



Prevalence of equine gastrointestinal parasites in Montana, correlation of *Parascaris equorum* egg per gram counts and worm burdens, and comparison of two parasite egg counting techniques for equine feces

by Carl Albert McQueary

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Veterinary Science

Montana State University

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Abstract:

One hundred eighty-six horses in Gallatin County, Montana were examined for gastrointestinal parasites by fecal egg counts during June, 1975. The over-all prevalence of infection was 96 per cent, with the one month to two year-old group having a 89 per cent infection rate, the three to six year-old group a 98 per cent infection rate, and the older horses a 97 per cent infection rate.

The strongyles were the most prevalent parasite, infecting 92 per cent of the horses examined. *Parascaris equorum* occurred in 21 per cent of the horses examined, *Strongyloides westeri* 7 per cent, *Eimeria leuckarti* 6.5 per cent, *Oxyuris equi* 5 per cent, and *Anoplocephala* sp. 1.6 per cent.

The prevalence of strongyles was 89, 94, and 93 per cent respectively, for the one month to two year-old group, the three to six year-old group, and the older horses. For *P. equorum* the prevalence was 55, 6, and 3 per cent respectively, with *Anoplocephala* sp. being 3, 2, and 0 per cent, *S. westeri* 20, 2, and 0 per cent, *O. equi* 15, 0, and 0 per cent, and *E. leuckarti* 20, 0, and 0 per cent. From 616 case reports of equine internal parasites compiled from the last forty years, the following parasites were recorded as occurring in Montana: *Anoplocephala perfoliata*, *Paranoplocephala mamillana*, *Dictyocaulus arnfieldi*, *E. leuckarti*, *Gastrophilus intestinalis*, *G. haemorrhoidalis*, *G. nasal* is, *O. equi*, *Probstmayria vivipara*, *P. equorum*, *Setaria equina*, *Strongylus edentatus*, *S. equinus*, *S. vulgaris*, small strongyles, *Strongyloides westeri*, and *Tichostrongylus axei*. The most prevalent parasites were the strongyles (50%), with *P. equorum* (18%) ranking second. *S. westeri* occurred 15 per cent of the time and *O. equi* 2.6 per cent. The remaining parasites were detected infrequently with percentages between 2 and 0.1.

The coccidium, *E. leuckarti*, was detected by fecal examination in 59 per cent of twenty-two foals observed for intestinal parasites. The duration of patency was between five and twelve days with the prepatent period in an experimental infection being thirty-one days.

The oocyst dimensions were 75.5% in length with a range of 84.7 to 61.6% and 50.2% in width with a range of 53.9 to 47.2%.

The relationship of egg per gram (EPG) counts to worm burdens of *P. equorum* in the equine was not significantly correlated when data from both sexes were employed. However, significant correlations did exist between EPG counts and worm burdens in female horses but because of a relatively few number of females the correlations were questionable. When foals showing high EPG counts harbored fewer worms than foals showing low EPG counts, an inverse relationship was noted between EPG counts and worm burdens.

Significant fluctuations were observed in the daily and day-to-day EPG counts of *P. equorum* in foals over a five-day period and trends were noted in the egg outputs of this parasite over weekly intervals.

The Remodified McMaster technique was considered to be more efficient and faster than the Direct Centrifugal Flotation (DCF) technique for the estimation of EPG counts in equine feces. The egg recovery rate on the first cover slip of the DCF technique compared to the McMaster technique was 40 per cent for ascarid eggs and 60 per cent for strongyle eggs when using Sheather's sugar flotation solution, and 18 per cent for ascarid eggs and 73 per cent for strongyle eggs when using saturated sodium chloride flotation solution. With the summation of counts from four successive cover slips, the DCF technique still produced lower EPG counts. For the DGF technique, Sheather's sugar solution was better than saturated sodium chloride solution for floating ascarid eggs, while both solutions were approximately as efficient for the recovery of strongyle eggs.

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PREVALENCE OF EQUINE GASTROINTESTINAL PARASITES IN MONTANA, CORRELATION
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by

CARL ALBERT MCQUEARY

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Approved:

David E. Worley
Co-chairman, Graduate Committee

J. L. Catlin
Co-chairman, Graduate Committee

R. E. Dierks
Head, Major Department

Henry L. Parsons
Graduate Dean

MONTANA STATE UNIVERSITY
Bozeman, Montana

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TABLE OF CONTENTS

	PAGE
VITA.	ii
ACKNOWLEDGMENTS	iii
LIST OF TABLES	vi
LIST OF FIGURES	vii
ABSTRACT	ix
INTRODUCTION	1
MATERIALS AND METHODS	5
Study area and survey	5
<i>Eimeria leuckarti</i>	7
EPG counts and worm burdens of <i>Parascaris equorum</i>	8
EPG counting techniques	10
Fecal examinations	14
Statistical procedures	14
RESULTS	15
Types and prevalence of parasites	15
<i>Eimeria leuckarti</i>	19
EPG counts and worm burdens of <i>Parascaris equorum</i>	23
DCF and McMaster techniques	44
DISCUSSION	54
SUMMARY	65

	PAGE
APPENDIX	67
LITERATURE CITED	69

LIST OF TABLES

TABLE	PAGE
I. Incidence of intestinal parasites in Gallatin County horses	16
II. Internal parasites reported in Montana horses	18
III. Correlation (r) of worm burden, weight and volume of <i>Parascaris equorum</i> in horses to average egg output . . .	24
IV. Correlation (r) of worm burden, weight and volume of <i>Parascaris equorum</i> in female horses to average egg output	25
V. Comparison between the Direct Centrifugal Flotation (DCF) technique and the Remodified McMaster technique using two flotation solutions for nematode egg counts in equine feces	47
VI. Number of eggs recovered on successive cover slips on Direct Centrifugal Flotation (DCF) of nematode eggs in equine feces	50

LIST OF FIGURES

FIGURE	PAGE
1. Areas surveyed in Gallatin County	6
2. <i>Eimeria leuckarti</i> , oocyst (unsporulated); approxi- mately xl500.	20
3. <i>Eimeria leuckarti</i> , oocyst (sporulated); approxi- mately xl500.	21
4. <i>Eimeria leuckarti</i> , oocyst (sporulated) with outer coat partially removed; approximately xl200	22
5. Percentage of females in sixteen worm populations of <i>Parascaris equorum</i>	27
6. Passage of <i>Parascaris equorum</i> eggs by foal 1 during a five day period	28
7. Passage of <i>Parascaris equorum</i> eggs by foal 2 during a five day period	29
8. Passage of <i>Parascaris equorum</i> eggs by foal 3 during a five day period	30
9. Passage of <i>Parascaris equorum</i> eggs by foal 4 during a five day period	31
10. Passage of <i>Parascaris equorum</i> eggs by foal 5 during a five day period	32
11. Passage of <i>Parascaris equorum</i> eggs by foal 6 during a five day period	33
12. Passage of <i>Parascaris equorum</i> eggs by foal 7 during a five day period	34
13. Passage of <i>Parascaris equorum</i> eggs by foal 8 during a five day period	35
14. Passage of <i>Parascaris equorum</i> eggs by foal 9 during a five day period	36

FIGURE	PAGE
15. Passage of <i>Parascaris equorum</i> eggs by foal 10 during a five day period	37
16. Passage of <i>Parascaris equorum</i> eggs by foal 11 during a five day period	38
17. Passage of <i>Parascaris equorum</i> eggs by foal 12 during a five day period	39
18. Passage of <i>Parascaris equorum</i> eggs by foal 13 during a five day period	40
19. Passage of <i>Parascaris equorum</i> eggs by foal 14 during a five day period	41
20. Passage of <i>Parascaris equorum</i> eggs by foal 15 during a five day period	42
21. Passage of <i>Parascaris equorum</i> eggs by foal 16 during a five day period	43
22. Egg output in foals following initial infection with <i>Parascaris equorum</i>	45
23. Egg output in foals following initial infections with <i>Parascaris equorum</i>	46
24. Per cent egg recovery on the first cover slip on DCF using Sheather's sugar solution	52
25. Per cent egg recovery on the first cover slip on DCF using saturated sodium chloride solution	53

ABSTRACT

One hundred eighty-six horses in Gallatin County, Montana were examined for gastrointestinal parasites by fecal egg counts during June, 1975. The over-all prevalence of infection was 96 per cent, with the one month to two year-old group having a 89 per cent infection rate, the three to six year-old group a 98 per cent infection rate, and the older horses a 97 per cent infection rate.

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The relationship of egg per gram (EPG) counts to worm burdens of *P. equorum* in the equine was not significantly correlated when data from both sexes were employed. However, significant correlations did exist between EPG counts and worm burdens in female horses but because of a relatively few number of females the correlations were questionable. When foals showing high EPG counts harbored fewer

worms than foals showing low EPG counts, an inverse relationship was noted between EPG counts and worm burdens.

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INTRODUCTION

Although information on the types of parasites infecting the equine has been reported for a number of geographical locations (2, 5,10,13,54) and from a number of areas (8,25,34), specific information pertaining to the incidence of these parasites, worm burden estimations, and examination of egg counting techniques for equine feces is limited.

By knowing the incidence of various parasites, it helps to understand the degree of contamination that exists in an area. In reports compiled for Ontario (44) and Wisconsin (17), the incidence of parasitic infections indicated a high degree of infection for some gastrointestinal parasites and a low degree for others. The incidence of some parasites, particularly *Parascaris equorum*, decreases as a horse ages while other parasites, like the strongyles, increase or remain the same (29). In addition, some parasites infect a high percentage of horses in an area while others are seldom seen (17,37,44).

Case reports can be an aid in determining the incidence of parasitism, as was found in the necropsies of 1041 horses in Brazil (55) and of 105 native horses in Panama (13). However, most reports are in the form of surveys indicating only the occurrence of particular parasites, as was done in Hawaii (14) and Mississippi (56).

Most of the regional surveys report the same types of parasites. The presence of one parasite found in Montana, is seldom listed. This being the equine coccidium, *Eimeria leuckarti*, which has been found in the mucosa of the small intestine. Both Levine (30) and Pellerdy (35) described the coccidium in moderate detail and gave reports on its occurrences. Although the reports are few, the presence of this parasite has been detected in a wide variety of areas throughout the world (1,19,20,33,42). In some cases the parasite has been detected by the presence of the oocysts in the feces (3,12,23) and other cases by the presence of the oocysts in the walls of the small intestine (24,33,42). To gain further information on the development, attempts were made to infect horses experimentally with sporulated oocysts of *E. leuckarti* (1,12).

From the standpoint of pathogenicity, it would be a help to know if quantitative fecal egg per gram counts are correlated with worm burdens. This has been examined for specific parasites in a number of domestic animals (9,22,41,53) but not for the equine. Of these parasites that were examined, some reports state definite relationships (53) and others do not (9,22,41). In the case of human parasites, there have been reports of direct relationships between fecal egg counts and number of hookworms (23,45,49). In making correlations of worm burdens and egg counts, it should be noted that the age of the worm affects the rate of egg production (53) and a number of factors

can effect the fecal egg count (47). Ractliffe and Lejamber (38) indicated that the rate of egg production for certain nematodes increases as the worm grows, included were two horse parasites, *Oxyuris equi* and *Parascaris equorum*.

In relating EPG counts to worm burdens, the accuracy of the count is of prime importance. Thus to get an accurate count, the best counting technique for a particular parasite egg must be employed. Two general methods used are the dilution method and the flotation method. Two varieties of the dilution method in common use are the Stoll dilution technique introduced by Stoll (48) and the McMaster technique introduced by Gordon and Whitlock (16). A flotation method used often is the Direct Centrifugal Flotation (DCF) technique formulated by Lane (28) and modified by Stoll (50).

The efficiency of these techniques has been reported for a number of parasite eggs and types of feces, with most reports indicating the flotation method to be less accurate than the dilution method (18,31,50,51). However, Wilson (57) found no significant difference between the two methods. In a comparison of the two dilution techniques, Peters and Leiper (36) demonstrated that the McMaster technique gave higher counts than the Stoll technique. Hunter and Quenouille (21), in evaluating the McMaster technique, stated the efficiency of the McMaster count depends on the sample size.

With the flotation method lower in efficiency in most cases, the count obtained would be a less accurate estimation of the egg count per gram of feces. This is evident by the fact that there is less than one hundred per cent egg recovery on the first cover slip (6,50). In addition, the type of flotation solution has an effect on the efficiency of the DCF technique (15,31,39).

Since information on the incidence of parasitic infections, worm burden estimations, and the best technique for the estimation of EPG counts in the equine is limited, it was the purpose of this study to examine these areas. A county in Montana was surveyed and past reports were compiled to get an idea of the types and prevalence of equine parasites on a state wide basis. In addition, a study was done to gain further information on the life cycle of the coccidium, *Eimeria leuckarti*.

Experiments were designed to investigate the relationship between EPG counts and worm burdens of *Parascaris equorum* and to analyze the accuracy of the Direct Centrifugal Flotation (DCF) technique and the McMaster technique for the estimation of EPG counts in equine feces. Also, Sheather's sugar solution and saturated sodium chloride solution were examined for their egg floating ability with the DCF technique.

MATERIALS AND METHODS

Study Area and Survey

Gallatin County was the area selected to record the types and prevalence of equine parasites in southwestern Montana. The area contained many types of ecological conditions ranging from dry hilly areas to moist river bottoms, thus giving both climatic and geographic differentiations. Four classes of horses were represented: the pleasure horse, the show horse, the racing horse, and the working horse.

To get the best representative sample of the parasites in the area, the county was subdivided into eleven areas to account for all climatic and geographic conditions (Figure 1). Along with this, three groups were set up to show the effect of the horse's age on the prevalence of parasitism. The groups were: one month to two years, three to six years, and older horses.

The types and prevalence of parasites were recorded from examinations of feces collected from a random sample of horses in each area. This was accomplished by first obtaining information from the owner as to the breed of the horse, the age, the last date dewormed, and the horse's use. A fecal sample was collected from the pasture immediately after deposition. All samples were refrigerated after collection and when all areas had been sampled a differential

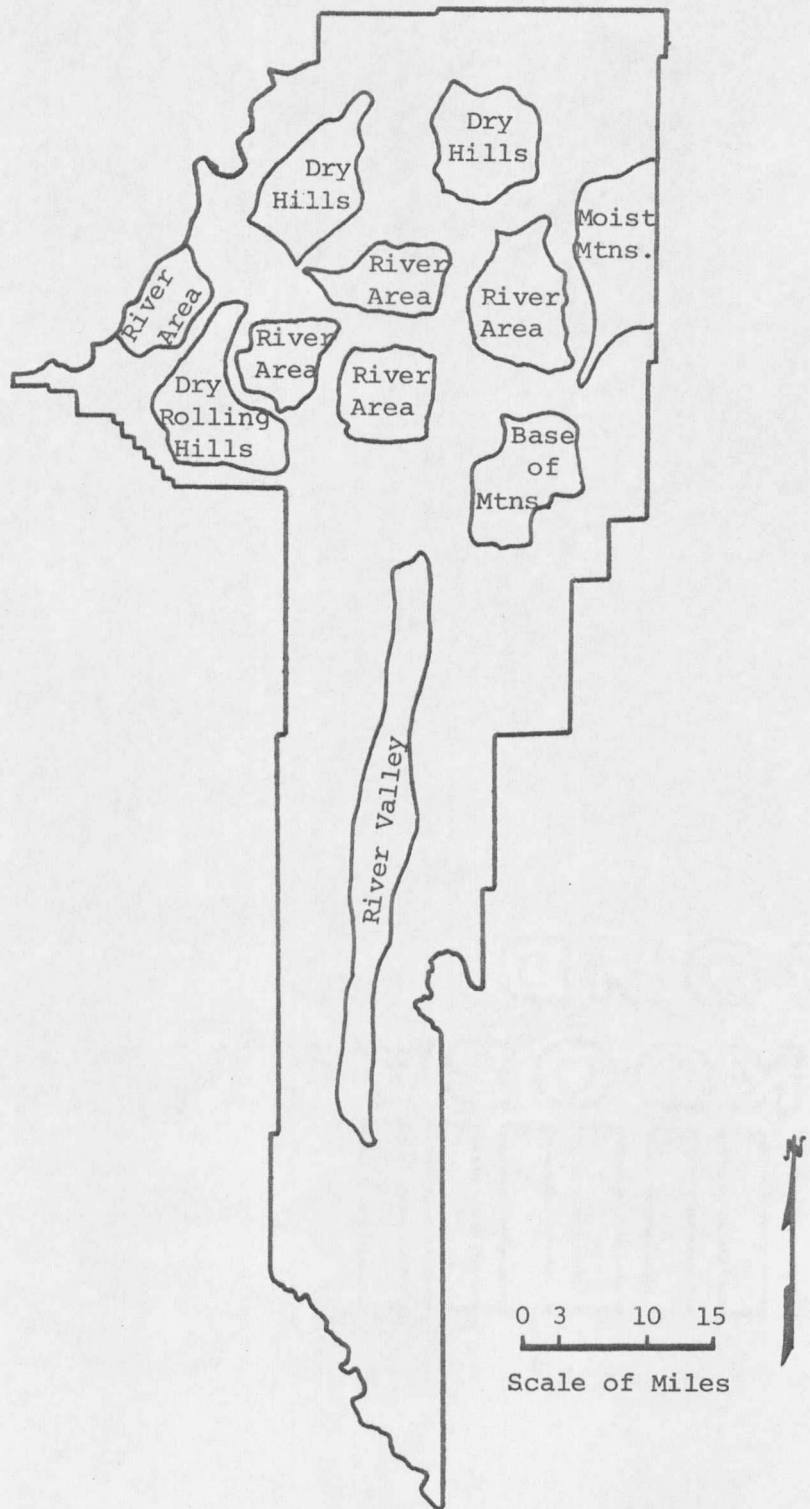


Figure 1. Areas surveyed in Gallatin County.

egg count was performed on each sample. However, no differentiation was made as to the genus and species of the strongyles due to the indistinguishability of the eggs.

In conjunction with the survey work, parasites recovered from the necropsy of two five-to-six month old foals and the deworming of sixteen horses gave added information on the types of parasites in Montana. Also, reports from records of the Diagnostic Laboratory of the Animal Health Division of Montana Department of Livestock, practicing veterinarians, Veterinary Research Laboratory at Montana State University and work done prior to this study were compiled to record the types and number of case reports of parasites occurring in Montana during the last forty years.

Eimeria leuckarti

Twenty-two foals between two and three months of age from four sources were observed weekly for gastrointestinal parasites by fecal examination. Upon discovery of *Eimeria leuckarti* oocysts, the feces of four positive animals were used as sources of oocysts. The oocysts were concentrated by suspending the feces in 86 per cent saline and comminuting in a Waring blender. The feces were then strained through two layers of cheesecloth with tap water to remove the coarse debris. The washings were collected in flasks and after sedimentation, the supernatant was aspirated and the sediment was washed through a 200

mesh screen to remove the fine debris. The washings, containing the oocysts, were collected on filter paper. The oocysts were placed in a two per cent sodium dichromate solution approximately 3.5 cm. deep for two months. In the two months, periodic checks were made to determine the sporulation time.

To study the coccidium in greater depth, a dewormed foal, five to six months old was experimentally infected with 2000 sporulated oocysts by stomach tube. Periodic fecal examinations were performed the first two weeks post-infection, then daily up to and through the patent period. After patency, fecal examinations were performed three times a week for five weeks.

Ocular micrometer measurements were made of seventy-five random oocysts from the four source animals' feces and photomicrographs were taken of both unsporulated and sporulated oocysts.

EPG Counts and Worm Burdens of *Parascaris equorum*

Sixteen foals, approximately 130 to 160 days old, were acquired from five sources. All foals had been on contaminated pastures and were naturally infected with *Parascaris equorum* as determined by fecal examination. The foals were assumed to have been exposed to the parasite eggs shortly after birth, thus the prepatent period was calculated from birth to the initial detection of the eggs in the feces.

For the correlation of EPG counts and worm burdens of *P. equorum*, fecal samples were collected two times per day for a five-day period. The daily collections were taken once between eight and nine A.M. and again between five and six P.M. Egg per gram counts were performed for each sample and from these counts a graph was plotted and an average EPG count was obtained for each foal.

During the afternoon on the fifth day of the five-day collection period, the foals were treated with two anthelmintics, piperazine (Pipzine-34; Affiliated Laboratories Division, Whitmoyer Laboratories, Inc., Myerstown, Pennsylvania) and thiabendazole (Omnizole; Merck Chemical Division, Merck and Co. Inc., Rahway, New Jersey). Piperazine was used because of its efficacy against ascarids and thiabendazole was used to eliminate the strongyles. At first, double dosages of each drug were administered to insure complete elimination of these parasites. However, due to some constipation and intestinal upset in some foals at this level, the drugs were reduced to the prescribed therapeutic dosages. The foals were treated at approximately the same time in the patent period of *Parascaris equorum*.

After treatment, the foals were penned on concrete slabs for the convenience of collecting the expelled worms. A five-day period was allowed for the removal of the ascarids. All fecal material passed in this time interval was sorted macroscopically and the ascarids collected. A fecal examination was performed two days after

the five-day waiting period to determine if eggs were still being produced.

The ascarids collected from each foal were counted and classified as to sex and stage of maturity, then tabulated into the following groups: total ascarids, mature females, and total females. Also, weight and volume displacement of the total number of ascarids expelled by each foal were recorded. Correlations were then computed between the average five-day EPG count and the total number of ascarids, number of mature females, total number of females, weight, and volume displacement.

In addition, five foals were observed by weekly fecal examinations for trends in the egg output of *P. equorum*. The observations lasted for ten weeks on two foals and thirteen weeks on the remaining three.

EPG Counting Techniques

The procedures of the Remodified McMaster technique and the Direct Centrifugal Flotation (DCF) technique used for the estimation of EPG counts in equine feces are listed below.

Remodified McMaster Technique (McMaster)

1. Place 10 grams of feces in 300 milliliters of tap water.
2. Commminute in Waring blender for one and a half minutes.
3. Pour 30 milliliters of the well mixed suspension into a 50 milliliter centrifuge tube.

4. Centrifuge for four minutes at 1500 RPM.
5. Aspirate supernatant.
6. Resuspend the sediment with 30 milliliters of water.
7. Recentrifuge for four minutes at 1500 RPM.
8. Aspirate supernatant.
9. Add Sheather's sugar solution to make up a total volume of 15 milliliters.
10. Mix thoroughly with a wide bore Pasteur pipette to insure an even distribution of eggs.
11. Using the pipette, transfer an aliquot of the suspension to two McMaster slides (4 chambers).
12. Average the total number of eggs from the four chambers and multiply by a dilution factor of 100.
13. The resultant figure is the number of eggs per gram of feces (EPG).

This technique is an alteration of the original technique introduced by Gordon and Whitlock (16). Two significant modifications were made. The first was a step to insure an even distribution of eggs in the feces. According to the original McMaster technique, two grams of a fecal sample were placed directly into a flotation solution and from this an aliquot was withdrawn to be placed in a McMaster slide. In the remodified version, ten grams of a fecal sample were comminuted in a designated amount of water and from this suspension

a one gram fecal sample was taken. The one gram sample was suspended in a flotation solution and an aliquot was placed in a McMaster slide. Therefore by mixing the ten grams of feces in water, it reduces the possible error resulting from an uneven distribution of eggs in the feces.

The second modification was the reduction of the dilution factor from 200 to 100. The dilution of the original technique was two grams of feces in sixty milliliters of flotation solution, whereas the remodified version was one gram in fifteen milliliters. The reduction in the dilution factor would decrease the chance of overestimating the EPG count and the lower dilution would increase the chance of detecting low EPG counts.

The McMaster slides used in this study had two cell chambers with each chamber having a counting area of 1 square centimeter and a depth of 1.5 millimeters.

The other technique, the DCF, was mechanized from the technique introduced by Lane (28) and modified by Stoll (50). The technique was not significantly modified but changed to increase the rate at which the samples were examined. The procedure is as follows.

Direct Centrifugal Flotation Technique (DCF)

1. Place 10 grams of feces in 300 milliliters of tap water.
2. Commminute in Waring blender for one and a half minutes.

3. Pour 15 milliliters of the well mixed suspension into a 15 milliliter centrifuge tube.
4. Centrifuge for four minutes at 1500 RPM.
5. Pour off the supernatant and resuspend with flotation solution until a meniscus forms on top of the tube.
6. Place a coverslip (22 mm. sq.) on top of the tube.
7. Centrifuge for two minutes at 1000 RPM.
8. Carefully remove the coverslip by lifting straight up and place it on a microscope slide.
9. Multiply the number of eggs counted under the entire coverslip by 2.
10. The resultant figure is the number of eggs per gram of feces (EPG).

The total EPG count for this technique included the counts of four successive coverslips. After the removal of each coverslip, the sediment was agitated and a new meniscus was formed by adding more flotation solution, and then a new coverslip was placed on the tube and the suspension recentrifuged.

The techniques were compared for their accuracy in estimating the EPG counts of both *P. equorum* and strongyle eggs. Also, two flotation solutions were compared for their egg floating ability in the DCF technique. Therefore, two comparisons were established. Comparison one (Comp. 1) involved both techniques and Sheather's

sugar solution (sp.gr. 1.275). Comparison two (Comp. 2) involved both techniques and saturated sodium chloride solution (sp.gr. 1.20). For both comparisons, sixteen positive samples were used to calculate an average EPG count and the same fecal suspension of each sample was used for both techniques in each comparison.

The accuracy of the techniques was determined by comparing the average count from each of the four successive coverslips of the DCF technique for both flotation solutions with the average count obtained by the McMaster technique. Also, the efficiency of the two flotation solutions was calculated by expressing the average count for each of the four successive counts as a percentage of the total DCF count.

Fecal Examinations

The Remodified McMaster technique was used for all fecal examinations, except for the weekly counts taken to observe trends in the egg output of *P. equorum*. In this case, the DCF technique was used.

Statistical Procedures

Table VI of *Statistical Tables for Biological Agricultural and Medical Research* by Fisher and Yates was used to test the significance of the correlation values. The Student's t-test was used for testing the significance of all other values. Significance was calculated at $P=.05$.

RESULTS

Types and Prevalence of Parasites

Ninety-six per cent of 186 horses examined in the study area were positive for gastrointestinal parasites. An analysis of the prevalence data by age groups revealed that all groups had approximately the same per cent of infection. The one month to two year-old group showed a 94 per cent infection rate, the three to six year-old group a 98 per cent infection rate, and the older horses a 97 per cent infection rate.

By analyzing the prevalence of individual parasites, the strongyles were the most predominate parasite detected in the study area, infecting 92 per cent of the horses examined. *Parascaris equorum* occurred in 21 per cent of the horses examined, *Strongyloides westeri* 7 per cent, *Eimeria leuckarti* 6.5 per cent, *Oxyuris equi* 5 per cent, and *Anoplocephala* sp. 1.6 per cent.

Table I presents the prevalence of the individual parasites for each age group. In all cases but one the prevalence decreased with increasing age of the horse. The exception was the strongyles where approximately the same rate of infection occurred in all age groups. The parasites *E. leuckarti*, *O. equi*, and *S. westeri*, had the most drastic reduction in prevalence due to the age of the horse. They were found in a low per cent in the younger group but were absent or very low in the other two groups.

TABLE I

Prevalence of Intestinal Parasites in Gallatin County Horses

Age group	Number horses	Per cent prevalence					strongyles ^a
		<i>Anoplocephala</i> sp.	<i>Eimeria</i> <i>leuckarti</i>	<i>Oxyuris</i> <i>equi</i>	<i>Parascaris</i> <i>equorum</i>	<i>Strongyloides</i> <i>westeri</i>	
1mo.-2yrs.	66	3	20	15	55	20	89
3-6yrs.	52	2	0	0	6	2	94
older	68	0	0	0	3	0	93

* Fecal examinations used to detect presence of parasites

^a Not differentiated as to genus

The parasite demonstrating the most variation was *P. equorum*. The prevalence in the one month to two year-old group was nine times greater than the three to six year-old group and eighteen times greater than the older horses.

Although the occurrence of *Anoplocephala* sp. was very low in all age groups, the prevalence declined with the increasing age of the horse. The younger group exhibited a 3 per cent infection rate, the middle age group a 2 per cent infection rate, and the older group was negative.

From the previously indicated records, 616 case reports have been filed on internal parasites of horses in Montana. The types and number of case reports for each parasite are presented on Table II. Four groups of internal parasites were represented: the Arthropoda, the Cestoidea, the Nematoda, and the Protozoa. Eleven species of the Class Nematoda occurred in Montana, two species of the Class Cestoidea, three species of the Class Arthropoda, and one species of the Phylum Protozoa.

Of the 616 case reports, the strongyles and *P. equorum* were reported as occurring the most, 50 per cent and 18 per cent, respectively. *S. westeri* was reported 15 per cent of the time and *O. equi* 2.6 per cent. The remaining parasites were detected infrequently with percentages between 2 and 0.1.

TABLE II

Internal Parasites Reported in Montana Horses

Parasite	Location in host	Reported cases*
Arthropods		
<i>Gastrophilus intestinalis</i>	stomach	2
<i>G. nasalis</i>	stomach	1
<i>G. haemorrhoidalis</i>	stomach	2
Cestodes		
<i>Anoplocephala perfoliata</i>	cecum	6
<i>Paranoplocephala mamillana</i>	small intestine	2
Nematodes		
<i>Dictyocaulus arnfieldi</i>	bronchi	2
<i>Oxyuris equi</i>	colon	16
<i>Probstmayria vivipara</i>	colon	2
<i>Parascaris equorum</i>	small intestine	111
<i>Setaria equina</i>	abdomen	3
<i>Strongyloides westeri</i>	small intestine	95
<i>Strongylus edentatus</i>	cecum & colon	1
<i>S. equinus</i>	cecum & colon	6
<i>S. vulgaris</i>	cecum & colon	8
<i>Trichostrongylus axei</i>	stomach	1
strongyles**	large and small intestine	305
Protozoa		
<i>Eimeria leuckarti</i>	small intestine	13

* Case reports compiled from records of the Diagnostic Laboratory of the Animal Health Division of the Montana Department of Livestock, practicing veterinarians, Veterinary Research Laboratory at Montana State University, and work done prior to this study. Most cases detected by fecal examination.

** May contain both large and small strongyles

Eimeria leuckarti

Fifty-nine per cent of the 22 foals being observed for intestinal parasites were infected with *Eimeria leuckarti*. The patency lasted between one and two weeks.

The successful experimental infection exhibited a prepatent period of thirty-one days and a patent period between five and ten days. The oocysts were detected on day thirty-one in low numbers and rose to a high count of 525 oocysts per gram on day thirty-five. Due to an error in fecal collecting, fecal examinations were not performed until day forty-one, on which day the examination was negative. Fecal examinations remained negative up to day sixty-nine at which time the experiment was terminated. The foal exhibited no clinical signs or symptoms during the patent period.

Of the 75 oocysts measured, the mean length was revealed to be 75.5_{μ} with a range of 84.7 to 61.6_{μ} and the mean width was 50.2_{μ} with a range of 53.9 to 46.2_{μ} . Figure 2 presents a typical unsporulated oocyst, having a dark brown outer shell with a distinct micropyle and a lighter granular inner portion. The sporulated oocyst that is presented in Figure 3 exhibits three of the four sporocysts contained in the inner portion. The sporulation time approximated thirty-five days at 21 to 22°C. To examine the sporocysts in more detail, the oocyst can be dehulled as indicated by Dunlap (11). This is demonstrated in Figure 4.

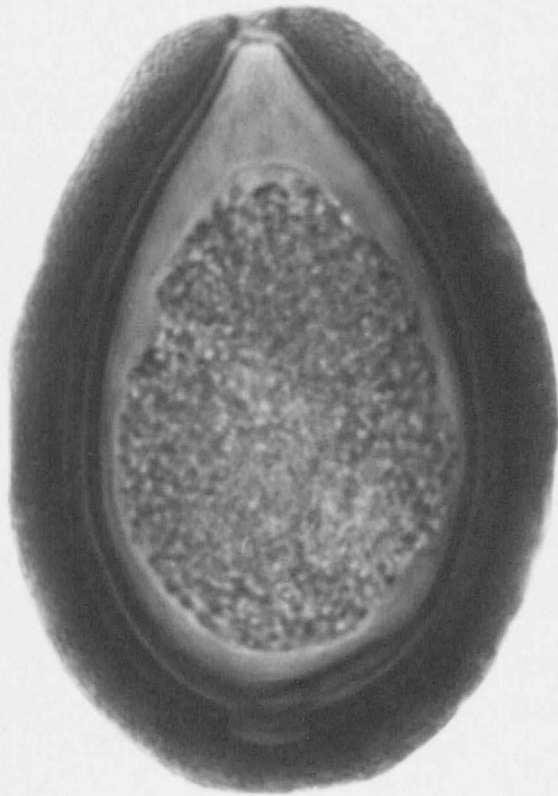


Figure 2. *Eimeria leuckarti*, oocyst (unsporulated); approximately x1500.



Figure 3. *Eimeria leuckarti*, oocyst (sporulated); approximately x1500.



Figure 4. *Eimeria leuckarti*, oocyst (sporulated) with outer coat partially removed; approximately x1200.

EPG Counts and Worm Burdens
of *Parascaris equorum*

No significant correlations existed between the average EPG count and the total ascarids, number of mature females, total females, weight, and volume displacement of *Parascaris equorum* when data from both sexes of horses were employed (Table III). However, when data from only the female horses were used significance existed in all correlations (Table IV) but due to the small sample size the significance was questionable.

To reduce error, all foals were about the same age and were treated at approximately the same time in the patent period of *P. equorum*. The ages ranged between 133 and 161 days with an average of 146 ± 9 days and the length of patency ranged between 47 and 65 days with an average of 56 ± 2 days.

From the reported 95 to 100 per cent efficacy of the anthelmintic piperazine (7) and the negative fecal examinations taken seven days after treatment, it was assumed that all ascarids in the intestinal tract of each foal were expelled. Thus, possible error resulting from ascarids still remaining in the intestinal tract was rejected.

In addition, the prepatent period of *P. equorum* was approximately 92 ± 2 days with a range between 82 and 103 days.

Even though no straightforward correlations existed, there was an inverse relationship between EPG counts and worm burdens in some foals. This relationship was that large worm burdens exhibited low

TABLE III

Correlation (r) of Worm Burden, Weight, and Volume of
Parascaris equorum in Horses to Average Egg Output

Animal No.	Sex	Average egg output per gram of feces*	Total ascarids expelled by treatment	Mature female ascarids	Total female ascarids	Weight of ascarids in grams	Volume displacement of ascarids in milliliters
1	F	9320	76	62	64	89.1	95.0
2	M	10092	41	33	33	52.3	50.1
3	F	3245	81	52	62	85.5	88.0
4	M	3550	5	4	5	7.2	1.3
5	M	21510	37	29	31	59.9	60.0
6	F	2925	70	21	58	53.1	55.2
7	F	875	34	7	26	22.5	20.1
8	M	1528	23	15	20	38.6	39.0
9	M	25	73	9	38	50.7	50.0
10	M	3618	92	61	78	132.6	125.3
11	F	550	12	10	10	15.6	15.0
12	M	1543	265	120	240	230.6	220.0
13	F	373	36	20	33	42.7	38.2
14	M	183	76	29	67	67.8	60.0
15	M	1325	423	173	355	478.5	456.0
16	M	1553	186	88	171	164.7	155.2
		r**	.20	.07	.19	.13	.11

* Average two samples per day for five days

** Significance at $r=.45$

TABLE IV

Correlation (r) of Worm Burden, Weight, and Volume of *Parascaris equorum* in Female Horses to Average Egg Output

	Average egg output per gram of feces*	Total ascarids expelled by treatment	Mature female ascarids	Total female ascarids	Weight of ascarids in grams	Volume displacement of ascarids in milliliters
1	9320	76	62	64	89.1	95.0
3	3245	81	52	62	85.5	88.0
6	2925	70	21	58	53.1	55.2
7	875	34	7	26	22.5	20.1
11	550	12	10	10	15.6	15.0
13	373	36	20	33	42.7	38.2
	r**	.71	.95	.74	.80	.83

* Average two samples per day for five days

** Significance at $r=.45$

EPG counts and small worm burdens exhibited high EPG counts. This was evident in foals 12 and 15 which had large worm burdens (265 and 423, respectively) with low EPG counts (1543 and 1325, respectively) and in foals 2 and 5 which had small worm burdens (41 and 37, respectively) with high EPG counts (10092 and 21510, respectively). In the large worm burdens, the worms seemed to be immature and stunted. Some females were comparable in length to well developed females but their posterior end, containing the reproductive organs, appeared underdeveloped. In the small worm burdens, the worms were mature and seemed to reach maximum length according to Krull (26).

Another fact was the consistent sex ratio in the worm populations. The average percentage of females was 84.6 ± 2.7 with a range between 52 and 100 per cent. Although the range was very wide, the majority of the values were clustered around the average (Figure 5).

When considering the relationship between egg counts and worm burdens of *P. equorum*, the fluctuations in the daily and day-to-day counts must be observed. In Figures 6-21, the fluctuations are exhibited for each foal over a five-day period. Significant differences existed between the daily and day-to-day counts for each foal except for foal nine (Figure 14). Here no significant difference was observed.

Even though considerable variations existed in the EPG counts, trends did develop when counts were taken over a long time period. Figures 22 and 23 indicate these trends with weekly EPG counts taken

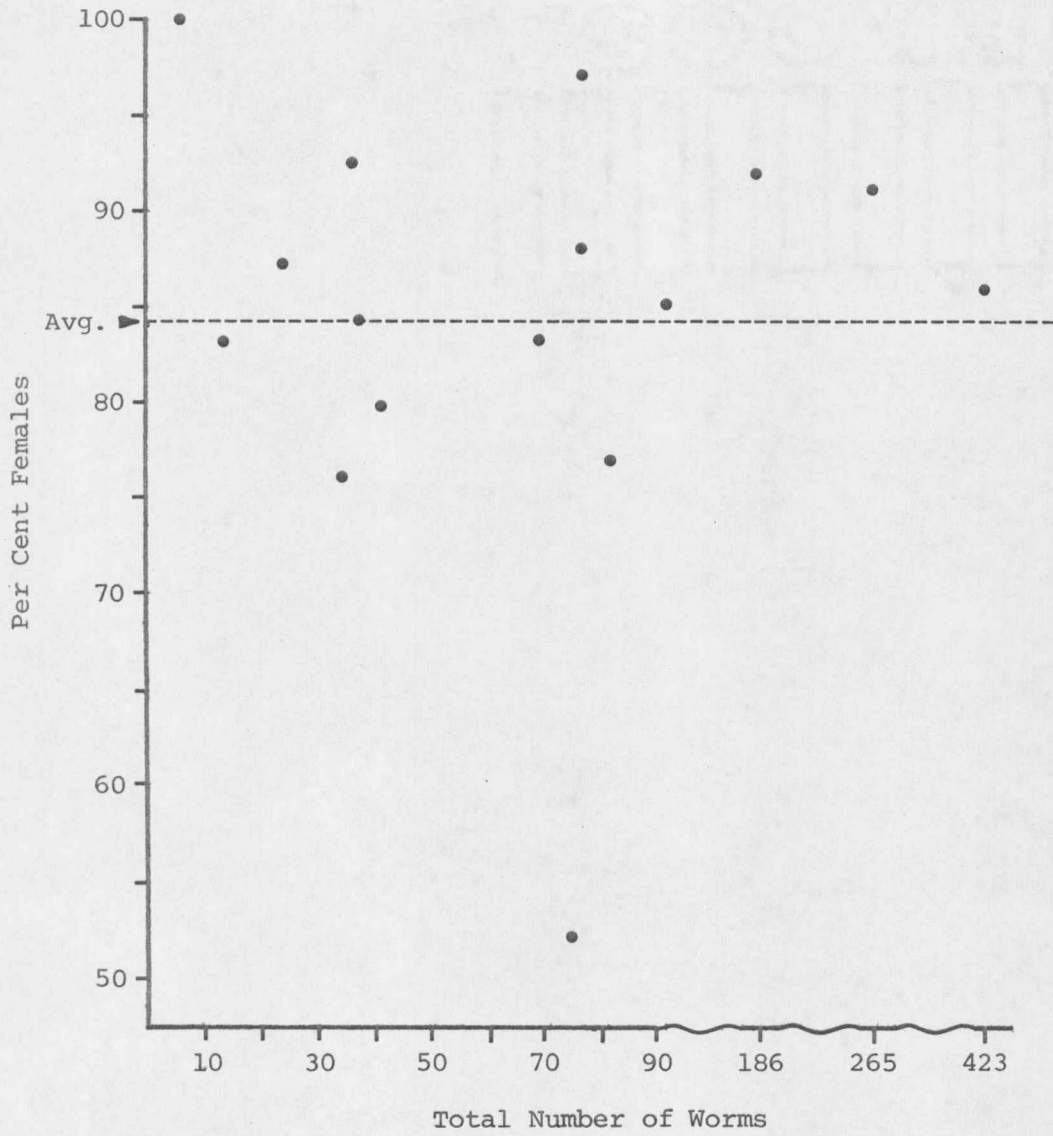


Figure 5. Percentage of females in sixteen worm populations of *Parascaris equorum*.

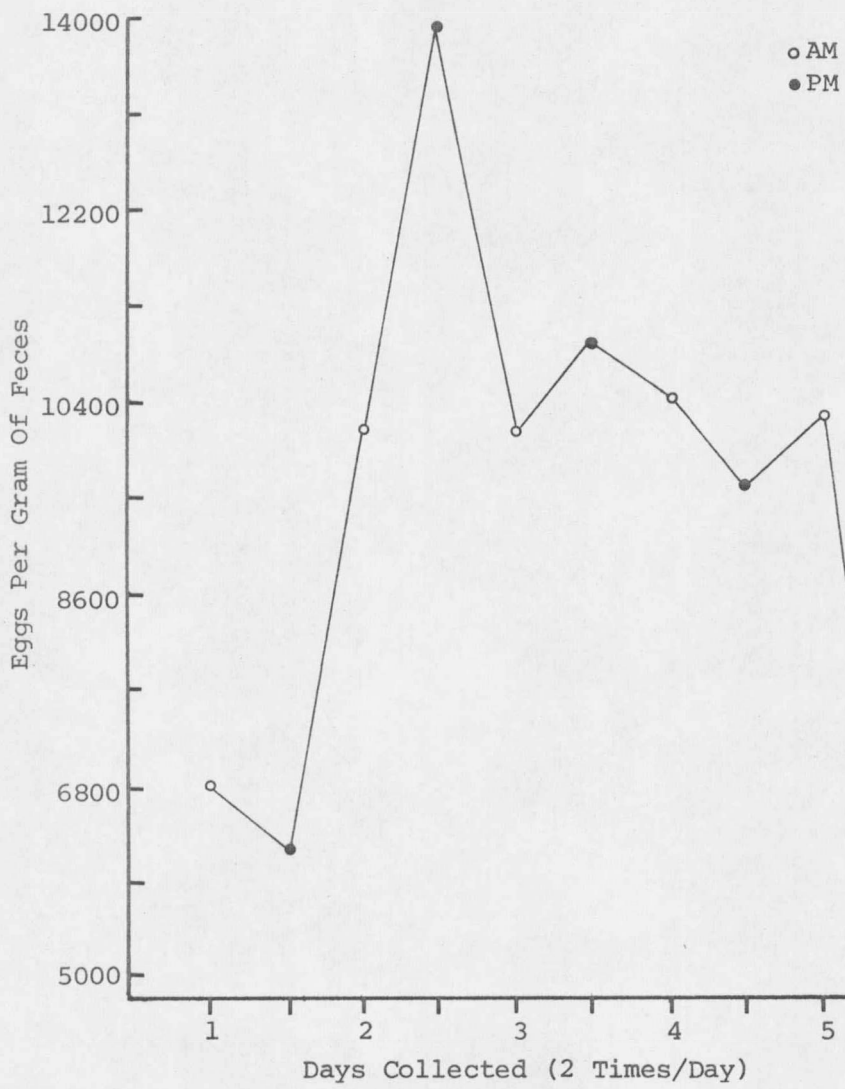


Figure 6. Passage of *Parascaris equorum* eggs by foal 1 during a five day period.

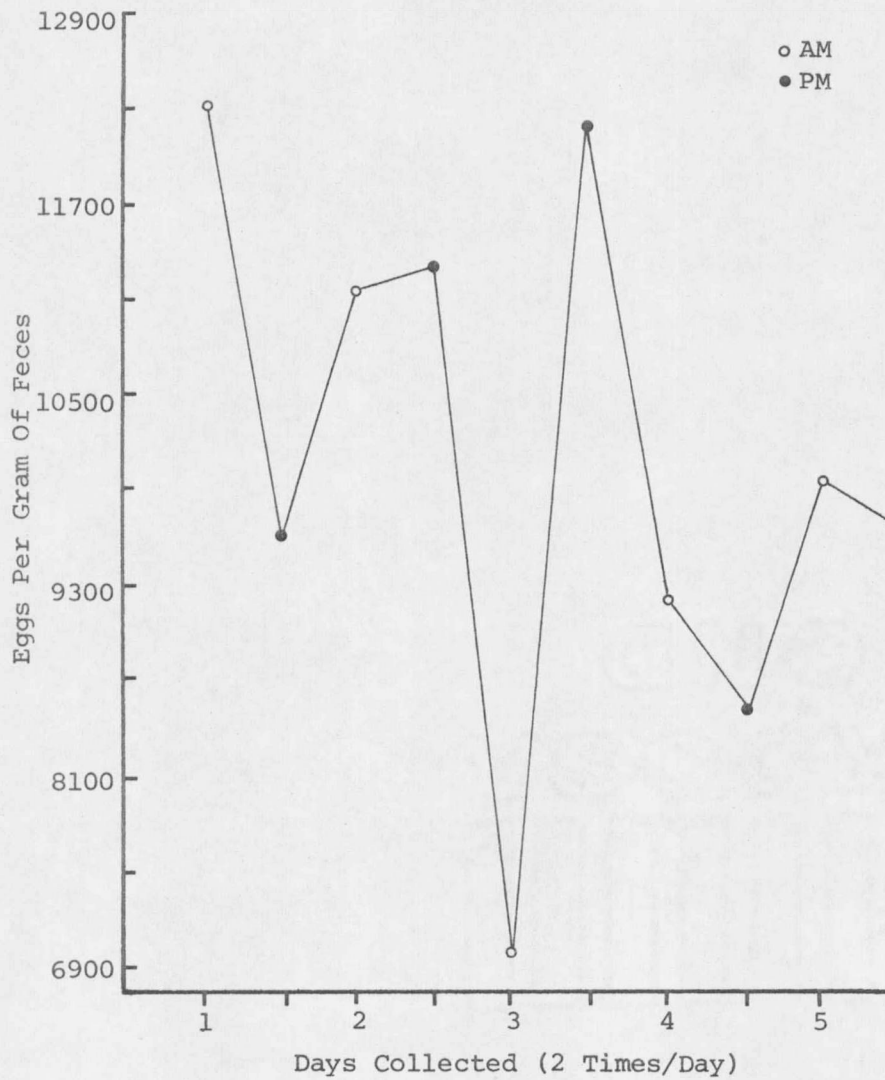


Figure 7. Passage of *Parascaris equorum* eggs by foal 2 during a five day period.

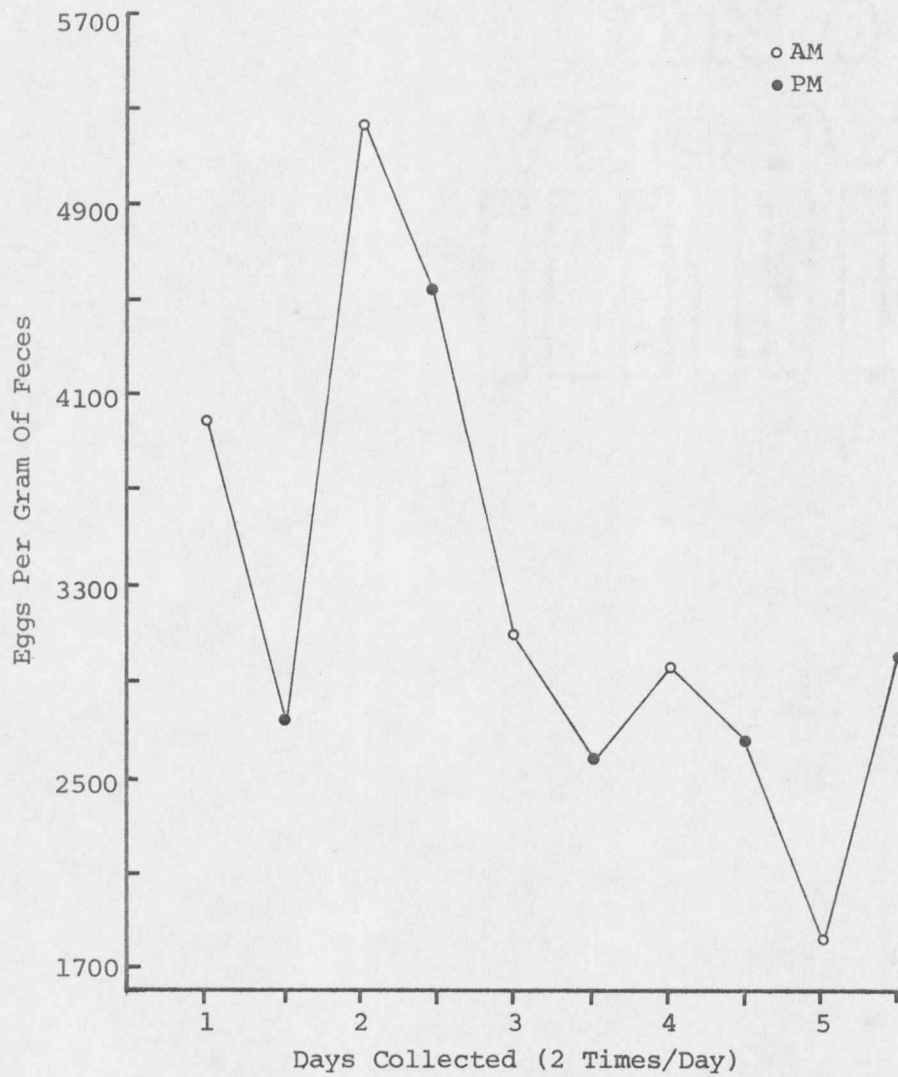


Figure 8. Passage of *Parascaris equorum* eggs by foal 3 during a five day period.

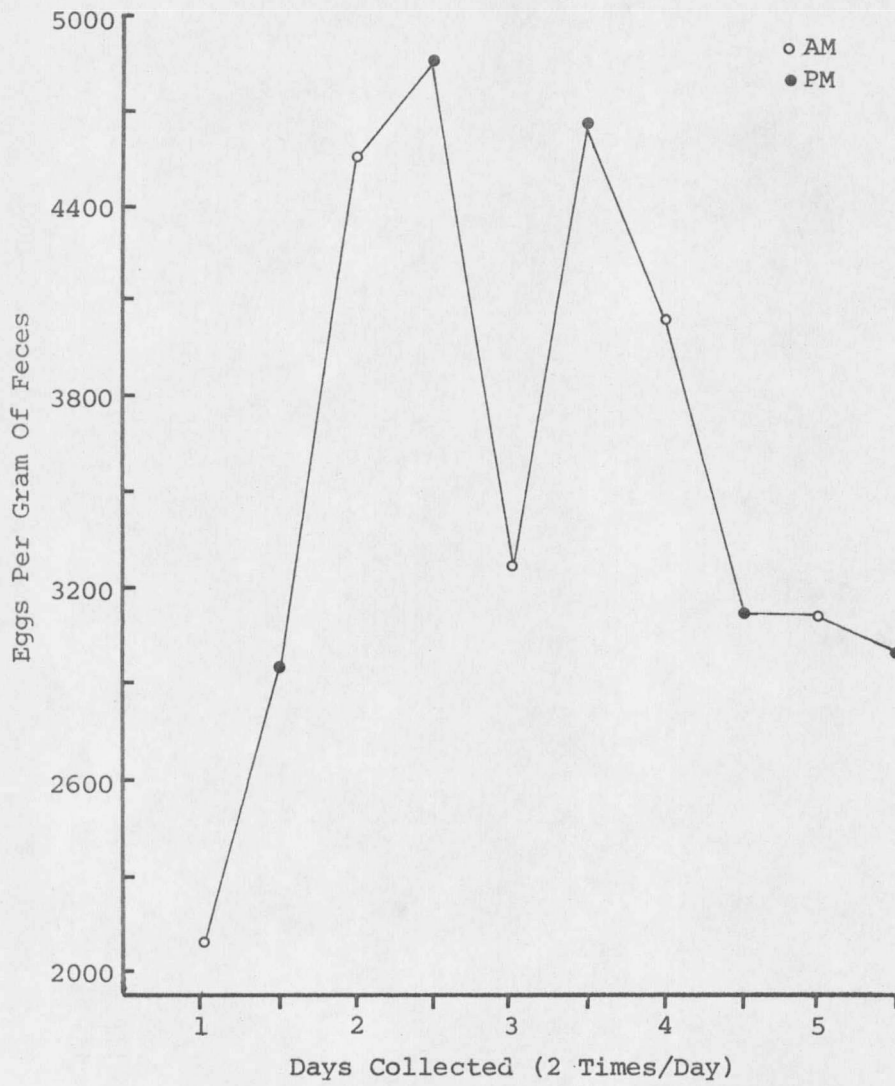


Figure 9. Passage of *Parascaris equorum* eggs by foal 4 during a five day period.

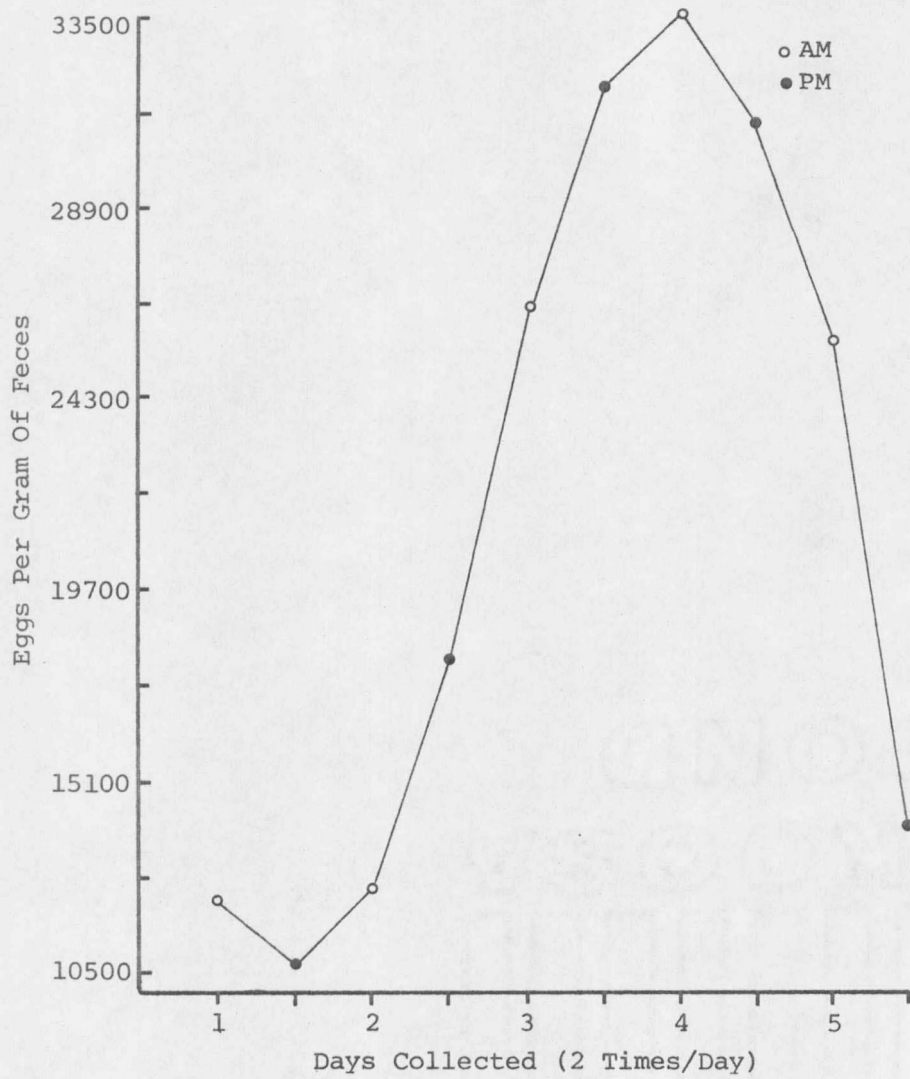


Figure 10. Passage of *Parascaris equorum* eggs by foal 5 during a five day period.

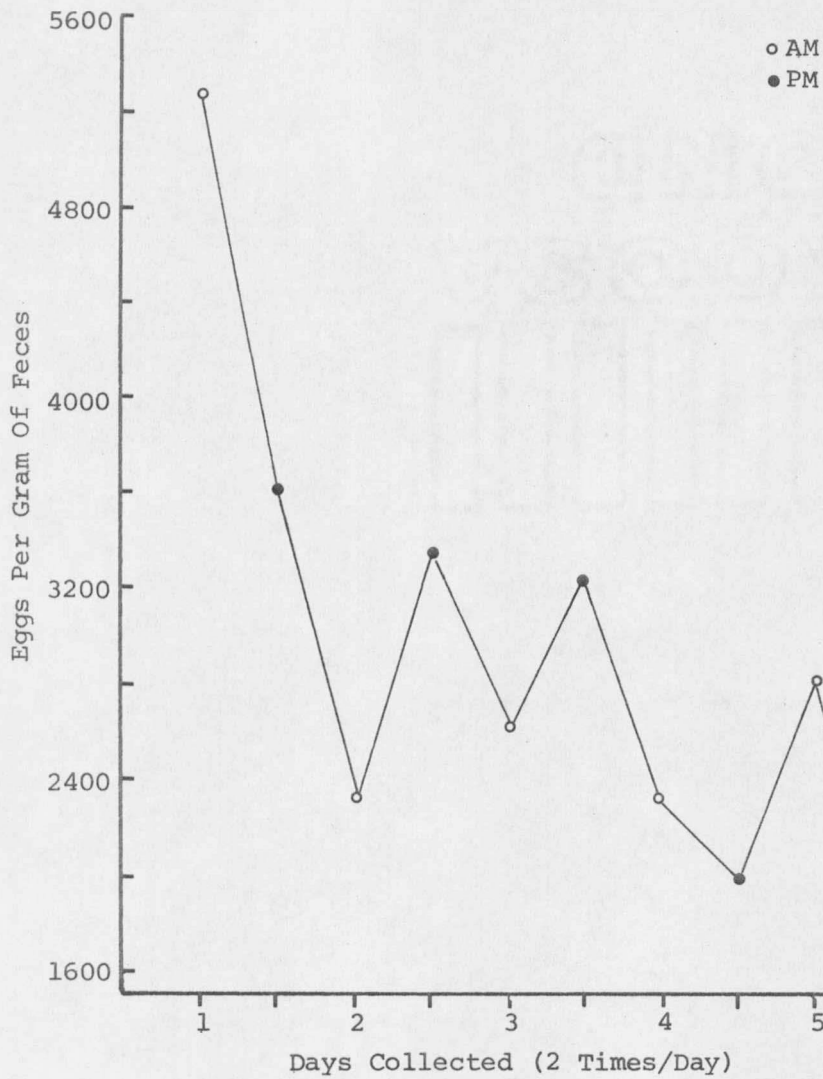


Figure 11. Passage of *Parascaris equorum* eggs by foal 6 during a five day period.

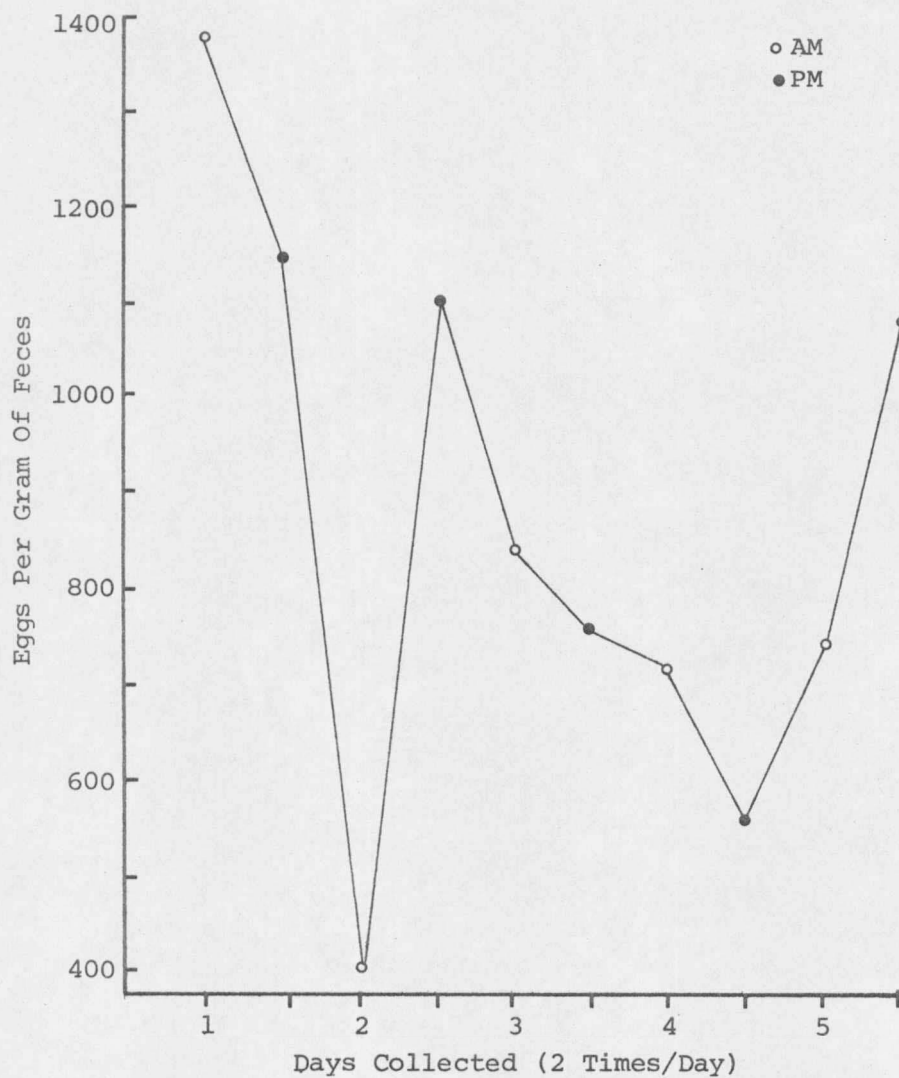


Figure 12. Passage of *Parascaris equorum* eggs by foal 7 during a five day period.

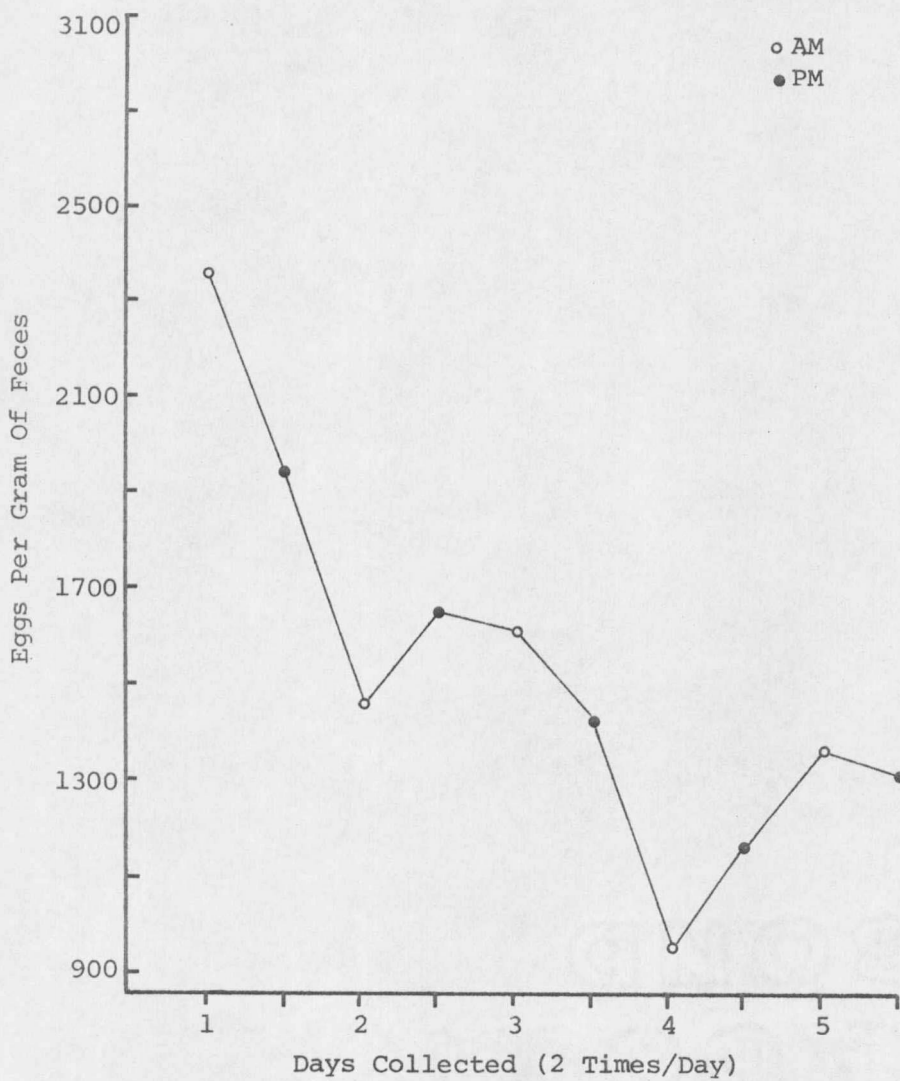


Figure 13. Passage of *Parascaris equorum* eggs by foal 8 during a five day period.

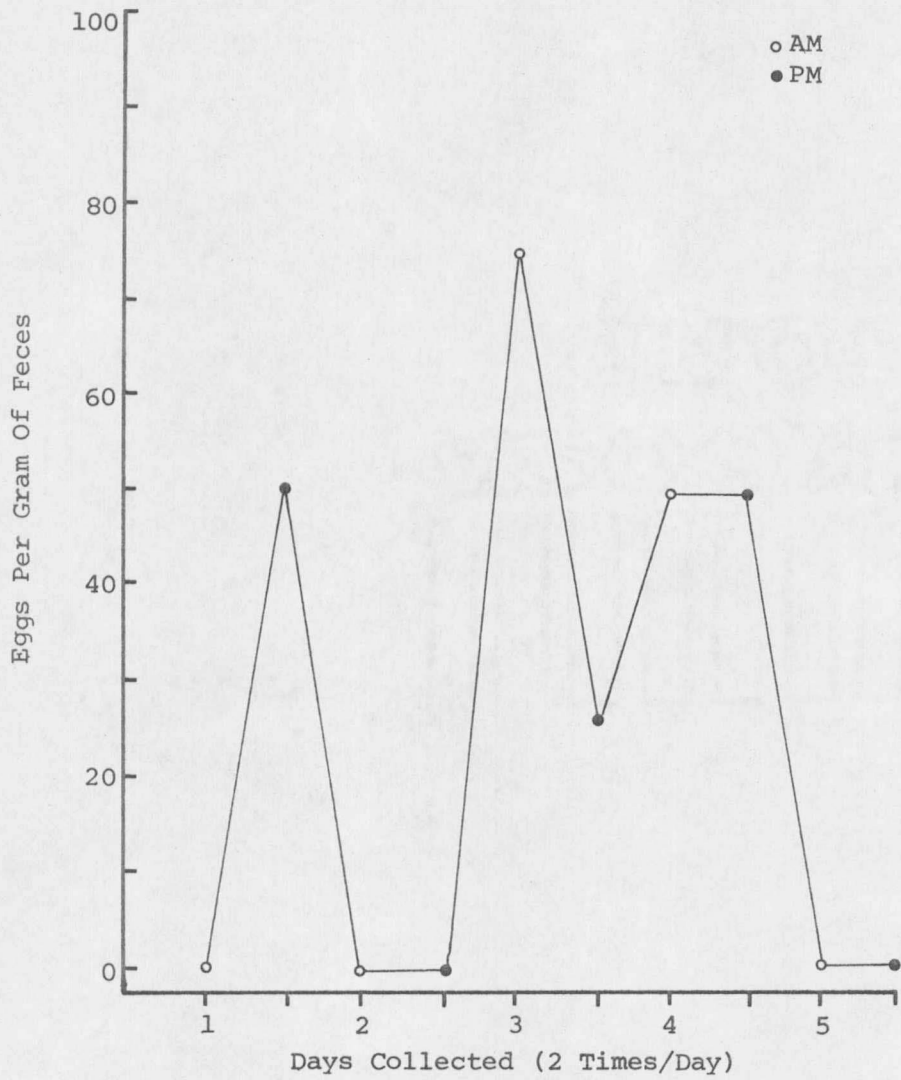


Figure 14. Passage of *Parascaris equorum* eggs by foal 9 during a five day period.

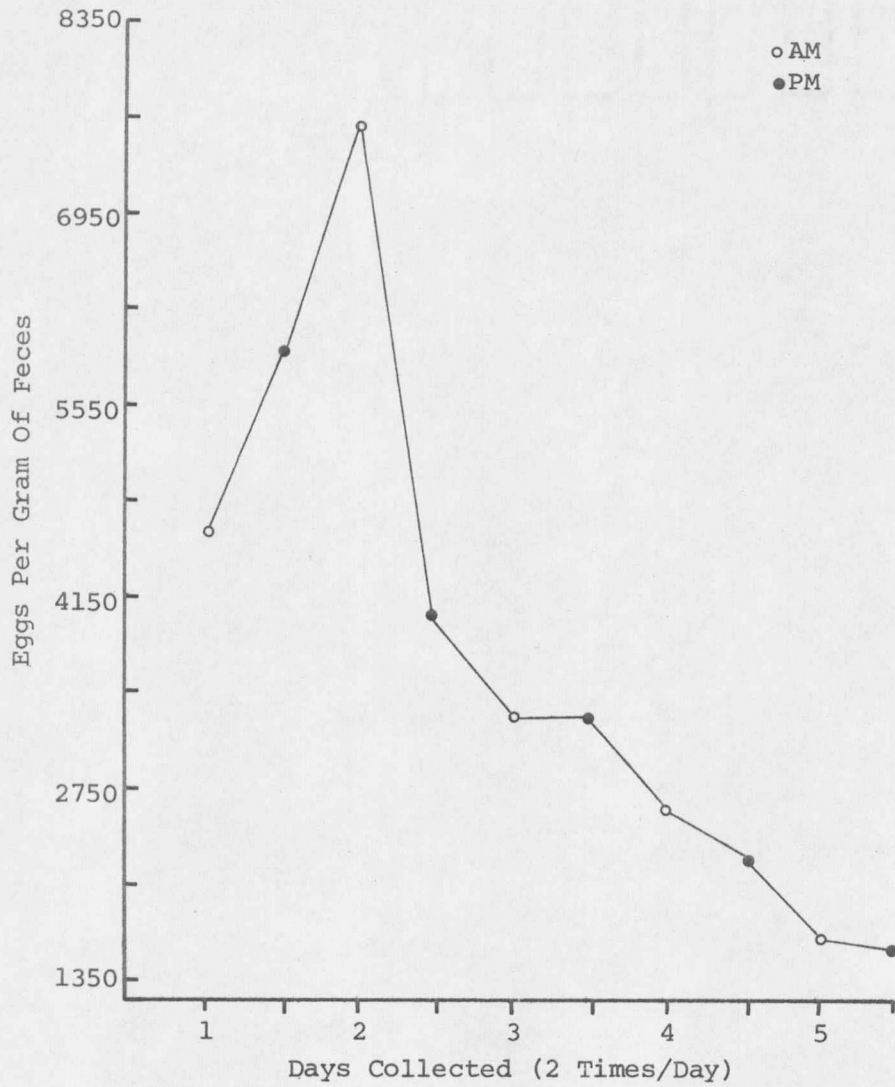


Figure 15. Passage of *Parascaris equorum* eggs by foal 10 during a five day period.

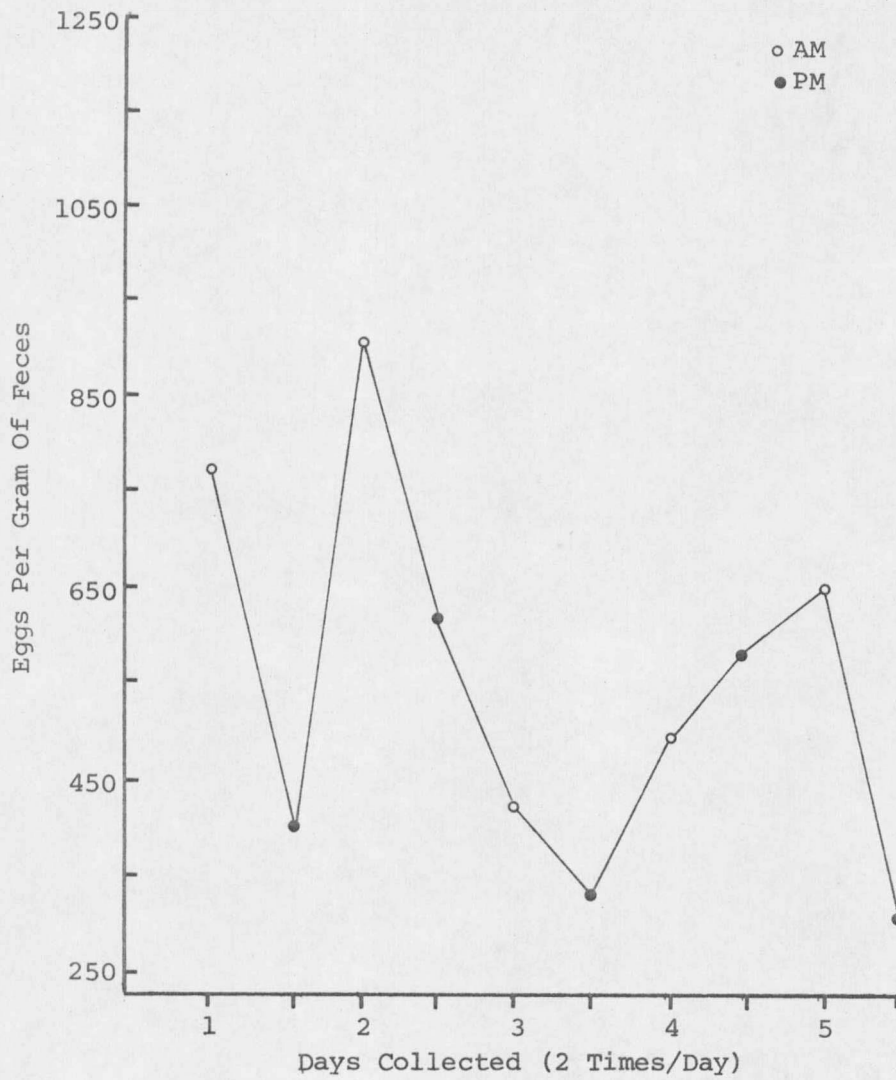


Figure 16. Passage of *Parascaris equorum* eggs by foal 11 during a five day period.

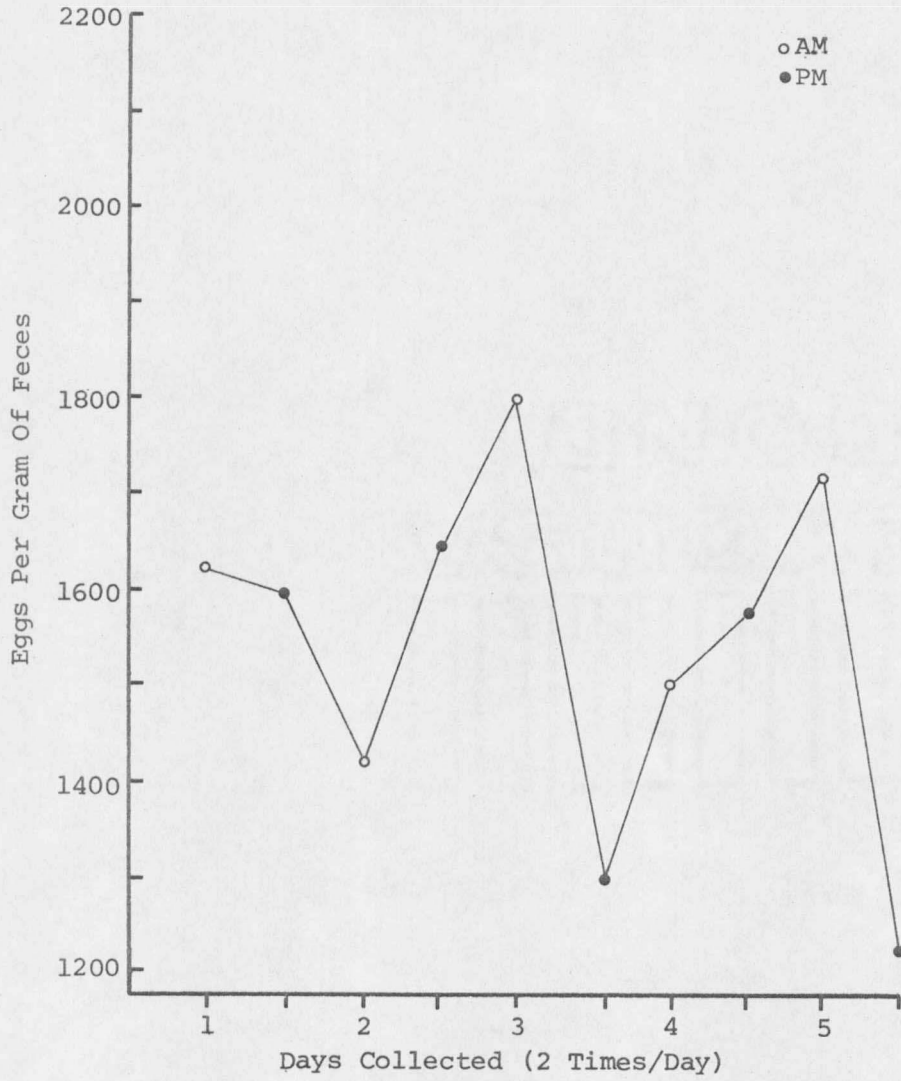


Figure 17. Passage of *Parascaris equorum* eggs by foal 12 during a five day period.

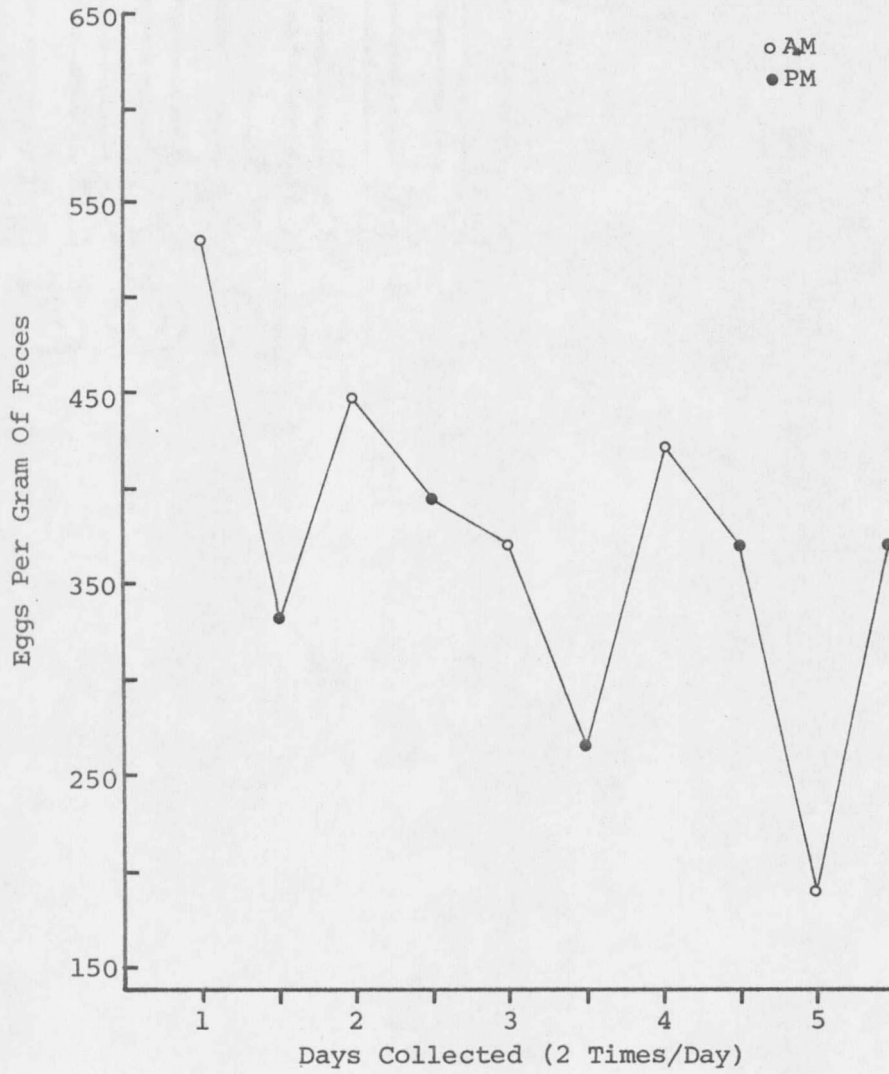


Figure 18. Passage of *Parascaris equorum* eggs by foal 13 during a five day period.

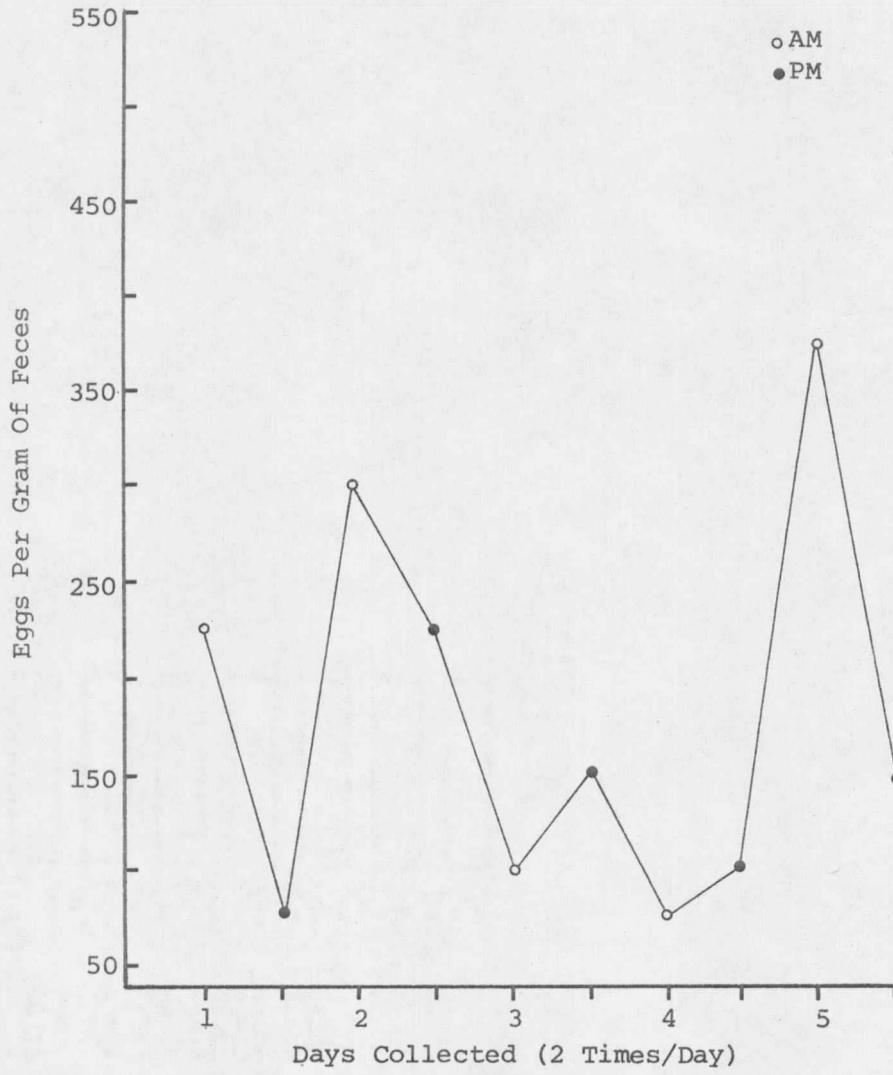


Figure 19. Passage of *Parascaris equorum* eggs by foal 14 during a five day period.

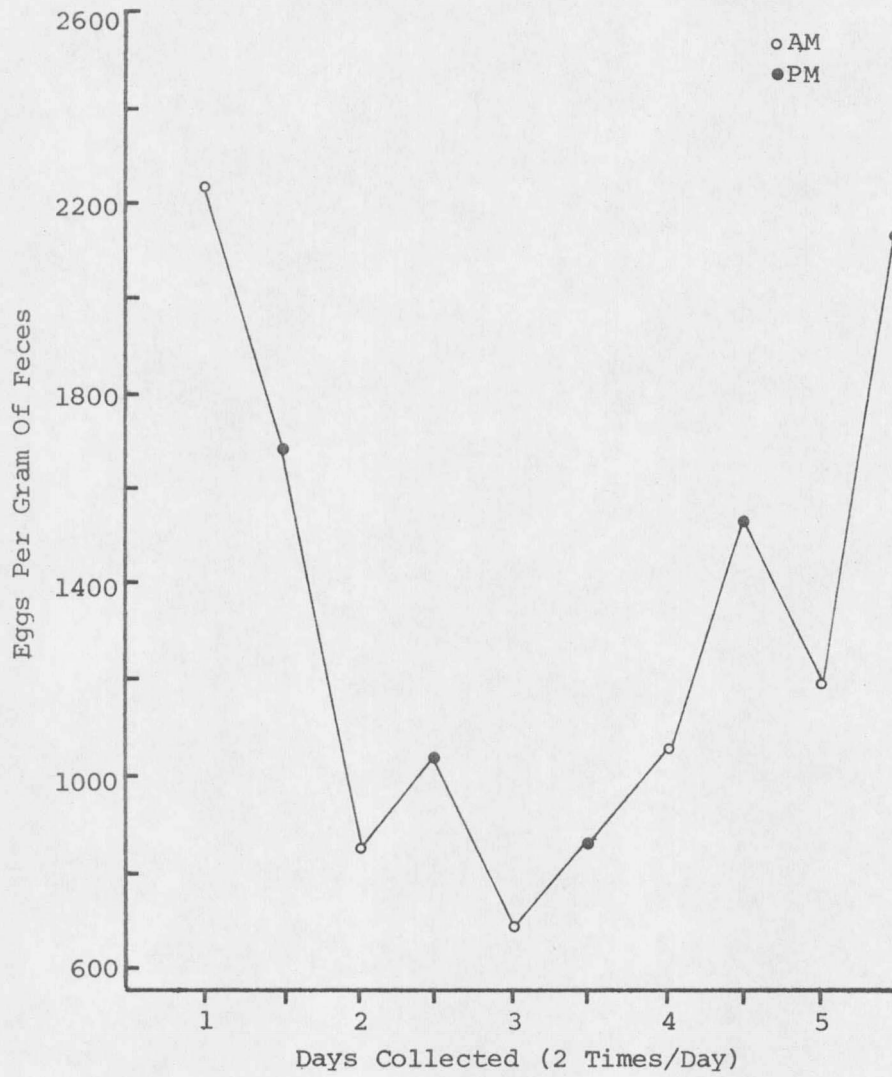


Figure 20. Passage of *Parascaris equorum* eggs by foal 15 during a five day period.

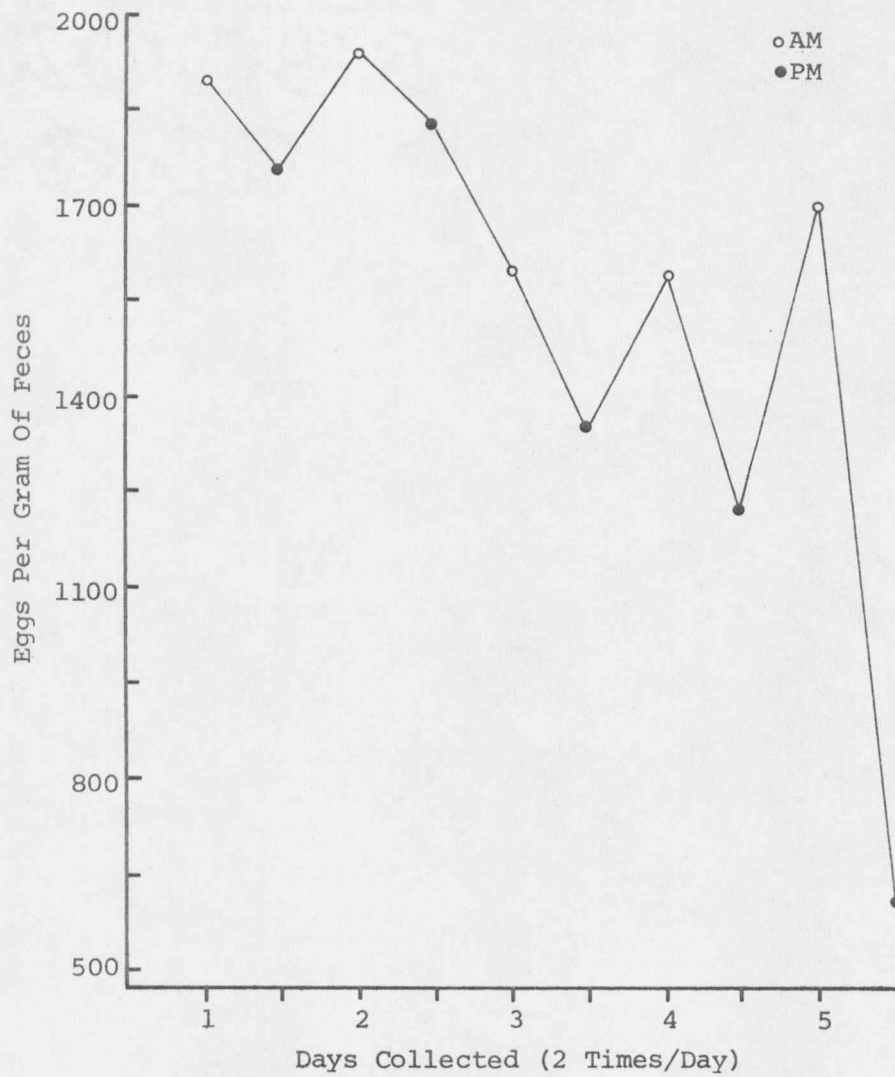


Figure 21. Passage of *Parascaris equorum* eggs by foal 16 during a five day period.

from five foals after an initial infection with *P. equorum*. Foals 21-23 (Figure 22) all showed a definite peak in egg production with a second, lesser peak occurring some weeks later. Although foals 20 and 24 (Figure 23) exhibited considerably higher egg counts, there still existed the peak in egg production with a second, lesser peak. However, the second, lesser peak in foals 20 occurred before the highest peak instead of after it.

The DCF and McMaster Techniques

By comparing these two techniques, the more accurate technique for the estimation of the EPG count in equine feces was found. For both the ascarid and the strongyle egg counts, the DCF technique was lower in efficiency than the McMaster technique for both flotation solutions (Table V). On the first cover slip, Comp. 1 demonstrated the DCF technique to be 40 and 60 per cent as efficient as the McMaster technique for the recovery ascarid and strongyle eggs, respectively. Comp. 2 demonstrated similar low efficiencies for the DCF technique except the per cent efficiency for the ascarid egg recovery was considerably lower than observed in Comp. 1, being only 18 per cent and the strongyle egg recovery was somewhat higher, being 73 per cent. All per cent values were significantly different from the McMaster technique count except the 73 per cent strongyle egg recovery in Comp. 2. This value was not significantly different because a large standard error prevailed.

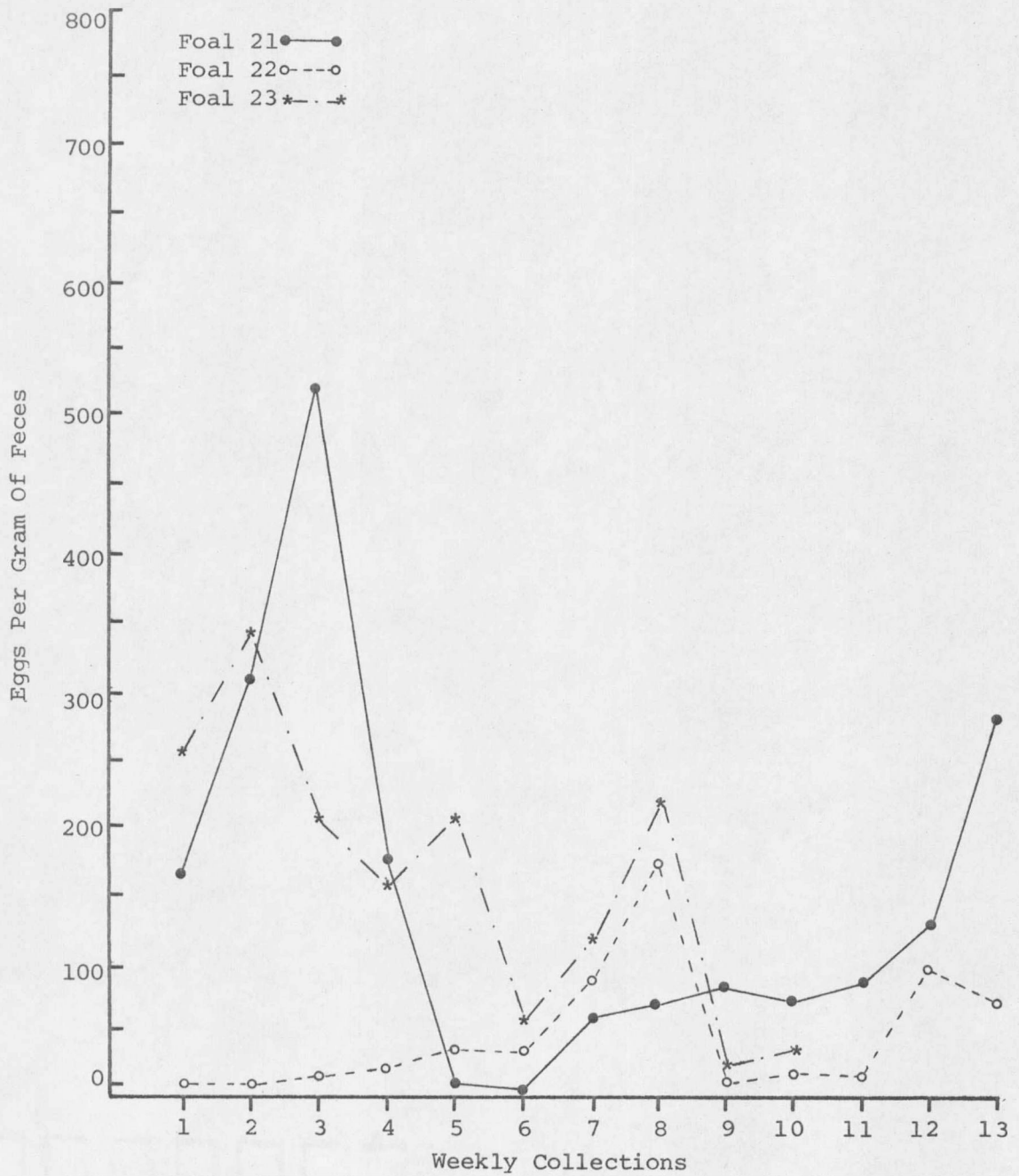


Figure 22. Egg output in foals following initial infection with *Parascaris equorum*.

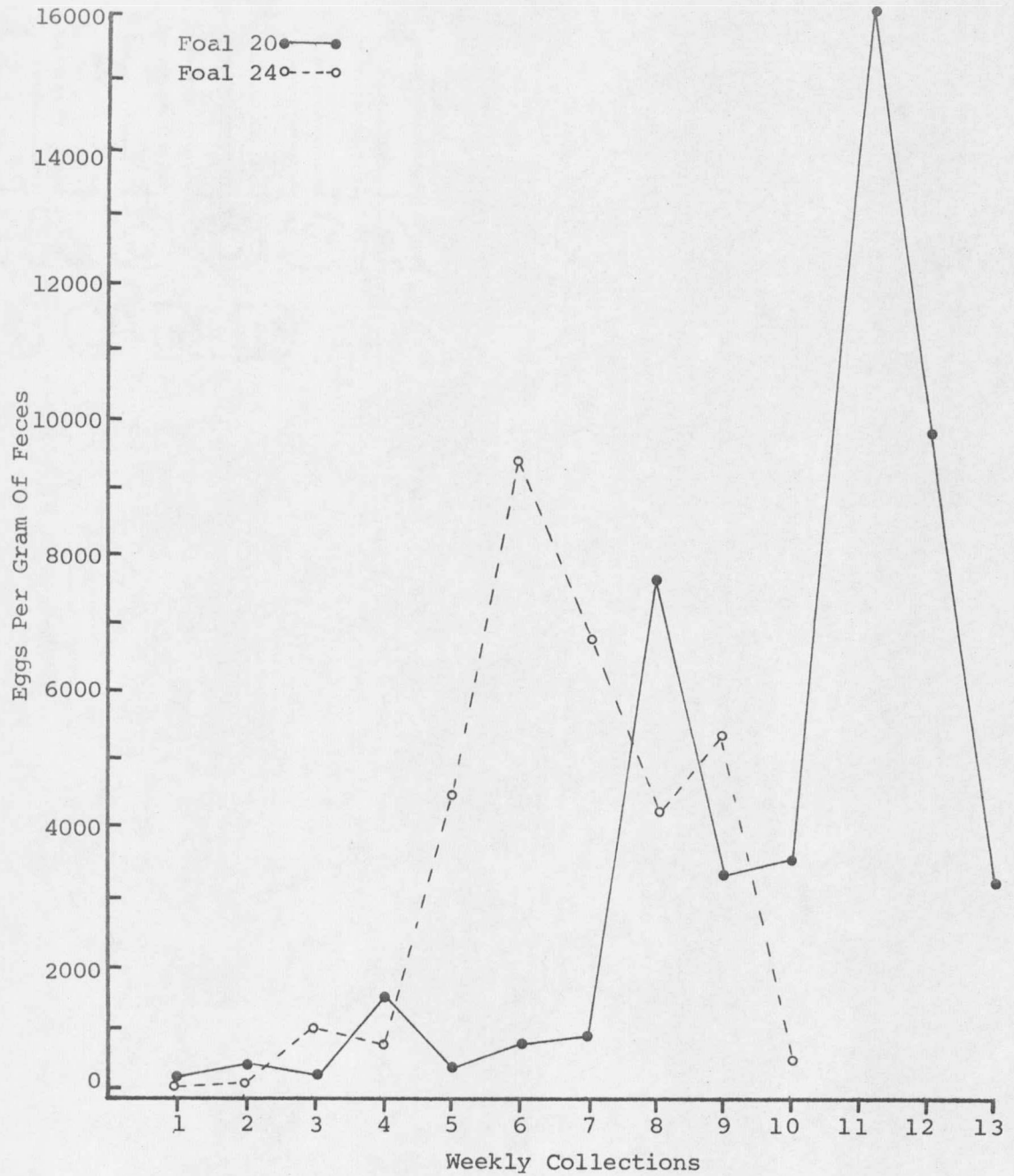


Figure 23. Egg output in foals following initial infection with *Parascaris equorum*.

TABLE V

Comparison between the Direct Centrifugal Flotation (DCF) Technique and the Remodified McMaster Technique using Two Flotation Solutions for Nematode Egg Counts in Equine Feces

Comparison	Number samples	Mean EPG McMaster Technique		Per cent eggs recovered on successive cover slips on DCF-percentages based on McMaster counts									
				1st		2nd		3rd		4th			
		A. ^a	S. ^b	A.	S.	A.	S.	A.	S.	A.	S.		
1**	16	6387	1403										
				$s_{\bar{x}}^c$	40	60	29	16	15	3	6	7	
					5.1	4.3	3.6	2.7	2.3	.7	1.2	.3	
2***	16	7413	1456										
				$s_{\bar{x}}^c$	18	73*	11	15	9	5	7	4	
					3.7	15.0	1.5	1.9	1.2	.8	.9	1.1	

* Not significantly different (P=.05)

** Sheather's sugar solution (sp.gr. 1.275) DCF flotation solution

*** Saturated sodium chloride solution (sp.gr. 1.20) DCF flotation solution

^a *Parascaris equorum* eggs

^b Large and small strongyle eggs

^c Standard error \pm

By accumulating the counts obtained on successive cover slips an estimate can be made as to how many cover slips are needed to get an EPG count for the DCF technique that is not significantly different from the McMaster technique count. In Comp. 1, the cumulative counts for the first and second, first through third, and first through fourth cover slips were 69, 84, and 90 per cent, respectively, for ascarid eggs and 76, 79, and 86 per cent, respectively, for strongyle eggs. The only count not significantly different was the 90 per cent count for ascarid eggs.

In Comp. 2, the respective cumulative counts were 29, 38, and 45 per cent for the ascarid eggs and 88, 93, and 97 per cent for the strongyle eggs. Since there was no significance on the first cover slip count for the strongyle eggs, the cumulative counts were not significant. However, the cumulative counts for the ascarid eggs were all significantly different.

Although the DCF technique was, on the average, lower in efficiency than the McMaster technique, some individual counts by the DCF technique were higher. Out of 64 counts (16 ascarid and 16 strongyle counts per comparison) 14 per cent (9 counts) of the total counts on four cover slips were higher by the DCF technique and only 6.2 per cent (4 counts) of the counts on the first cover slip were higher.

As seen in the two comparisons (Table V), the type of flotation solution affects the per cent egg recovery. Therefore, to examine

the effectiveness of the solutions, Table VI was constructed, showing the per cent egg recovery on successive cover slips as a percentage of the total DCF technique count obtained on four cover slips. The effectiveness of the solutions became evident on the first cover slip count. The ascarid egg recovery was found to be 47 and 34 per cent for Sheather's sugar solution and saturated sodium chloride solution, respectively. The strongyle egg recovery was 74 and 74 per cent, respectively.

Since the efficiency of both solutions was less than 100 per cent, the accumulation of cover slip counts was an aid in determining the more reliable solution. In accumulating the first and second, and the first through third counts, the ascarid egg recovery was 77 and 92 per cent, respectively, with Sheather's sugar solution, and 59 and 82 per cent, respectively, with saturated sodium chloride solution. The cumulative strongyle egg counts were 94 and 99 per cent, respectively, with Sheather's sugar solution, and 91 and 97 per cent, respectively, with saturated sodium chloride solution. The only value that did not differ significantly was the 99 per cent strongyle egg count on three cover slips.

After identifying the low efficiency of the DCF technique and the difference in the flotation solutions, it was thought that a correction factor could be used to adjust for the discrepancies. However, there exists a certain degree of fluctuation in the per cent egg

TABLE VI

Number of Eggs Recovered on Successive Cover Slips on Direct Centrifugal Flotation (DCF) of Nematode Eggs in Equine Feces

Flotation solution	Mean total EPG (DCF)		Per cent egg recovery on four successive cover slips*								
			1st		2nd		3rd		4th		
	A. ^a	S. ^b	A.	S.	A.	S.	A.	S.	A.	S.	
16 Sheather's sugar	5702	1036	47	75	30	19	16	5	7	1	
			$s-\frac{c}{x}$	5.1	3.9	2.9	2.9	2.7	.9	1.7	.4
16 Saturated sodium chloride	4175	991	34	74	25	17	23	6	18	3	
			$s-\frac{c}{x}$	3.8	1.9	1.7	1.3	3.4	1.0	2.7	.6

* All values significant (P=.05)

^a *Parascaris equorum* eggs

^b Large and small strongyle eggs

^c Standard error \pm

recovery from sample to sample (Figures 24 and 25). Figure 24, representing the per cent egg recovery by the DCF technique with Sheather's sugar solution, has a range of values between 5 and 75 per cent for ascarid eggs, and between 35 and 101 per cent for strongyle eggs. Figure 25, representing the same except with saturated sodium chloride solution, has a range of values between 3 and 45 per cent for ascarid eggs, and between 33 and 101 per cent for strongyle eggs.

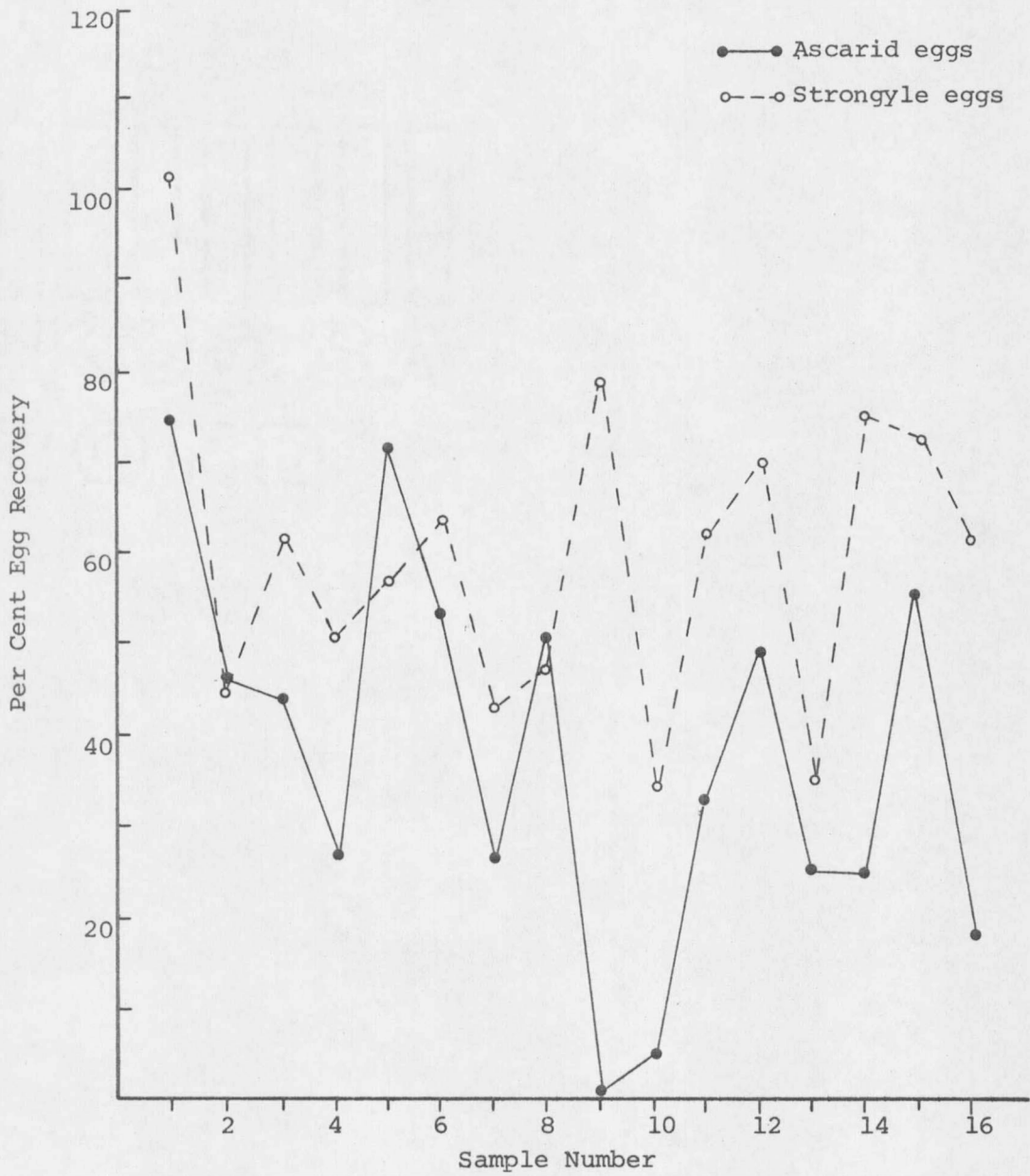


Figure 24. Per cent egg recovery on the first cover slip with DCF using Sheather's sugar solution.

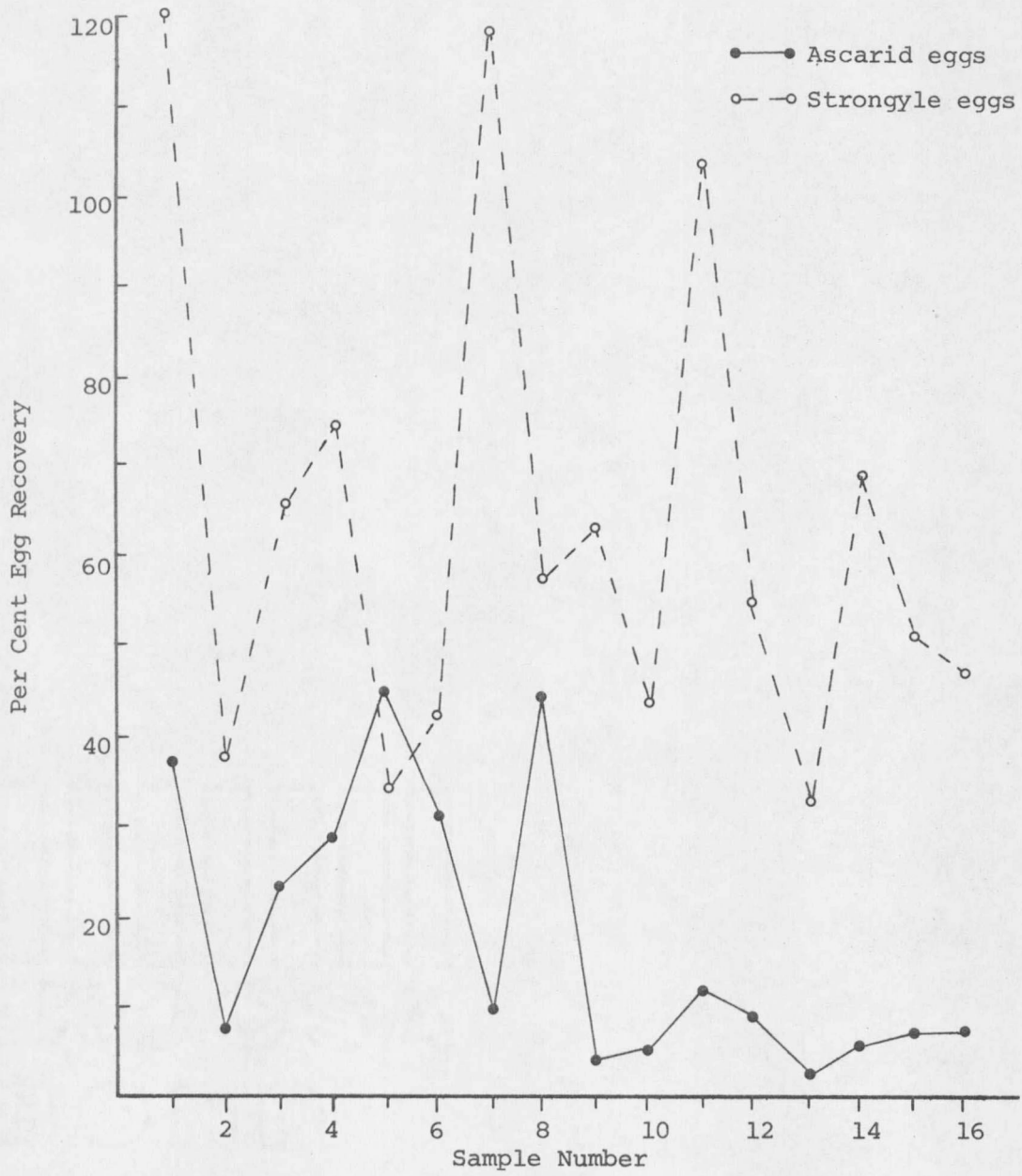


Figure 25. Per cent egg recovery on the first cover slip with DCF using saturated sodium chloride solution.

DISCUSSION

The higher per cent prevalence of helminth infection in the horse in the present study coincides with reports from other areas. In Ontario, Slocombe (43) reported 74 per cent of the horses were positive for parasites by fecal examination. Another report limited to gastrointestinal nematodes of horses indicated on three occasions in 1970 that more than 87 per cent of the horses had worm eggs in the feces (44). Hadley (17) reported a 100 per cent infection in the horses examined in Wisconsin.

Looking at the prevalence of individual parasites, the findings in the present study were in agreement with all three of the above reports, in that the strongyles were the dominant type of parasite. This dominance was possibly due to the array of genera and species included in this grouping (Appendix 1).

Although the occurrence of *Parascaris equorum* exhibited a higher per cent incidence in one report (17) and a lower per cent incidence in another (44) as compared to the present study, the large round-worm displayed the second highest incidence of infection in all reports. The other parasites, *Strongyloides westeri*, *Oxyuris equi*, *Anoplocephala* sp., and *Eimeria leuckarti*, exhibited moderate to low rates of infection. Even though the coccidium, *E. leuckarti*, was found in a low per cent of the horses examined in this study, it occurred in a large number

of horses as compared to other areas where it has been seldom reported or was only mentioned as being present (43).

The decline in the prevalence of infection with increasing age of the horse provides some information on the resistance of the host to parasites. The higher prevalence of *P. equorum* and *S. westeri* in the younger animals is indicative of this decline. Statements on the affinity of these two parasites for younger animals has been mentioned in the literature (26,44,46). However, the declining prevalence of infections with *Anoplocephala* sp., *O. equi*, and *E. leuckarti* has not been noted previously.

An assumption for these declines could be the combination of both physiological and immunological functions interfering with the development of the parasites. Although specific information on this subject is limited, it seems to be a valid hypothesis to assume that as the horse ages the change in physical functions and the increased immunity through exposure tends to increase the resistance in the horse to parasitic infections.

When considering the strongyles, the prevalence of infection does not seem to change with the age of the horse (29). This consistent prevalence possibly is related to the many genera and species of this group. Since a horse may harbor a variety of these parasites, it is possible that the number of any one of these parasites is not sufficient

to stimulate an adequate immune response, thus the parasites are not rejected and continue to be prevalent regardless of age.

While the types of equine parasites present in Montana may not all be listed (Table II), most of the species noted have been reported in other areas in the United States (8,14,34,56). Along with these areas, check lists of horse parasites have been compiled for geographical locations indicating the presence of the same types of parasites (2,10,13,54). Of these parasites, the most damaging for all age groups are the large strongyles, *Strongylus edentatus*, *S. equinus*, and *S. vulgaris*, commonly know as red or blood worms. Of these, *S. vulgaris* is considered to be the most harmful (17). This particular species has been associated with the verminous aneurysm seen in the anterior mesenteric artery (11). Since these parasites persist in the abdominal arteries, it has been estimated by Teeter (52) that 90 per cent of the colic in some areas is caused by these strongyles.

In younger animals, one of the most harmful parasites is *P. equorum* (5). This parasite often occurs in large numbers, and because of its large size may cause, at times, physical obstruction of the peristaltic movement in the small intestine. If this impairment results, it can cause colic or even death in the animal.

For the other gastrointestinal parasites, the degree of infection is generally too low to cause any specific problems. However, pathogenicity could arise if the parasite burden increases to large numbers.

Although most of the parasites found in Montana horses have been indicated as occurring in other areas and are included in most regional checklists, one parasite seldom listed is *Eimeria leuckarti*. The present evidence of this parasite in the feces of foals in Montana is a new locality record for Montana. This parasite was identified from the appearance and dimensions of the oocysts. Both Dunlap (12) and Benbrook and Sloss (3) describe the oocyst as having a thick outer shell and being dark brown in color. The dimensions given by them were 77.04 by 54.55_u and 77.0 by 51.7_u, respectively. Kistner *et al.* (23) also, described the same appearance but revealed larger dimensions, 80.0 by 57.4_u.

The successful experimental infection to patency and the observations of thirteen naturally infected foals with this parasite indicated the duration of patency to be between five and twelve days. Barker and Rummeler (1) in reporting a successful experimental infection, did not state any definite length of infection or prepatent periods. However, their work indicated a short duration of patency in one foal and revealed inconsistent prepatent periods in a number of other foals. With these inconsistent prepatent periods and the one observed in the present study, it could be postulated that the prepatency may run between thirty-one and thirty-five days. Even though post-mortem specimens were not examined in this study, others have

specified the location in the small intestine and the probable tissues that this coccidium infects (3,24,33,42).

The few reports on this protozoan parasite appear to indicate its rarity. However, those reporting the parasite suggest it is not as rare as it seems but tends to be overlooked during routine fecal analysis. Perhaps one of the reasons it goes unnoticed is that the oocysts which have such a dense structure often are undetected by routine fecal examination techniques using a low specific gravity flotation solution. Adding to the difficulty in diagnosis of *E. leuckarti* is the short duration of patency and the relatively low oocyst output. Also in most cases, infected animals showed no clinical signs or symptoms.

By examining the biological and physiological properties of worm parasites and their eggs, it was concluded that fecal examinations for determination of the prevalence of some gastrointestinal infections can be misleading. Thus, it is possible the prevalence of some parasites are higher than reported. For instance, *Strongyloides westeri* eggs, being susceptible to destruction at cold temperatures (26) may be overlooked during fecal examination if refrigeration is used to prevent the hatching of other ova. The pinworms, *Oxyuris equi* and *Probstmayria vivipara*, are difficult to diagnose because of their peculiar life cycles. The eggs of *O. equi* are laid in the perianal region and

therefore may not be disseminated in the feces. *P. vivipara* is ovoviviparous and thus no eggs are laid.

Tapeworm eggs were seldom seen in fecal examinations in the present study. This could be explained by the low prevalence of infection for the area surveyed. However, an interesting fact was observed during the study. Two horses, prior to necropsy, were considered by fecal examination to be negative for tapeworms but on examination of the lower small intestine and the ileocecal valve area a patent infection existed with both mature and immature worms.

Another parasite that may go undetected by routine microscope fecal examination is the horse bot, *Gastrophilus* sp. Since these parasites reside as larval forms in the stomach, they are not seen in the feces unless they are passed at the time of the examination and then they are observed macroscopically.

Although the fecal examination can be misleading in determining the prevalence of some equine parasites, most gastrointestinal parasite eggs can be detected by using this method. By obtaining a quantitative EPG count, it is possible to relate this value to worm burdens in certain animals. This has been examined for certain parasites in cattle (41) and for the ascarid in chickens (53). When the EPG count and worm burdens of *Parascaris equorum* of both male and female foals were compared, no significant correlations existed. However, when data from only the female horses were related, significant correlations

prevailed. Because of the small sample size the significance of the correlations was questionable (9). This relationship difference due to the sex of the host was reported in chickens by Train and Hansen (53) but here both sexes had significant positive correlations.

Even though no straightforward significant correlations were observed, the EPG counts of *P. equorum* can be used to some degree in determining worm burdens. Kates (22) stated that as the number of worms increase in the host the number of eggs per female decreases. This was seen in the present study where high EPG counts related to low worm burdens while low EPG counts related to high worm burdens. This finding could be attributed to the degree of crowding of the worms in a particular area of the small intestine. In mild infections, the worms have ample room to mature and in heavy infections, the worms become crowded, causing stunted worms. Thus, when considering the clinical significance of an EPG count of *P. equorum* it must be realized that a low EPG count may mean a serious infection while a high EPG count could mean a relatively mild infection.

Since this relationship is prevalent, it may explain the peaks and declines observed in the EPG counts of *P. equorum* in individual horses over a long time interval. The peaks may represent the points where the worms have ample room to mature and the declines may represent an increase in the parasites, causing the crowding affect and reduction in egg output. This seems to be a justifiable assumption, although

other factors could also be involved. One possibility for the trends seen in the egg output of *P. equorum* may have been the use of the DCF technique in determining the EPG counts. This technique has been shown to have a great deal of fluctuation in the per cent egg recovery on the first cover slip (Figures 24 and 25).

Since the fluctuations observed in the daily and day-to-day EPG counts of *P. equorum* over a short period of time are significantly different, a single count can be disregarded as a quantitative estimation of the eggs per gram of feces for a worm population of *P. equorum*. The significant differences in the daily and day-to-day EPG counts could have been attributed to the inconsistent physical condition of the stool, the amount of fecal material passed in a day, the diet of the horse, the inconsistent egg production, or the increase or decrease of the female population of *P. equorum*. These factors were considered by Spedding (47) in the variations of egg counts he saw in sheep feces over a period of 24 hours. Peters and Leiper (36) stated that variation in egg counts is partly a factor working independently in each animal and partly an overriding factor affecting animals together. However, according to the study by Brambell (4), no significant variation in egg counts occurred in sheep feces over a ten-day period. Perhaps the factors affecting the daily and day-to-day EPG counts are overshadowed when counts are taken for a long period of time.

These egg count variations could in part be accounted for by the egg counting technique that is employed. An egg counting technique must be accurate in estimating the EPG count of feces and have a small amount of variation. In this study, the McMaster technique was found to be on the average far superior to the DCF technique for recovery of nematode eggs in equine feces. Others have found this to be true for parasite eggs in feces other than equine. Stoll (50) indicated that the DCF technique was lower in efficiency than the dilution method for *Haemonchus* ova in sheep feces. Levine *et al.* (31) found the same to be true for strongyle eggs in cattle and sheep feces. A report by Hausheer *et al.* (18) indicated a low efficiency of the DCF technique for counting human hookworm eggs. In a study of the accuracy of the flotation method, Casteline and Herbert (6) stated that the method was not of reproducible accuracy for nematode eggs in porcine feces.

Although the above reports consider the dilution method more efficient, Wilson (57) indicated the two techniques were not significantly different and that half of the counts were higher by the DCF technique and half were higher by the McMaster technique. This similarity in efficiency is in contrast with the present study where counts, higher by the DCF technique, only accounted for a small percentage of the total counts made.

In the case of nematode eggs in equine feces, the type of ova had some influence on the accuracy of the DCF technique, where

strongyle eggs were recovered more readily than ascarid eggs. The difference was possibly due to the physical properties possessed by each type of egg.

Since the per cent egg recovery from equine feces by the DCF technique was lower than the 95 to 99 per cent recovery of nematode eggs from bovine feces reported by Dewhirst and Hansen (9) and the 90 per cent egg recovery of gastrointestinal nematodes in sheep feces reported by Kates (22), it was considered that the coarse fecal debris in equine feces was responsible for the poor recovery. According to Castelino and Herbert (6) coarse fecal debris inhibits egg flotation and if the eggs can be separated from the coarse debris there can be predictable accuracy in the DCF technique.

Also, in order to get predictable accuracy in the DCF technique the type of flotation solution must be considered. Ray (39) found that zinc chloride solution recovered the highest per cent of sheep and goat oocysts, with sugar and sodium chloride solutions having the next two higher recovery rates. In a report by Levine *et al.* (31), Sheather's sugar solution was nine per cent more reliable than saturated sodium chloride solution for the recovery of nematode eggs from sheep and cattle feces. In the present study, Sheather's sugar solution was more efficient than saturated sodium chloride solution for the recovery of ascarid eggs while both solutions were approximately the equivalent for the recovery of strongyle eggs. The difference in

the ascarid egg recovery is probably due to the weight of the egg, thus a flotation solution with a high specific gravity will float the eggs more readily.

Even though the McMaster technique has been shown to be more efficient than the DCF technique in most cases, the high dilution is questioned as to its reliability for low EPG counts. Hunter and Quenouille (21) stated the efficiency of the McMaster count to be 80 per cent if the mean number of eggs counted was four and only 50 per cent if the mean number was one. Thus, the efficiency of the McMaster technique would decrease in the case of low EPG counts. However, by increasing the number of slides (chambers) counted the efficiency of the technique can be improved according to Brambell (4) and Hunter and Quenouille (21).

SUMMARY

1. The types and prevalence of equine gastrointestinal parasites in Gallatin County, Montana were: Strongyles (92%), *Parascaris equorum* (21%), *Strongyloides westeri* (7%), *Eimeria leuckarti* (6.5%), *Oxyuris equi* (5%), and *Anoplocephala* sp. (1.6%). The prevalence of these equine parasites except the strongyles decreased with the increasing age of the horse. In addition, reports from records of the Diagnostic Laboratory of the Animal Health Division of the Montana Department of Livestock, practicing veterinarians, Veterinary Research Laboratory at Montana State University, and work done prior to this study were compiled to record the types and number of cases of equine parasites occurring in Montana during the last forty years.

2. Fecal examinations for the determination of the prevalence of some gastrointestinal parasites may be misleading. Thus, both the biological and the physiological properties of worm parasites and their eggs must be considered when evaluating a fecal egg count.

3. The relationship of egg per gram counts to worm burdens of *P. equorum* in the equine was not significantly correlated when data from both sexes were employed. However, significant correlations did exist in the data taken only from the female horses but because of a relatively few number of females the correlations were questionable. An inverse relationship was noted when foals showing

high EPG counts harbored fewer worms than foals showing low EPG counts.

4. Significant fluctuations were observed in the daily and day-to-day EPG counts of *P. equorum* in foals over a five-day period and trends were noted in the egg outputs of this parasite over weekly intervals.

5. The Remodified McMaster technique was considered to be more efficient and faster than the Direct Centrifugal Flotation technique for the estimation of EPG counts in equine feces. The egg recovery rate on the first cover slip of the DCF technique compared to the McMaster technique was 40 per cent for ascarid eggs and 60 per cent for strongyle eggs when using Sheather's sugar flotation solution and 18 per cent for ascarid eggs and 73 per cent for strongyle eggs when using saturated sodium chloride flotation solution. With the summation of four successive cover slips, the DCF technique still produced lower counts. For the DCF technique, Sheather's sugar solution was better than saturated sodium chloride solution for floating ascarid eggs while both solutions were approximately as efficient for the recovery of strongyle eggs.

APPENDIX

APPENDIX I

Large and Small Strongyle List*

Large Strongyles	Small Strongyles con't
<i>Strongylus edentatus</i>	<i>C. asymmetricus</i>
<i>S. equinus</i>	<i>C. hybridus</i>
<i>S. vulgaris</i>	<i>Cylicocyclus radiatus</i>
	<i>C. auriculatus</i>
Small Strongyles	<i>C. insigne</i>
	<i>C. elongatus</i>
<i>Triodontophorus minor</i>	<i>C. nassatus</i>
<i>T. serratus</i>	<i>C. leptostomus</i>
<i>T. brevicauda</i>	<i>Cylicobrachytus brevicapsulatus</i>
<i>T. tenuicollis</i>	<i>Cylicocerus alveatus</i>
<i>Craterostomum mucronatum</i>	<i>C. catinatus</i>
<i>C. acuticaudatum</i>	<i>C. pateratus</i>
<i>Cyathostomum tetracanthum</i>	<i>C. goldi</i>
<i>C. labratum</i>	<i>Cylicodontophorus mettami</i>
<i>C. orantum</i>	<i>C. bicoronatus</i>
<i>C. labiatum</i>	<i>C. euproctus</i>
<i>C. coronatum</i>	<i>C. ultrajestinus</i>
<i>Cylicostephanus calicatus</i>	<i>Poteriostomum imparidentatum</i>
<i>C. minutus</i>	<i>P. ratzii</i>
<i>C. longibursatus</i>	<i>Gyalocephalus capitatus</i>
<i>C. poculatus</i>	<i>Oesophagodontus robustus</i>

* From Morgan, B. B. and P. A. Hawkins. 1949. *Veterinary Helminthology*. pg. 367-368.

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