, M. Logan, J. Yang, B. Flynn, H. de Boer, C. Clarke, J. White and my friends and family for their time, expertise and support.

I would also like to thank Saint Mary's University, the Purebred Sheep Breeders Association of Nova Scotia, Agri-Futures, the Sheep Producers Association of Nova Scotia, and Agriculture and Agri-Food Canada for their contributions and funding.

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INTRODUCTION

With regards to sheepherding, Canada in general is not as heavily invested in the wool and meat industry as other countries such as the United Kingdom, Australia, South Africa and New Zealand (Guthrie *et al*, 2010; Terrill *et al*, 2012). Despite this, Canada still maintains lively sheepherding communities across the country. Within Canada, the majority of sheepherding can be found within the Eastern provinces (Terrill *et al*, 2012). However, there is currently a major lack of information regarding the presence of nematodes and parasites in sheep and other ruminants in Nova Scotia. This is surprising considering the amount of activity in the field of veterinary parasitology in other provinces such as Ontario and Quebec (Slocombe, 2009). This is quite problematic, as gastrointestinal nematodes (GINs) and parasites greatly impact the health of animals in which they reside and can in turn affect industry and agriculture.

According to the Handbook for the Control of Internal Parasites of Sheep and Goats (University of Guelph, 2012), commonly found GINs and parasites residing in sheep include: *Haemonchus* spp., *Telodorsagia (Ostertagia)* spp. and *Trichostrongylus* spp. found in the abomasum; *Cooperia* spp., *Trichostrongylus* spp., *Bunostomum* spp., *Nematodirus* spp., *Moniezia* spp., *Eimeria* spp. and *Strongyloides* spp. found in the small intestine; and *Oesophagostomum* spp., *Chabertia* spp., and *Trichuris* spp. found in the cecum and colon (Maal-Bared, 1998; Foreyt, 2001; Mederos *et al*, 2010; Abbot *et al*, 2012). Details about each GIN can be found in Tables 1, 2 and 3 in Appendix I.

In addition to the presence of GINs in different locations within the gastrointestinal tract of sheep, the presence of parasite species can differ regionally and locally as well. Common species of nematodes found in Ontario and Quebec are *Trichostrongylus* spp., *Haemonchus* spp. (globally common), and *Telodorsagia*

(Ostertagia) spp. (Mederos *et al*, 2010; University of Guelph, 2012), whereas *Haemonchus* spp. and *Nematodirus* spp. are more common to Nova Scotia (Winter, 2002; University of Guelph, 2012). It is interesting to note that *Haemonchus* spp. is typically found in the topics and sub tropics, while *Nematodirus* spp. is typically found in more northern climates, yet both can be found in abundance together in Nova Scotia (Winter, 2002; Mapes and Coop, 2009; van Dijk and Morgan, 2010).

The typical lifecycle of GINs can be summarized as follows (Figure 1): nematode eggs are passed into the faeces which are defecated onto pasture where the eggs hatch to release first stage larvae (L1). The L1 larvae moult to second stage larvae (L2), then moult to third stage larvae (L3, the infective stage), which then migrate up pasture vegetation. The L3 larvae are consumed along with the pasture vegetation by sheep and once established in the gastrointestinal tract, the L3 larvae moult to fourth stage larvae (L4). If the climate is still temperate and moist, as seen with spring or summer weather, the L4 larvae moult into adult worms within the gastrointestinal tract whereby female GINs produce and lay eggs. However, if the climate has begun to cool, as seen with autumn weather, sheep will be brought into barns for the winter and the L4 larvae will become hypobiotic (i.e. they go into a state of dormancy/arrested development). The L4 larvae will remain in the lining of the gastrointestinal tract until spring when sheep are moved out onto pasture again. Once spring has arrived, the L4 larvae moult into adult worms within the gastrointestinal tract whereby female GINs produce and lay eggs (Eysker, 1997; Eysker *et al*, 2005; University of Guelph, 2012). Also, a small percentage of the larvae and eggs on pasture will survive over winter and provide a light source of infection come the spring (Coop *et al*, 1991).

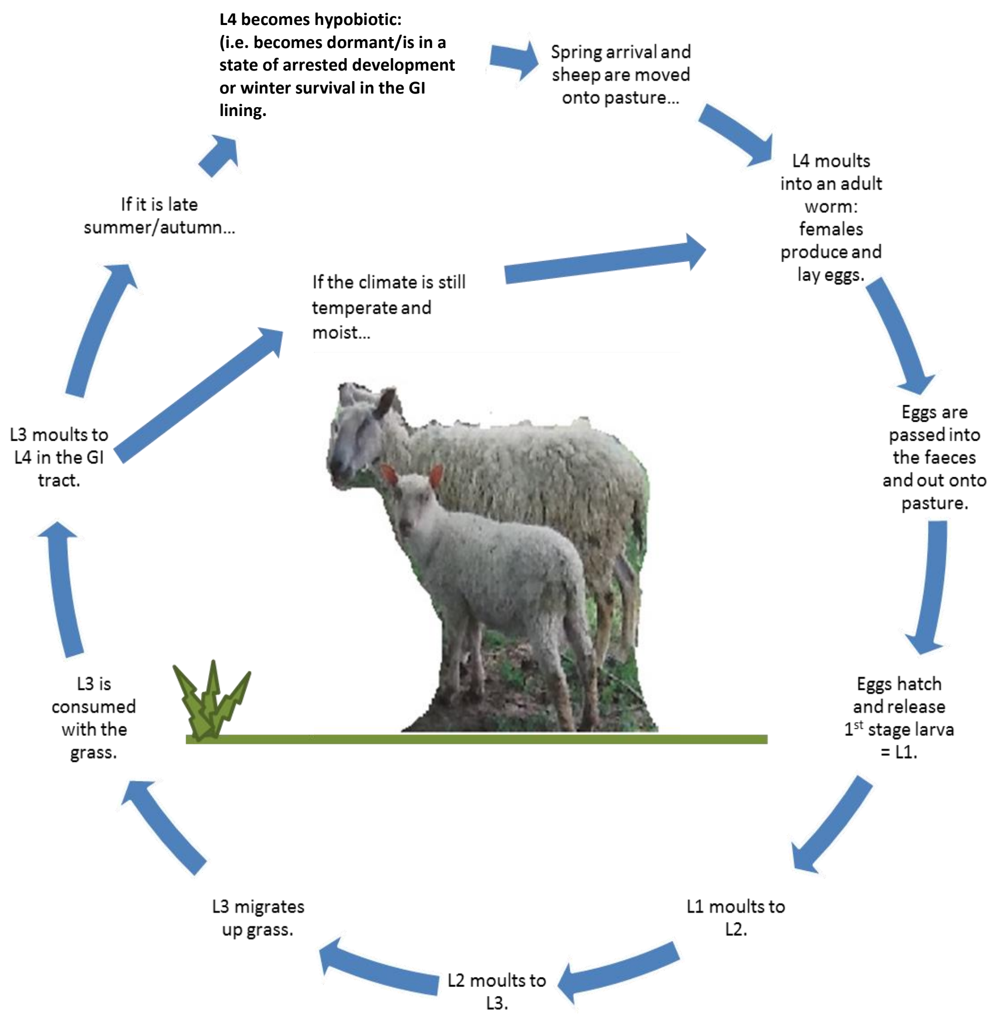


Figure 1: The typical life cycle of a gastrointestinal nematode.

There are multiple factors that affect the prevalence of GINs in sheep (Kaplan and Vidyashankar, 2012). Such factors include regional presence of parasite species, climate, pasture and livestock management, a sheep's natural immunity to parasites, and anthelmintic resistance in GINs (i.e. drug resistance to medications that destroy GINs). For example, certain breeds and ages of sheep are more susceptible to parasitic infection than others (Mugambi *et al*, 1997; Miller *et al*, 1998). Lambs and yearlings typically exhibit high GIN infections due to underdeveloped immune systems, while elderly sheep exhibit high infections due to degraded immune systems (Israf *et al*, 1997). Also, larger sheep tend to have a better tolerance towards parasitic infections than smaller sheep with a similar worm burden (Coltman *et al*, 2001). It is important to note that some sheep are genetically resistant to parasitic infection (i.e. their immune system is able to destroy and resist the establishment of infections), while other sheep are resilient to parasitic infection (i.e. an individual is able to survive and grow without disease symptoms in spite of a relatively high infection, but remain a prime source of pasture contamination) (University of Guelph, 2012).

However, it can be argued that climate and anthelmintic resistance in GINs are the primary variables that control GIN prevalence in sheep, regional presence of parasite species, pasture and livestock management, and can even influence a sheep's natural immunity to parasites regardless of breed, age, size or sex.

The local climate with regards to soil moisture, soil composition, rainfall amount and seasonal variation in temperature play vital roles in the lifecycle of GINs, especially in the survival of the larval stages on pasture (Agyei, 1997; O'Connor *et al*, 2007; Guthrie *et al*, 2010; van Dijk and Morgan, 2012). According to Khadijam *et al* (2013), increasing initial soil moisture provides a water film for larval stages to move in, and therefore results in an increased recovery of total L3 larva from pasture, as does increased amounts of rainfall. The increased recovery of L3 larva from pasture increases the likelihood that the larva will be eaten by sheep, and therefore can increase the severity of GIN infections should the L3 larva be consumed. However, the benefit from increased rainfall may reduce the benefit from increased soil moisture: if rainfall amounts are too great, the soil becomes oversaturated with water and the larvae and eggs on pasture may be swept away in rainfall run off (Stromberg, 1997). In contrast, if the climate is too dry, the larvae and eggs on pasture will likely experience prolonged desiccation and may die (Agyei, 1997).

Larvae will not develop at temperatures below 10ºC, which allows for prolonged storage of nutrients within larval sheaths, while temperatures above 28ºC cause increased metabolic activity which reduces the availability of stored nutrients (van Dijk and Morgan, 2008; University of Guelph, 2012). In general, temperatures between 25ºC and 37ºC provide an ideal range for the development of parasites and nematodes on pasture (Eysker, 1997; Waller and Chandrawathani, 2005; University of Guelph, 2012). Therefore, increased soil moisture in conjunction with increased rainfall amounts (enough to wet the soil and pasture vegetation but not enough to oversaturate the pasture), and temperatures between 25ºC and 37ºC create a perfect environment for increased larval activity on pasture.

The length of a grazing season is also a direct reflection of the climate (Jones, personal communication, 2013). Seasonal changes affect when sheep are let out onto pasture after wintering in barns and stables, exposing sheep to parasites that have survived on pasture over the winter. The length of time sheep are able to remain on pasture before once again returning to their barns/stables is also dependent on seasonal changes and will determine the flock's exposure time to infected pasture.

For example, sheep released onto pasture due to an early spring (or lack of feed) results in an early periparturient egg rise when nematodes come out of hypobiosis (i.e larval arrest) and pass parasitic eggs through the faeces of ewes a few weeks before giving birth, which increases initial pasture contamination (University of Guelph, 2012). The periparturient egg rise will continue throughout the eight week nursing period then decrease in late spring/early summer. An earlier build-up of larvae on pasture increases flock exposure to said parasites.

Sheep farmers and producers must also be concerned with anthelmintic resistance in GINs. The GINs themselves can have a genetic predisposition to drug resistance (Kaplan, 2004; Kaplan and Vidyashankar, 2012). It is believed that this is due to over use of anthelmintics, whereby parasites evolve and become immune to the wormer used. The presence of drug resistance in GINs is a far reaching and rapidly growing problem, especially considering that only two effective wormers are available in Canada (Terrill *et al*, 2012; Falzon *et al*, 2013).

The objective of this study is to provide documentation that focuses on the seasonal changes in prevalence of GINs encountered in sheep in Nova Scotia. Doing so will provide researchers and farmers/producers with a better understanding of the severity of GIN infections as they occur throughout the year. The primary focus was placed on the correlation between climate/seasonal changes and the prevalence of GINs. Experimentation on the increasing anthelmintic resistance of GIN in sheep in Nova Scotia is ongoing, and will only be briefly discussed in this research paper.

Considering patterns of pasture infection due to climate and exposure to the infected pasture, it would be expected that in Nova Scotia, the prevalence of GINs will increase slightly in the early spring due to the periparturient egg rise, decrease during the late spring/early summer, remain low during a hot dry summer, increase in conjunction with the late summer/autumn rainfall and accumulated build-up of infective larvae (L3) and GIN eggs on pasture, and decrease again as the GINs go into hypobiosis in the late autumn (Kenyon *et al*, 2009; Sargison *et al*, 2012).

For this study, particular focus was placed on the ova produced by *Haemonchus* spp., *Telodorsagia (Ostertagia)* spp., *Trichostrongylus* spp., *Cooperia* spp., *Bunostomum* spp., *Nematodirus* spp., and *Trichuris* spp.

MATERIALS AND METHODS

Sample Collection and Flock Characteristics

Faecal samples for this study were collected from the sheep flock at Nantymor Farm, located in Noel Shore, Nova Scotia (Figure 2). Samples were obtained by gathering droppings into a glove by Danielle Thibault or Dr. Gwyneth Jones. Droppings were either taken from the pasture shortly after defecation, or rectally during defecation, and were marked with the individual's identification number/name. Sample collection was opportunistic and occurred from July to November in 2012 (mostly lamb samples), and from April to November in 2013 (mostly ewe samples from April to June, and mostly lamb samples from July to November).

Figure 2: Dr. G. Jones' flock at Nantymor farm as of 2012.

The flock at Nantymor Farm consisted of 90 to 100 Clun Forest sheep (with a low number of crossbreeds), that ranged from one to twelve years of age. In 1997, Jones maintained a mix of genetic lines within her flock that consisted of Clun Forest sheep and crossbreeds, but currently maintains only five genetic lines within a purebred flock.

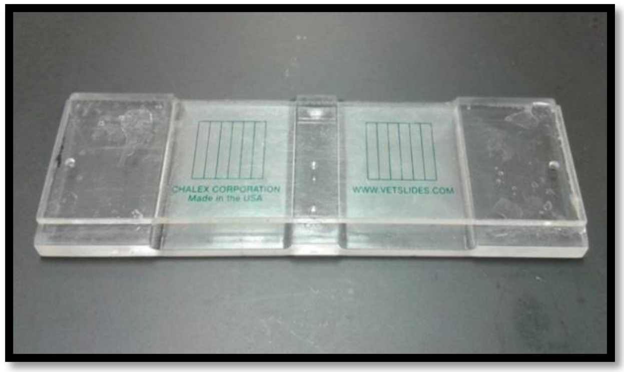
This particular flock was chosen due to several key characteristics: 1) samples were easily accessible, 2) well-kept records dating from 1997 were available for comparison, 3) pasture/dosing management and general characteristics have remained the same since 1997, 4) the flock is considered to be a closed flock (i.e. sheep within the flock belong to one breed of sheep and new sheep are rarely added), and 5) the flock is a good representation of a typical sheep flock encountered in Nova Scotia (i.e. the sheep were maintained on native pasture at low stocking density).

Faecal Egg Count (FEC) and McMaster Technique

According to Foreyt (2001) and the UK Ministry of Agriculture, Fisheries and Food (1971), faecal egg count (FEC; the estimated number of GIN eggs per gram of faecal matter) is the most practical method used to monitor GIN prevalence within a population. For example, a high FEC score is indicative of a high prevalence of GINs. Therefore, FECs were used for this study to monitor seasonal changes in GIN prevalence.

In order to determine FECs, the McMaster Technique was used (Ministry of Agriculture, Fisheries and Food, 1971). Firstly, 3g of faecal matter was mixed with 45ml of over-saturated salt solution and then strained through a tea strainer (or drain strainer of similar hole size) to remove excess debris. Two sub-samples were drawn with a pipette as the filtrate was stirred and placed within a McMaster Counting Chamber (Chalex Corporation) (Figure 3a). After letting the chamber sit for several minutes, a microscope set at 100x magnification was used to count GIN eggs within the grid lines on the McMaster Counting Chamber (Figure 3.b and Figure 4) (Foreyt, 2001). The amount counted was then multiplied by a factor of 50 to determine FEC. An example calculation is as follows: (GIN egg count) x (50) = FEC (eggs/g of faecal matter).

Typically, *Nematodirus* spp. eggs were recorded separately from other GIN eggs. However, for the sake of statistical analysis chosen for this study, *Nematodirus* spp. eggs were recorded together with the other GIN eggs when eggs were counted.



(a)

(b)

Figure 3: a) McMaster Counting Chamber used for counting GIN ova, and b) observation of contents within the McMaster Counting Chamber with a microscope set at 100x magnification.

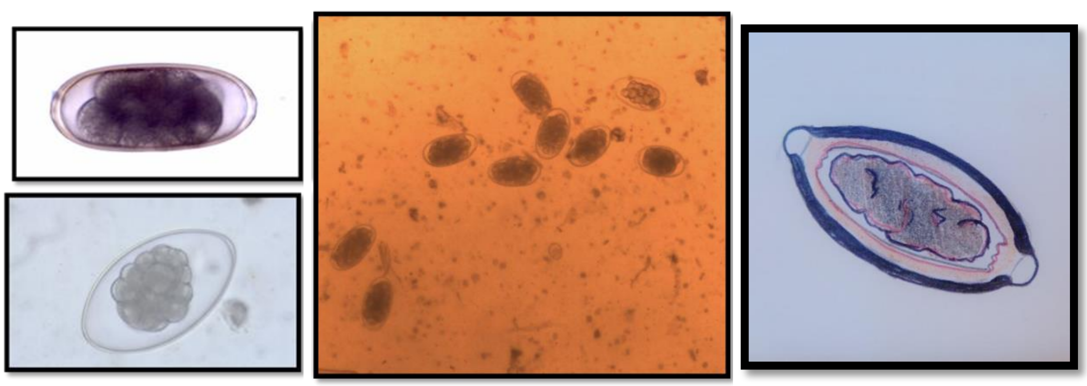


Figure 4: GIN eggs observed within the gridlines of the counting chamber. Top left: *Nematodirus battus*; Bottom left: *Nematodirus filicollis*; Middle: eggs that may belong to *Haemonchus* spp., *Telodorsagia (Ostertagia)* spp., *Trichostrongylus* spp., *Bunostomum* spp. or *Cooperia* spp. or a combination of these species; Right: *Trichuris* spp. (drawn).

Identification of Larvae

Third stage larvae (L3) were also examined and identified, as the eggs from *Haemonchus* spp., *Telodorsagia (Ostertagia)* spp., *Trichostrongylus* spp., *Bunostomum* spp. and *Cooperia* spp. are difficult to distinguish from one another (Figure 5). It is important to note that eggs from *Nematodirus* spp. were not reared due to complicated rearing requirements.

Figure 5: An example of recovered and cultured larvae (*Haemonchus contortus*) at 40x magnification and phase contrast.

Cultures were set up by placing 3-5g of faeces onto a strip of filter paper and placed on a microscope slide. Then, the slide was moved into a petri-dish and propped up at one end with a short, thin wooden stick. Enough water was added to the petri-dish to cover the non-elevated end of the slide. Larvae were gathered roughly a week later by pipetting a small amount of liquid from the petri-dish onto another microscope slide. A drop of iodine was added. L3 larvae were then observed and identified under a microscope set at 40x or 100x magnification (Foreyt, 2001; Gibbons *et al*, accessed 2013).

Alternatively, Baermann Funnels set up over petri dishes were used to recover active larvae from faeces (Ministry of Agriculture, Fisheries and Food, 1971). Between 3-

5g of faecal matter was wrapped in a piece of cheese cloth, placed at the top of the Baermann Funnel, and covered in water (Figure 6). Roughly after a week, larvae were collected by pipetting a small amount of liquid from the petri-dish onto a microscope slide and a very small drop of iodine was added. Once again, L3 larvae were then observed and identified under a microscope set at 40x or 100x magnification.

Figure 6: Baermann Funnel used to recover active larvae from faeces.

Statistical Analysis

In order to perform statistical analysis on the FEC data collected in 2012 and 2013, the mean FEC for each sheep was tabulated for each month (Table 1 to 13 in Appendix II). Several measures were determined for each month in 2012 and 2013 using the tabulated data, which included: sample size, mean FEC, standard deviation and standard error.

Data pertaining to maximum and minimum temperature, as well as total accumulated precipitation, were collected for each month in 2012 and 2013 from the Debert weather station in Debert, Nova Scotia (The Weather Network, 2013).

RESULTS

The mean FEC for each sheep for each month was tabulated in order to perform statistical analysis on the FEC data collected in 2012 and 2013 (Table 1-13 in Appendix II). A total of 221 samples were analyzed for 2012, and a total of 372 samples were analyzed for 2013. Statistical analysis included determination of sample size, mean FEC, standard deviation and standard error (eggs/g). Although the sample size and standard deviation are not shown on the graphs produced, they were used to calculate the standard error of the mean FEC.

Results for 2012.

Table 1: Statistical analysis for FEC data collected from July to November, 2012.

2012	**Number of Samples (N)**	**Mean FEC (eggs/g)**	**Standard Deviation (eggs/g)**	**Standard Error (eggs/g)**
January	-	-	-	-
February	-	-	-	-
March	-	-	-	-
April	-	-	-	-
May	-	-	-	-
June	-	-	-	-
July	48	913.85	1114.64	160.88
August	97	2594.56	2831.18	287.46
September	51	2768.93	2526.83	353.83
October	17	3067.65	3107.36	753.65
November	8	1362.50	1634.01	577.71
December	-	-	-	-
Total	221			

As seen in Table 1, the mean FEC was determined to be 913.85 ± 160.88 eggs per gram of faecal matter for the month of July (the lowest mean FEC). The mean FEC increased in August to 2594.56 ± 287.46 eggs per gram of faecal matter, increased again in September to 2768.93 ± 353.83 eggs per gram of faecal matter, and increased once again in October to 3067.65 ± 753.65 eggs per gram of faecal matter (the highest mean FEC). The mean FEC then decreased in November to 1362.50 ± 577.71 eggs per gram of faecal matter. The change in mean FEC per month for 2012 can be seen in Figure 7.

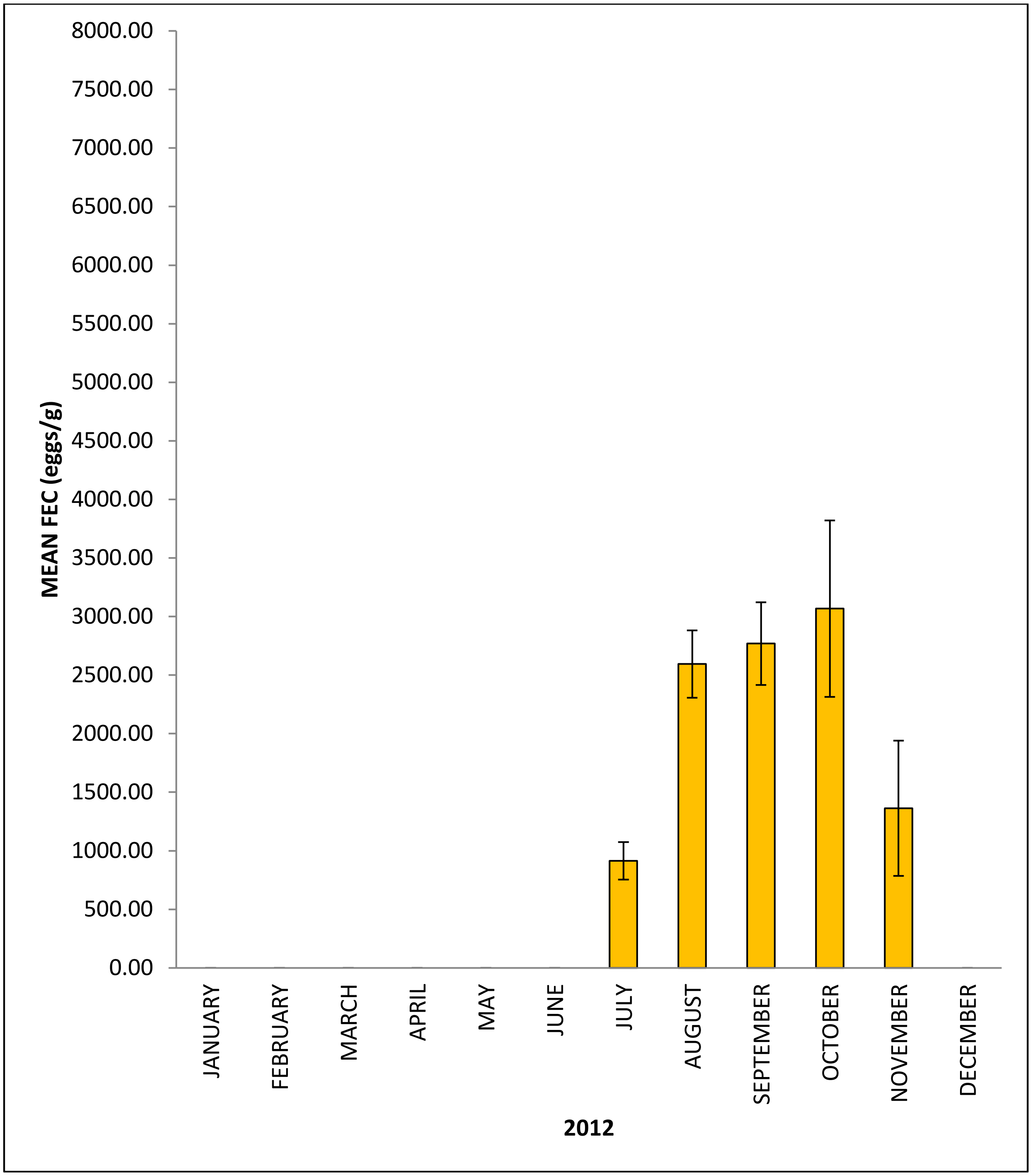


Figure 7: Mean FEC per month (with standard error bars) for samples collected from July to November, 2012.

Table 2: Monthly data for maximum/minimum temperature and accumulated precipitation for 2012, collected from the Debert Weather Station in Debert, Nova Scotia (The Weather Network, 2013).

2012	Maximum Temperature (°C)	Minimum Temperature (°C)	Precipitation Accumulation (mm)
January	10.7	-19.6	71.5
February	8.1	-24.3	91.7
March	19.4	-19.6	32.1
April	20.2	-8.5	49.9
May	25.6	-4.8	67.9
June	27.5	1.9	45.3
July	29.5	6.0	88.8
August	30.6	7.9	116.4
September	26.5	1.8	338.8
October	22.0	-4.4	80.3
November	19.1	-13.8	71.4
December	13.0	-16.3	112.5

As seen in Table 2, maximum and minimum temperatures decreased from 10.7°C and -19.6°C in January to 8.1°C and -24.3°C in February (the lowest maximum and minimum temperatures, respectively), increased from 8.1°C and -24.3°C in February to 30.6°C and 7.9°C in August (the highest maximum and minimum temperatures, respectively), and decreased from 30.6°C and 7.9°C in August to 13.0°C and -16.3°C in December. The change in monthly maximum and minimum temperatures for 2012 can be seen in Figure 8.

Also seen in Table 2, the accumulated precipitation increased from 71.9mm in January to 91.7mm in February, decreased from 91.7mm in February to 32.1mm in March (the lowest accumulated precipitation), increased from 32.1mm in March to 67.9mm in May, decreased from 67.9mm in May to 45.3mm in June, increased from 45.3mm in June to 338.8mm in September (the highest accumulated precipitation), decreased from 388.8mm in September to 71.4mm in November, and finally increased from 71.4mm in November to 112.5mm in December. The change in monthly precipitation accumulation can be seen in Figure 9.

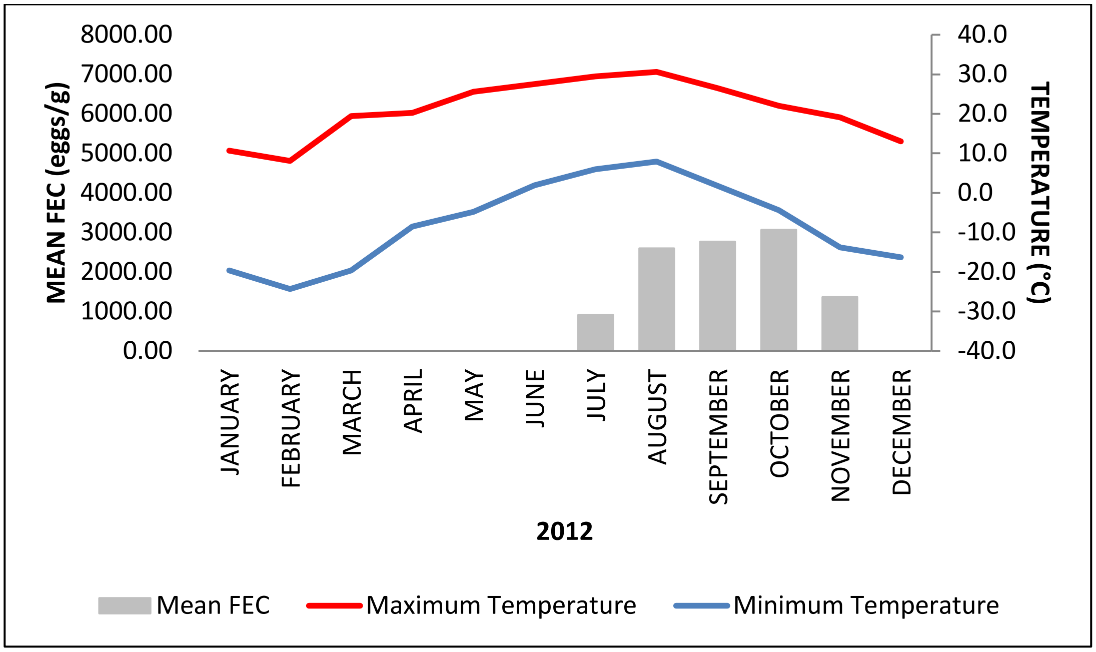


Figure 8: Maximum and minimum temperature per month collected from the Debert weather station in Debert, Nova Scotia, presented along with the mean FEC per month for 2012 (The Weather Network, 2013).

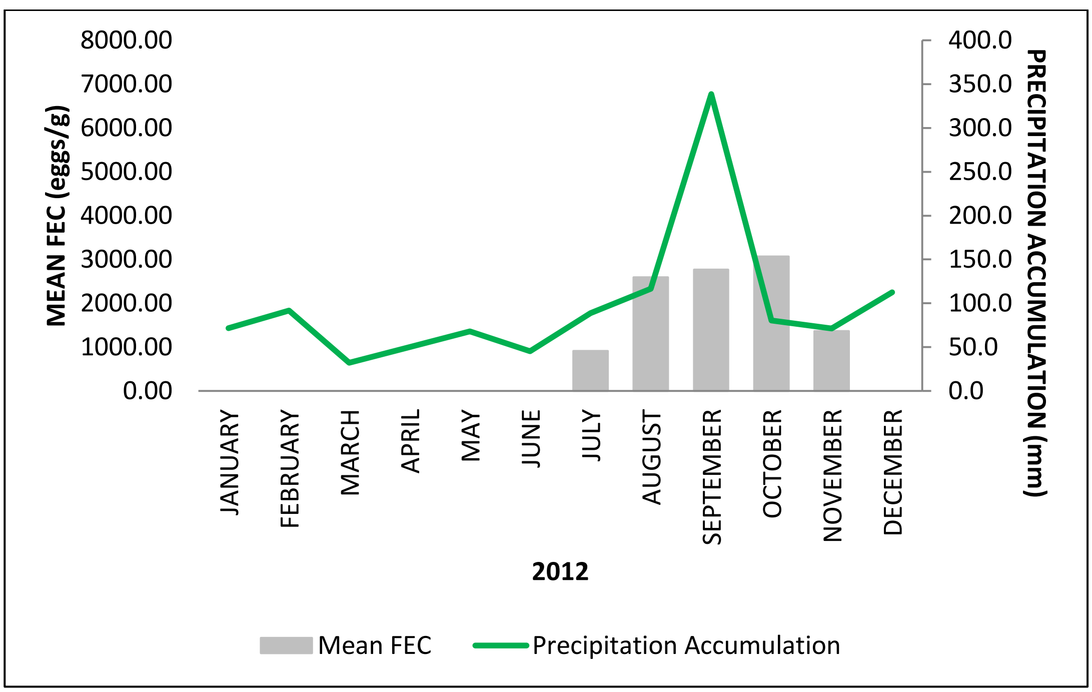


Figure 9: Accumulated precipitation per month collected from the Debert weather station in Debert, Nova Scotia, presented along with the mean FEC per month for 2012 (The Weather Network, 2013).

The weather graphs for 2012 were also presented along with the monthly mean FEC data for 2012. Figure 8 demonstrates that the mean FEC increased as temperature increased from July to August, then mean FEC continued to increase from August to October as temperature decreased, and finally, mean FEC decreased from October to November as temperature continued to decrease. Figure 9 demonstrates that the mean FEC increased as precipitation increased from July to September, the mean FEC continued to increase as precipitation decreased from September to October, and finally, the mean FEC decreased as the precipitation continued to decrease from October to November.

Results for 2013.

Table 3: Statistical analysis for FEC data collected from April to November, 2013.

2013	**Number of Samples (N)**	**Mean FEC (eggs/g)**	**Standard Deviation (eggs/g)**	**Standard Error (eggs/g)**
January	-	-	-	-
February	-	-	-	-
March	-	-	-	-
April	1	0	0	0
May	65	1977.69	4851.22	601.72
June	91	1039.50	1959.11	205.37
July	85	2764.87	3929.34	426.20
August	79	3115.82	4056.12	456.35
September	11	5110.23	7779.79	2345.70
October	38	2974.34	3778.95	613.03
November	2	3125.00	1096.02	775.00
December	-	-	-	-
Total	372			

As seen in Table 3, the mean FEC was determined to be 0 eggs per gram of faecal matter for the month of April. The mean FEC increased to 1977.69 ± 601.72 eggs per gram of faecal matter for May, but decreased to 1039.50 ± 205.37 eggs per gram of faecal matter for June. The mean FEC increased to 2764.87 ± 426.20 eggs per gram of faecal matter in July, increased again in 3115.82 ± 456.35 eggs per gram of faecal matter in August, and increased again to 5110.23 ± 2345.70 eggs per gram of faecal matter in September. The mean FEC then decreased in October to 2974.34 ± 613.03 eggs per gram of faecal matter, and increased again in November to 3125.00 ± 775.00 eggs per gram of faecal matter. The change in the mean FEC for 2012 can be seen in Figure 10.

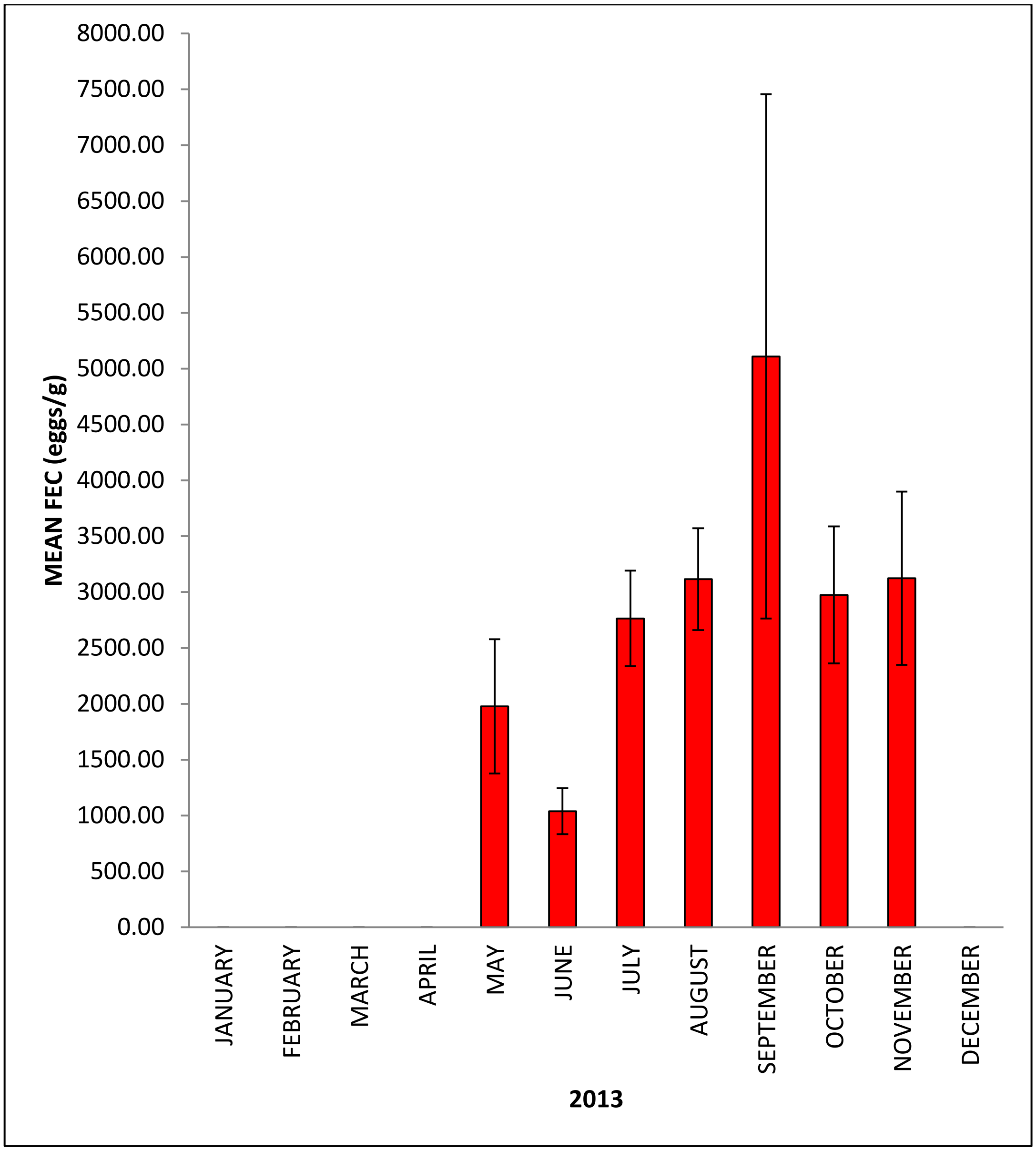


Figure 10: Mean FEC per month for samples collected from April to November, 2013.

Table 4: Monthly data for maximum and minimum temperature and accumulated precipitation for 2013, collected from the Debert Weather Station in Debert, Nova Scotia (The Weather Network, 2013).

2013	**Maximum Temperature (°C)**	**Minimum Temperature (°C)**	**Precipitation Accumulation (mm)**
January	12.8	-27.8	33.3
February	6.1	-28.1	73.0
March	13.0	-13.6	63.0
April	20.8	-7.5	58.4
May	25.4	-2.4	71.6
June	29.6	3.4	118.8
July	30.5	7.4	98.6
August	28.4	3.3	33.2
September	27.0	0.6	148.1
October	21.9	-8.1	123.7
November	16.7	-11.2	96.5
December	8.7	-23.8	168.0

As seen in Table 4, maximum and minimum temperatures decreased from 12.8°C and -27.8°C in January to 6.1°C and -28.1°C in February (the lowest maximum and minimum temperatures, respectively), increased from 6.1°C and -28.1°C in February to 30.5°C and 7.4°C in July (the highest maximum and minimum temperatures, respectively), and decreased from 30.5°C and 7.4°C in July to 8.7°C and -23.8°C in December. The change in monthly maximum and minimum temperature for 2012 can be seen in Figure 11.

Also seen in Table 2, the accumulated precipitation increased from 33.3mm in January to 73.0mm in February, decreased from 73.0mm in February to 58.4mm in April, increased from 58.4mm in April to 118.8mm in June, decreased from 118.8mm in June to 33.2mm in August (the lowest accumulated precipitation), increased from 33.2mm in August to 148.1mm in September, decreased from 148.1mm in September to 96.5mm in November, and finally increased from 96.5mm in November to 168.0mm in December (the highest accumulated precipitation). The change in monthly precipitation accumulation can be seen in Figure 12.

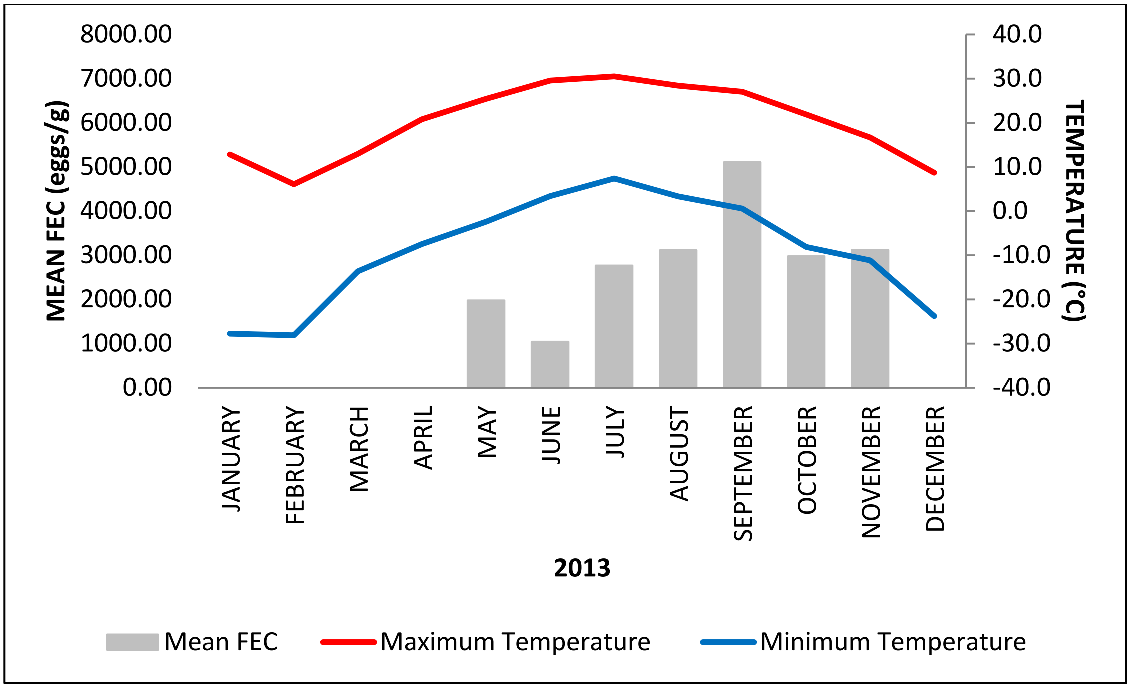


Figure 11: Maximum and minimum temperature per month collected from the Debert weather station in Debert, Nova Scotia, presented along with the mean FEC per month for 2013 (The Weather Network, 2013).

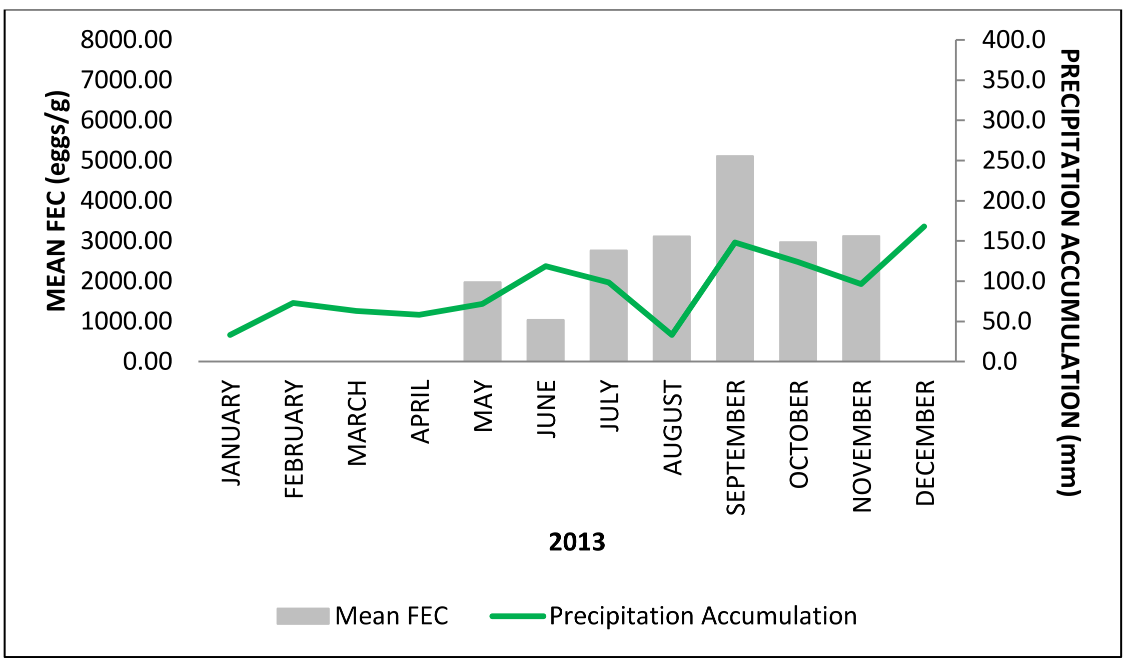


Figure 12: Accumulated precipitation per month collected from the Debert weather station in Debert, Nova Scotia, presented along with the mean FEC per month for 2013 (The Weather Network, 2013).

The weather graphs for 2013 were also correlated against monthly mean FEC data for 2013. Figure 11 demonstrates that the mean FEC increased from April to May as temperature increased, the mean FEC decreased from May to June as temperature continued to increase, the mean FEC increased from June to July as temperature continue to increase, the mean FEC continued to increase from July to September as temperature decreased, the mean FEC decreased from September to October as Temperature continued to decrease, and finally, the mean FEC increased from October to November as the temperature continued to decreases. Figure 12 demonstrates that the mean FEC increased from April to May as precipitation increased, the mean FEC decreased from May to June as precipitation continued to increase, the mean FEC increased from July to August as the precipitation decreased, the mean FEC continued to increase from August to September as the precipitation increased, the mean FEC decreased from September to October as the precipitation decreased, and finally, the mean FEC increased from October to November as the precipitation continued to decrease.

DISCUSSION

It can be argued that climate and anthelmintic resistance in GINs are the primary variables that control GIN prevalence in sheep, regional presence of parasite species, pasture and livestock management, and can even influence a sheep's natural immunity to parasites regardless of breed, age, size or sex.

Soil moisture, soil composition, rainfall amount and seasonal variation in temperature play vital roles in the lifecycle of GINs, especially in the survival of the larval stages on pasture (Agyei, 1997; O'Connor *et al*, 2007; Guthrie *et al*, 2010; van Dijk and Morgan, 2012). Increasing initial soil moisture provides a water film for larvae to move in, and results in increased recovery of L3 larva from pasture, as does increasing amounts of rainfall (Khadijam *et al*, 2013). However, if rainfall amounts are too great, the soil becomes oversaturated with water and the larvae and eggs on pasture may be swept away in rainfall run off (Stromberg, 1997). If the climate is too dry, the larvae and eggs on pasture will likely experience prolonged desiccation and may die (Agyei, 1997).

The time required for GINs to reach infective L3 stage is highly dependent on temperature, where temperatures between 25ºC and 37ºC provide an ideal range for the development of parasites and nematodes on pasture (Eysker, 1997; Waller and Chandrawathani, 2005; University of Guelph, 2012). Therefore, increased soil moisture in conjunction with increased rainfall amounts (enough to wet the soil and pasture vegetation but not enough to oversaturate the pasture), and temperatures between 25ºC and 37ºC create a perfect environment for increased larvae activity on pasture.

Seasonal changes affect when sheep are let out onto pasture after wintering in barns and stables, exposing sheep to parasites that have survived on pasture over the winter (Jones, personal communication, 2013). Sheep released onto pasture due to an early spring (or lack of feed) results in an early periparturient egg rise when nematodes come out of hypobiosis (i.e. larval arrest) and pass eggs through the faeces of ewes a few weeks before giving birth, which increases initial pasture contamination (University of Guelph, 2012). The periparturient egg rise will continue throughout the eight week nursing period then decrease in late spring/early summer.

Considering patterns of pasture infection due to climate and exposure to the infected pasture, it was expected that in Nova Scotia, the prevalence of GINs would increase slightly in the early spring due to the periparturient egg rise/cessation of larval hypobiosis, decrease during the late spring/early summer, remain low during a hot dry summer, increase in conjunction with the late summer/autumn rainfall and accumulated build-up of infective larvae (L3) and GIN eggs on pasture, and decrease again as the GINs go into hypobiosis in the late autumn (Kenyon *et al*, 2009; Sargison *et al*, 2012). Therefore, according to the results found, the prediction for this study was supported.

However, there were several unexpected results during this study. Firstly, the maximum and minimum temperatures recorded for 2012 were very similar to the maximum and minimum temperatures recorded for 2013. Secondly, the peak prevalence of GINs occurred in October of 2012, whereas the peak prevalence of GINs occurred in September of 2013. The high volume of precipitation recorded for September in 2012 was likely too great to support larval and egg survival on pasture, which would cause peak GIN prevalence to occur in a month that had a lower accumulated precipitation, such as October. Lastly, there was a major discrepancy in the association between monthly mean FEC and precipitation when mean FEC data and accumulated precipitation data from 2012 and 2013 were compared. In general, as precipitation decreases, GIN prevalence decreases. However, the GIN prevalence increased from 2012 to 2013, despite accumulated precipitation decreasing from 2012 to 2013.

This discrepancy may be caused by the following: As of 1997, *H. contortus* was not a commonly encountered GIN in Nova Scotia, and was therefore not a major problem (Maal-Bared, 1998). Yet, *Haemonchus* spp. (specifically *H. contortus)* was found to be the dominant species of GIN found during this study (Hipwell and Jones, personal communication, 2013). By nature, *H. contortus* produces more eggs than other species of GINs found in sheep (Foreyt, 2001). It produces thousands of eggs are per day versus tens/hundreds of eggs produced per day by other species. Therefore, increased monthly mean FEC data seen in 2013 may only be indicative of rising *H. contortus* levels. This would infer that an increasing number of *H. contortus* larvae and eggs are surviving on pasture during the winter, providing a higher level of initial pasture infection come the spring (i.e. GIN levels build up on pasture not only form month to month, but also from year to year) (Coop *et al*, 1991; University of Guelph, 2012).

The discrepancy may also be caused by increasing anthelmintic resistance in GINs (Kaplan and Vidyashankar. 2012). When farmers/producers dose sheep without fully understanding the consequences of their action on GINs, they are inadvertently selecting for drug resistant nematodes (Kaplan, 2004). Susceptible nematodes are killed by anthelmintics, but the resistant GINs remain without competition from the susceptible GINs.

In contrast, if farmers/producers do not dose their sheep at all, their flock may die from untreated GIN infection, while the volume of GIN larvae and eggs on pasture increase (Kaplan, 2004). According to Jones (personal communication, 2013), farmers will neglect to dose their sheep thinking that they have escaped the initial onset of parasites during the periparturient rise when their sheep do not exhibit signs of pathogenic nematode infection in the spring and early summer (Kenyon *et al*, 2009; Sargison *et al*, 2012). However, signs of infection are not usually observed in spring and early summer. Nematode levels build up on pasture over the spring and summer, and sheep will only exhibit health problems caused by high nematode infections, such as diarrhea, in the late summer/autumn. Farmers then assume that if they do not see diarrhea from their sheep, that their sheep are not infected with nematodes. Farmers are subsequently left baffled when anemia strikes rapidly from *H. contortus* infections (the only GIN that does not cause diarrhea) (Waller and Chandrawathani, 2005). Once again, *H. contortus* infections have not been problematic until the last fifteen to sixteen years, so farmers/producers are still unused to its presence (Maal-Bared, 1998).

With the use of the information gained by documenting seasonal changes in the prevalence of GINs in sheep in Nova Scotia, researchers and farmers/producers have now been provided with a current outlook of GIN prevalence, and will be able to better understand the severity of GIN infections as they occur throughout the year. However, it is important to note that there is an inherent variability in GIN prevalence for any field study and that the results found in this study may or may not be the norm. Further monitoring is required. Future research in this field should focus on pasture management strategies needed to prepare for and later combat seasonal changes in GIN prevalence in sheep according to climatic conditions encountered. Future research should also focus on increasing drug resistance in GINs, especially in *H. contortus*, before the GINs become resistant to the already small number of anthelmintics available in Canada. (University of Guelph, 2013).

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APPENDIX I

Table 1: Detailed summary of gastrointestinal nematode species encountered in sheep (Foreyt, 2001).

Commonly Encountered GIN in Sheep	Common Name	Location	Size	
			Egg (µm)	**Adult (mm)**
***Haemonchus* spp.:** *H. contortus*	Barber's Pole Worm	abomasum	80 x 45	10-30
***Telodorsagia (Ostertagia)* spp.:** *O. ostertagi*	Brown Stomach Worm	abomasum	80 x 45	6-10
***Trichostrongylus* spp.:** *T. axei* *T. colubriformis*	*T. axei*: Bankrupt Worm, Small Stomach Worm *T. colubriformis*: Hair Worm, Black Scour Worm	abomasum, small intestine	*T. axei*: 80 x 40 *T. colubriformis*: 85 x 40	4-8
***Cooperia* spp.:** *C. punctata* *C. pectinata*	Cattle Bankrupt Worm	small intestine	77 x 34	4-8
***Bunostomum* spp.:** *B. trigonocephalum*	Hookworm	small intestine	95 x 50	10-28
***Nematodirus* spp.:** *N. battus* *N. filicollis* *N. spathiger*	Thin-necked Intestinal worm	small intestine	*N. battus*: 175 x 75 *N. filicollis*: 200 x 90	10-25
***Moniezia* spp.:** *M. benedeni*	Tapeworm	small intestine	60 x 60	1000
***Eimeria* spp.**	Coccidia	small intestine	Oocyst: 16-47 x 13-32	n/a
***Strongyloides* spp.:** *S. papillosus*	Thread Worm	small intestine	50 x 22	3-6
***Oesophagostomum* spp.:** *O. columbianum* *O. venulosum*	Nodular Worm	cecum and colon	80 x 40	14-22
***Chabertia* spp.:** *C. ovina*	Large-mouth Bowel Worm	cecum and colon	100-120 x 40-50	13-20
***Trichuris* spp.:** *T. Ovis*	Whip Worm	cecum and colon	75 x 35	2-3

Table 2: Pathogenicity ratings of gastrointestinal nematode species encountered in sheep (Foreyt, 2001; Abbott *et al*, 2012)

Gastrointestinal Nematode	Pathological Effects	Pathogenicity
Haemonchus spp.	Anemia, bottlejaw, death, weight loss.	High
Telodorsagia (Ostertagia) spp.	Weight loss, gastric gland destruction, scours, anorexia.	High
Trichostrongylus spp.	Bottlejaw, scours, dehydration, emaciation, growth restriction.	Medium
Cooperia spp.	Scours, anorexia, growth restriction.	Low
Bunostomum spp.	Anemia, diarrhea, weight loss, death.	Medium
Nematodirus spp.	Death, scours.	*N. battus:* High *N. spathiger:* Medium *N. filicollis*: Low
Moniezia spp.	Not highly pathogenic.	Low
Eimeria spp.	Bloody diarrhea, death, decrease in production.	Low
Strongyloides spp.	Scours, foot rot.	Low
Oesophagostomum spp.	Scours, increase susceptibility to fly strike.	Low
Chabertia spp.	Anemia.	Low
Trichuris spp.	Hemorrhage.	Low

Table 3: Infection ratings for ratings of gastrointestinal nematode species encountered in sheep (SCOPS, 2012).

Gastrointestinal Nematode	**FEC (eggs/g)**		
	Low Infection	**Mild Infection**	**Heavy Infection**
Haemonchus spp.	<500	1000 - 5000	>5000
Mixed spp. (with *Haemonchus*)	<500	500 - 1500	>1500
Nematodirus spp.	50 - 150	150 - 300	>300

APPENDIX II

Table 1: Tabulated GIN egg data and FEC for July, 2012.

SHEEP ID	JULY	
	ORIGINAL COUNT	FEC
JONES Y		
61	25	1250
JONES Z (lambs)		
6	5.5	275
7	13	650
10	8	400
15	39	1950
17	17	850
18	6.5	325
21	14	700
22	17	850
26	11	550
27	2	100
30	6.3	315
31	6	300
38	11	550
43	17	850
45	54.5	2725
46	6	300
47	5	250
48	10	500
49	5	250
55	75	3750
58	26	1300
60	22	1100
61	5	250
64	4	200
65	26	1300
68	42	2100
69	1	50
70	15	750
71	14	700
80	1.5	75
82	11	550
83	7	350

85	3	150
86	14	700
90	1	50
97	70	3500
99	25	1250
102	0.5	25
112	4	200
147	23.5	1175
251	7	350
257	1	50
262	12	600
263	31	1550
267 (WM)	120	6000
269	18	900
275	19	950
JONES Other		
n/a		

Table 2: Tabulated GIN egg data and FEC for August, 2012.

SHEEP ID	AUGUST	
	ORIGINAL COUNT	FEC
JONES Y		
2	105.5	5275
23	6	300
41	18	900
45	67	3350
47	6	300
61	1	50
77	10	500
78	130	6500
681	39	1950
JONES Z (lambs)		
1	68.25	3412.5
2	1	50
3	179	8950
4	86	4300
7	17.5	875
11	42.83	2141.5
15	28	1400
17	15	750
18	39.5	1975
19	30.67	1533.5
20	37	1850
21	36	1800
22	26.67	1333.5
23	12	600
24	50.5	2525
26	42	2100
27	27.5	1375
30	53.5	2675
31	35.83	1791.5
32	57	2850
34	56.25	2812.5
36	24	1200
37	3	150
38	62.25	3112.5
39	58.5	2925
40	9.8	490

43	64.5	3225
46	10.75	537.5
47	170.5	8525
48	55.5	2775
49	7	350
50	44	2200
53	18	900
54	117.5	5875
55	49	2450
56	69	3450
58	36.5	1825
59	50.67	2533.5
60	45	2250
61	11	550
62	84	4200
64	20	1000
65	88.5	4425
66	32	1600
67	69	3450
68	91.5	4575
69	26.15	1307.5
70	20	1000
71	49.5	2475
72	30	1500
75	49	2450
77	209	10450
80	24.5	1225
82	8	400
83	38	1900
84	351.5	17575
85	37.5	1875
86	126.75	6337.5
89	59	2950
93	63	3150
95	58.5	2925
97	115	5750
99	33.5	1675
100	274.5	13725
102 (XB)	15	750
103	28.5	1425
237	8	400

251	9.5	475
257	162.5	8125
269 (BLACK)	30	1500
293	13.75	687.5
294	90	4500
510	30	1500
612 (BROWN FACE)	45.83	2291.5
823	0	0
832	19	950
877	15	750
JONES Other		
4M	0	0
NCC	15.5	775
NCC Y	5	250
BROWN LONGTAIL KNOBHORN	40	2000
BROWN RAM	42	2100
FEMALE IVO 2 WKS	41	2050
MALE IVO MON MUCKY	8.5	425
SM LAMB WORMED MON MUCKY	6	300
MALE BLUE SPOT	94	4700
NO TAG	9	450
B2W LAMB	116	5800

Table 3: Tabulated GIN egg data and FEC for September, 2012.

SHEEP ID	SEPTEMBER	
	ORIGINAL COUNT	FEC
JONES Y		
12	9	450
20	5	250
35	2	100
56	0	0
59	46	2300
64	1	50
68	0	0
98	0	0
99	1	50
657	0	0
JONES Z (lambs)		
1	79	3950
11	33	1650
18	100	5000
19	106	5300
21	103.75	5187.5
22	72	3600
26	72.33	3616.5
27	52	2600
30	50	2500
31	38.9	1945
38	46	2300
39	56	2800
40	64	3200
46	10.5	525
47	165.33	8266.5
48	140	7000
49	20	1000
50	52	2600
53	44	2200
60	162	8100
61	14	700
64	62	3100
65	5	250
66	15	750
67	13	650

69	41	2050
70	42.5	2125
72	27	1350
80	106	5300
83	150	7500
84	137	6850
85	31	1550
88	0	0
89	137	6850
95	67	3350
97	8	400
99	121	6050
100	154	7700
251	106	5300
265	54	2700
JONES Other		
81X	3	150

Table 4: Tabulated GIN egg data and FEC for October, 2012.

SHEEP ID	OCTOBER	
	ORIGINAL COUNT	FEC
JONES Y		
n/a		
JONES Z (lambs)		
18	152	7600
20	44	2200
26	114	5700
27	67	3350
40	86	4300
47	219	10950
53	25.5	1275
58	65	3250
61	6	300
66	2	100
67	3	150
68	29	1450
80	63	3150
91	7	350
98	8.5	425
101	133	6650
192	19	950
JONES Other		
n/a		

Table 5: Tabulated GIN egg data and FEC for November, 2012.

SHEEP ID	NOVEMBER	
	ORIGINAL COUNT	FEC
JONES Y		
n/a		
JONES Z (lambs)		
18	88.5	4425
27	59.5	2975
39	10	500
53	6	300
60	43	2150
61	1	50
68	7	350
80	3	150
JONES RANDOM		
n/a		

Table 6: Tabulated GIN egg data and FEC for April, 2013.

SHEEP ID	APRIL	
	ORIGINAL COUNT	**FEC**
JONES A (lambs)		
n/a		
JONES Y		
n/a		
JONES Z		
93	0	0
JONES Other		
n/a		

Table 7: Tabulated GIN egg data and FEC for May, 2013.

SHEEP ID	MAY	
	ORIGINAL COUNT	FEC
JONES A (lambs)		
8	0	0
9	0	0
10	0	0
12	0	0
25	3	150
28	0	0
29	0	0
30	0	0
36	2	100
37	0	0
43	0.5	25
52	0	0
54	0	0
65	0	0
82	1	50
94	0	0
111	0	0
463	48	2400
539	3	150
819	53	2650
871	5	250
926	3	150
3117	13	650
JONES Y		
2	61	3050
23	7	350
31	22	1100
35	55	2750
41	96	4800
61	4	200
64	209	10450
68	82	4100
70	7	350
71	7	350
72	171	8550
78	685	34250

79	10	500
93	257	12850
98	71	3550
99	54	2700
106	151	7550
JONES Z		
22	0	0
27	1	50
29	5	250
38	3	150
39	7	350
49	2	100
53	29	1450
58	1	50
64	1.5	75
65	1	50
66	7	350
68	3	150
70	50	2500
88	2	100
JONES Other		
8L	121	6050
4W	1	50
63W	15	750
67W	0	0
982W	11	550
45X	103	5150
59X	79	3950
81X	28	1400
RAM	18	900
Black Long Tail (BLT)	2	100
Black Short Tail (BST)	0	0

Table 8: Tabulated GIN egg data and FEC for June, 2013.

SHEEP ID	JUNE	
	ORIGINAL COUNT	FEC
JONES A (lambs)		
1	19	950
7	5.5	275
8	5	250
9	3.5	175
11	2.33	116.5
12	1	50
13	3.5	175
15	4	200
16	3	150
17	0	0
19	2	100
22	0	0
25	1	50
26	0	0
35	1.33	66.5
36	5.5	275
37	4	200
41	2	100
44	3.33	166.5
47	6	300
50	7.33	366.5
51	0.67	33.5
53	4	200
54	0.165	8.25
55	6	300
56	4.5	225
59	1.5	75
60	0	0
63	0	0
64	4.67	233.5
65	1.33	66.5
70	3	150
76	0	0
77	10	500
79	3	150
80	0.33	16.5

83	0	0
84	2	100
88	0	0
90	5	250
91	0	0
94	3	150
104	1	50
105	5	250
132	9	450
424	0	0
JONES Y		
2	3.5	175
23	10	500
35	2	100
41	122	6100
45	150	7500
47	33.5	1675
56	207.9	10395
61	13	650
62	15	750
67	63	3150
68	88	4400
70	8	400
72	119	5950
76	11	550
78	3	150
99	105	5250
251 (BLACK)	0	0
JONES Z		
3	14	700
5	18	900
20	7	350
22	22	1100
27	2	100
29	7	350
30	49	2450
31	118	5900
36	1	50
53	67	3350
58	122	6100
64	37	1850

66	49	2450
69	107	5350
70	18	900
71	7	350
88	10.5	525
93	0	0
JONES Other		
23T	23	1150
39U	58	2900
63W	10	500
45X	5	250
238 (XB)	0	0
300 (XB)	5	250
NUT	23	1150
39 MALE	9	450
Random (OTTN Blue Line 1A)	2	100
RX	4	200

Table 9: Tabulated GIN egg data and FEC for July, 2013.

SHEEP ID	JULY	
	ORIGINAL COUNT	FEC
JONES A (lambs)		
1	34	1700
2	2.5	125
3	13.25	662.5
7	37.33	1866.5
8	33.5	1675
9	66.75	3337.5
10	361	18050
11	12.5	625
13	5	250
15	3.5	175
16	43.5	2175
17	6.5	325
26	81	4050
28	280.67	14033.5
29	0	0
30	53.5	2675
35	1	50
36	9.5	475
37	12.5	625
38	24	1200
39	30.75	1537.5
41	0	0
42	123	6150
43	8.2	410
44	21.5	1075
50	49	2450
51	44.5	2225
52	10.5	525
54	18.5	925
55	6	300
56	8	400
58	26	1300
62	34	1700
63	17.33	866.5
64	5	250
65	90	4500

67	39.5	1975
70	238	11900
73	9.5	475
75	172	8600
77	29	1450
81	0	0
82	328	16400
83	47.25	2362.5
84	40	2000
85	8	400
86	24	1200
87	4	200
91	255	12750
94	19.67	983.5
95	25	1250
96	34	1700
97	3.5	175
99	181.5	9075
100	135	6750
101	99.5	4975
102	6	300
300	29	1450
507	209	10450
JONES Y		
n/a		
JONES Z		
2	27	1350
61	6	300
65	1	50
70	51	2550
83	0	0
JONES Other		
2R	0	0
DEC.	34	1700
BLACK MALE	8.33	416.5
0 TAG MALE	11	550
0 TAG (6) MALE 34 KG	129	6450
0 TAG FEMALE	111	5550
SM. WHITE FEMALE	12	600
BLACK FEMALE CX	213	10650
BL FEMALE	131	6550

83 O TAG	10	500
84 XX NO TAG	4	200
88 XB	2.75	137.5
88 XB FEMALE	22	1100
TAG 10	78	3900
TAG 84	22	1100
TAG 85	3	150
TAG 87	4	200
TAG 88	50	2500
TAG 89	5	250
TAG 91	177	8850
TAG 2 102	78	3900

Table 10: Tabulated GIN egg data and FEC for August, 2013.

SHEEP ID	AUGUST	
	ORIGINAL COUNT	FEC
JONES A (lambs)		
2	33	1650
3	1	50
7	151.5	7575
8	63.5	3175
9	138	6900
13	27.5	1375
15	64	3200
16	58	2900
17	61	3050
22	3	150
26	0	0
28	25	1250
35	1	50
36	14	700
37	42	2100
39	107	5350
41	3	150
42	291	14550
43	3	150
44	14	700
50	237	11850
52	164	8200
54	35	1750
55	89.5	4475
56	1	50
59	295	14750
61	24	1200
62	44	2200
64	9	450
65	55.5	2775
73	41.5	2075
75	176	8800
77	29	1450
79	227	11350
80	109.5	5475
81	62	3100

83	0	0
87	5.5	275
90	0	0
91	69	3450
92	80	4000
94	41.5	2075
96	92.5	4625
99	229	11450
100	79	3950
101	75	3750
103	53	2650
105	278	13900
DEC	1	50
JONES Y		
76	5	250
JONES Z		
2	1	50
13	3	150
27	3	150
31	8	400
38	1	50
39	1	50
53	11	550
58	18	900
61	12	600
66	15	750
68	2	100
88	4	200
JONES Other		
4H LAMB	12	600
TAG 15	101	5050
TAG 21	364	18200
TAG 83 - 289	34	1700
TAG 84	32	1600
TAG 88	31	1550
TAG 91	122	6100
SMALL BLACK	83	4150
BL FEMALE LT	12	600
BLACK FEMALE MT	52	2600
SOUTH DOWN	140	7000
RANDOM UNHAPPY SHEEP 1 (64)	138	6900

Random Unhappy Sheep 2 (1)	0	0
DEC.	1	50
SMALL WHITE FEMALE	11	550
NO LABEL	0	0
BL ST	3	150

Table 11: Tabulated GIN egg data and FEC for September, 2013.

SHEEP ID	SEPTEMBER	
	ORIGINAL COUNT	FEC
JONES A (lambs)		
23	452.25	22612.5
36	12	600
52	25	1250
64	347	17350
87	2	100
92	3	150
6637	32	1600
JONES Y		
n/a		
JONES Z		
n/a		
JONES Other		
B	33	1650
SM BLACK	0	0
0 TAG (NO TAG)	161	8050
XB MALE	57	2850

Table 12: Tabulated GIN egg data and FEC for October, 2013.

SHEEP ID	OCTOBER	
	ORIGINAL COUNT	FEC
JONES A (lambs)		
9	20	1000
11	26.5	1325
15	41	2050
25	1	50
30	45.5	2275
36	18	900
41	5	250
51	10	500
53	10	500
56	37.5	1875
59	35.5	1775
61	39	1950
64	182	9100
70	86	4300
75	122	6100
77	36.5	1825
78	39	1950
82	46	2300
88	15.5	775
90	59.5	2975
91	69.5	3475
92	37	1850
99	54	2700
100	52	2600
298	9	450
811 322	42	2100
JONES Y		
n/a		
JONES Z		
n/a		
JONES Other		
SM 0 Tag	88	4400
Sm M	190	9500
Small Black	0	0
Blue Spot	58	2900
0 TAG tail	305	15250

0 TAG male	41	2050
0 TAG tail male	27	1350
TAG 298	4	200
0 TAG tail female	337	16850
S. BL.	6	300
L. BL.	34	1700
Tag 84	31.5	1575

Table 13: Tabulated GIN egg data and FEC for November, 2013.

SHEEP ID	NOVEMBER	
	ORIGINAL COUNT	**FEC**
JONES A (lambs)		
15	47	2350
82	78	3900
JONES Y		
n/a		
JONES Z		
n/a		
JONES Other		
n/a		