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
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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, 0. 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 intestinal is, G. haemorrhoidalis, G. nasal is, 0. 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 0. 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 OF *PARASCARIS EQUORUM* EGG PER GRAM COUNTS AND WORM BURDENS, AND COMPARISON OF TWO PARASITE EGG COUNTING TECHNIQUES FOR EQUINE FECES

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A thesis submitted in partial fulfillment
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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. nasalis, 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_u in length with a range of 84.7 to 61.6_u and 50.2_u in width with a range of 53.9 to 47.2_u.

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 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.

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 effects 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 signficant 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

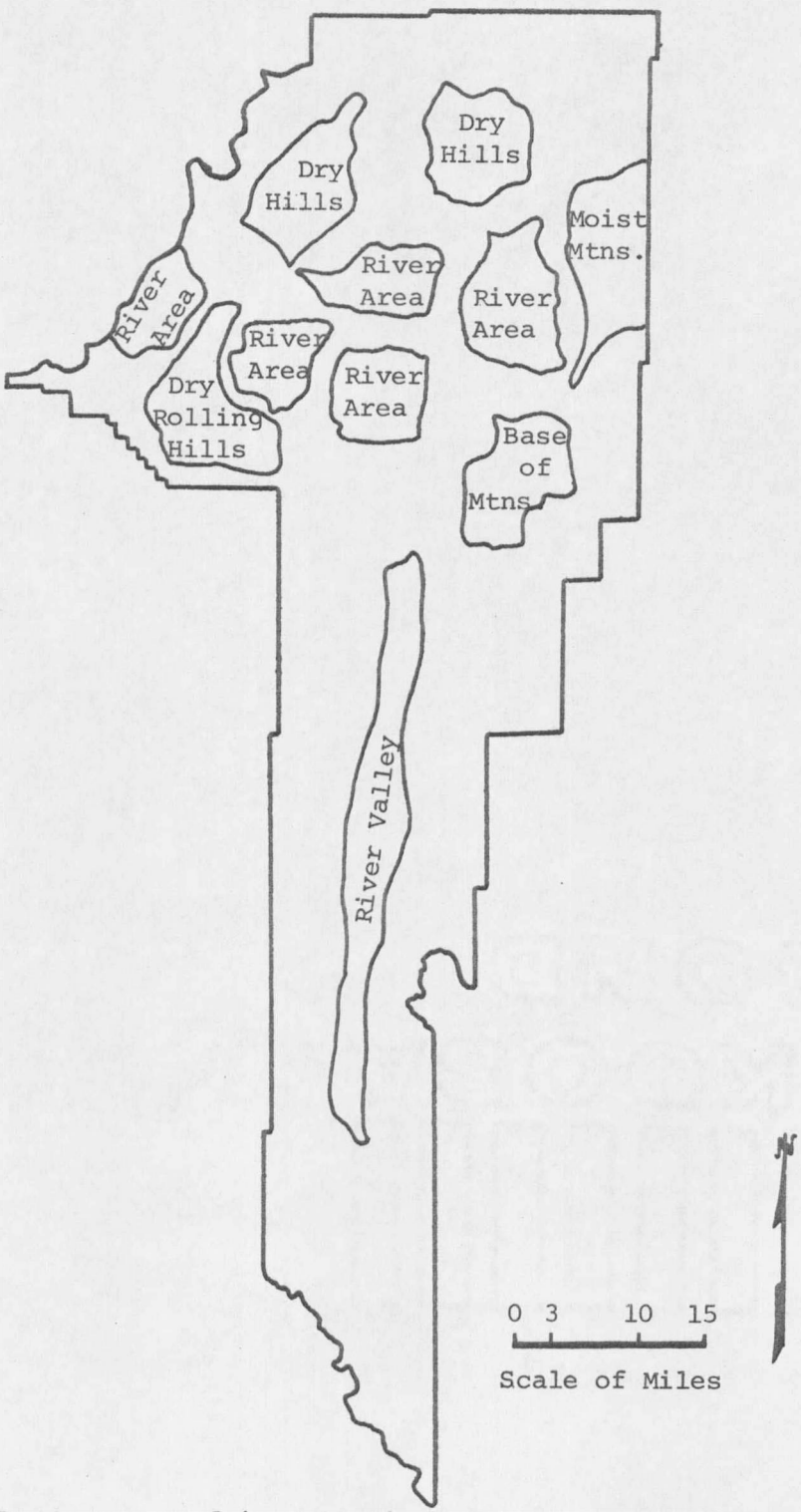

Figure 1. Areas surveyed in Gallatin County.

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 blendor. 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. Comminute in Waring blendor 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. Comminute in Waring blendor 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					
		Anoplocephala sp.	*Eimeria leuckarti*	*Oxyuris equi*	*Parascaris equorum*	*Strongyloides westeri*	strongyles[a]
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		
Gastrophilus intestinalis	stomach	2
G. nasalis	stomach	1
G. haemorrhoidalis	stomach	2
Cestodes		
Anoplocephala perfoliata	cecum	6
Paranoplocephala mamillana	small intestine	2
Nematodes		
Dictyocaulus arnfieldi	bronchi	2
Oxyuris equi	colon	16
Probstmayria vivipara	colon	2
Parascaris equorum	small intestine	111
Setaria equina	abdomen	3
Strongyloides westeri	small intestine	95
Strongylus edentatus	cecum & colon	1
S. equinus	cecum & colon	6
S. vulgaris	cecum & colon	8
Trichostrongylus axei	stomach	1
strongyles**	large and small intestine	305
Protozoa		
Eimeria leuckarti	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_u with a range of 84.7 to 61.6_u and the mean width was 50.2_u with a range of 53.9 to 46.2_u. 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.

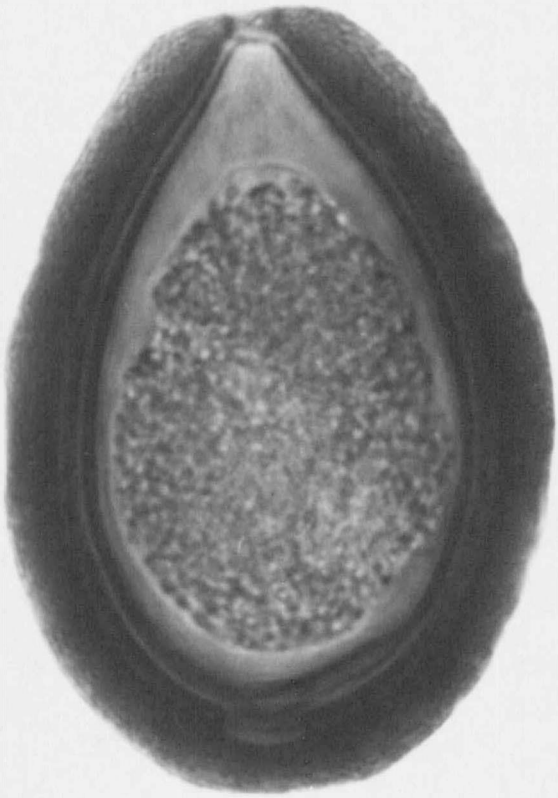

Figure 2. *Eimeria leuckarti*, oocyst (unsporulated); approximately x1500.

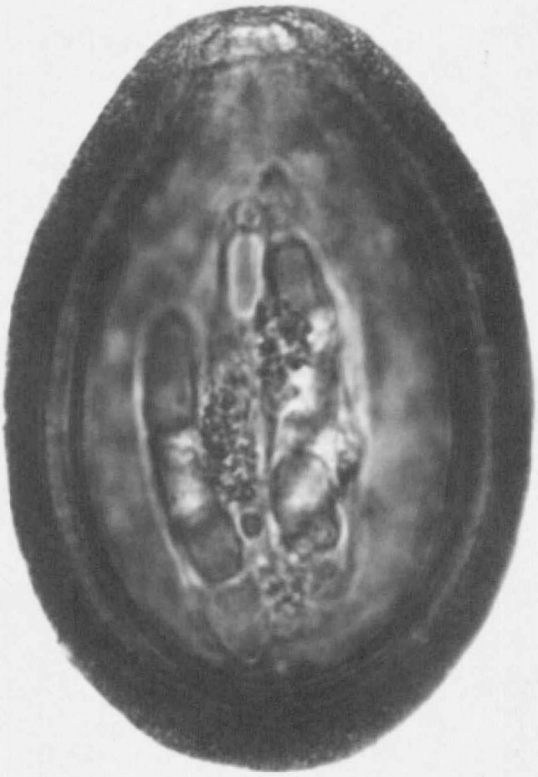

Figure 3. *Eimeria leuckarti*, oocyst (sporulated); approximately x1500.

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

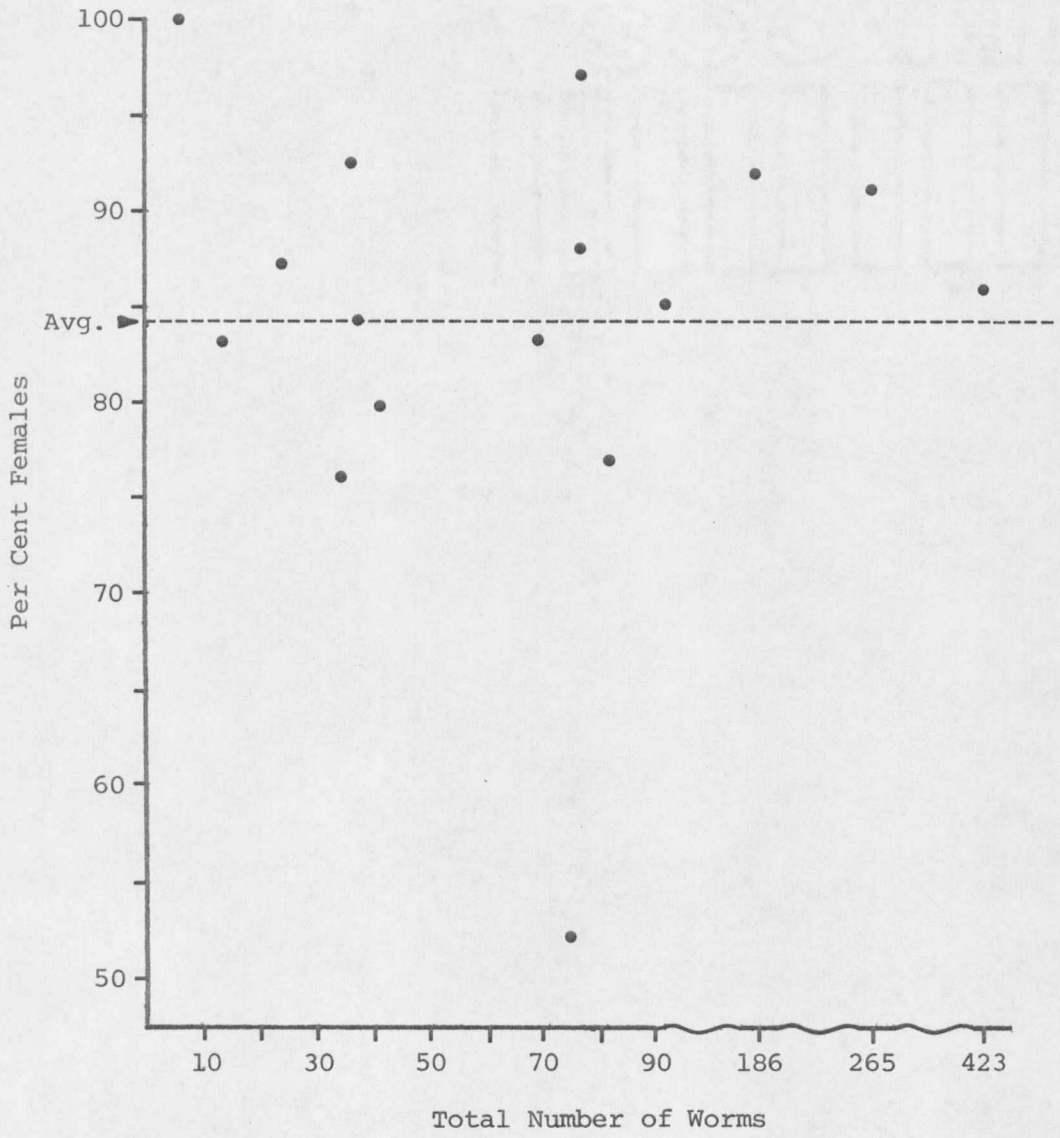

Figure 5. Percentage of females in sixteen worm populations of *Parascaris equorum*.

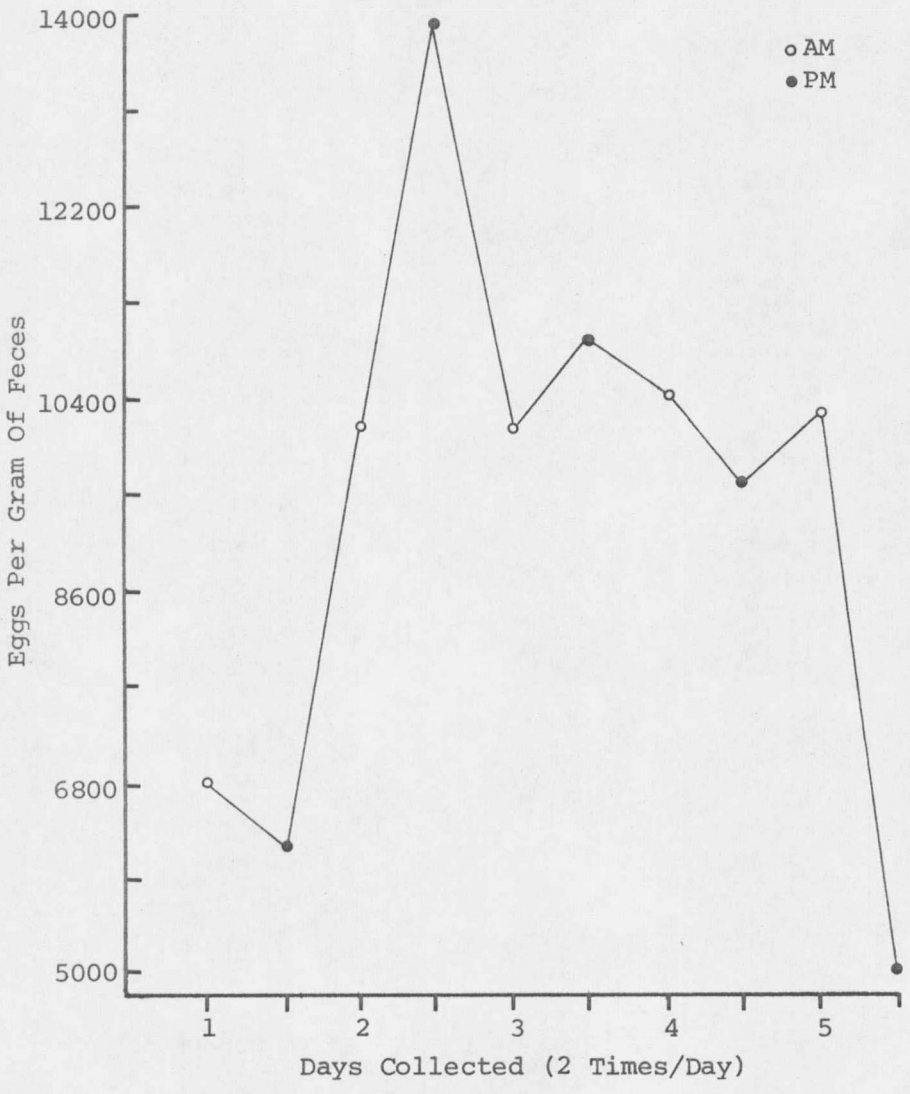

Figure 6. Passage of *Parascaris equorum* eggs by foal 1 during a five day period.

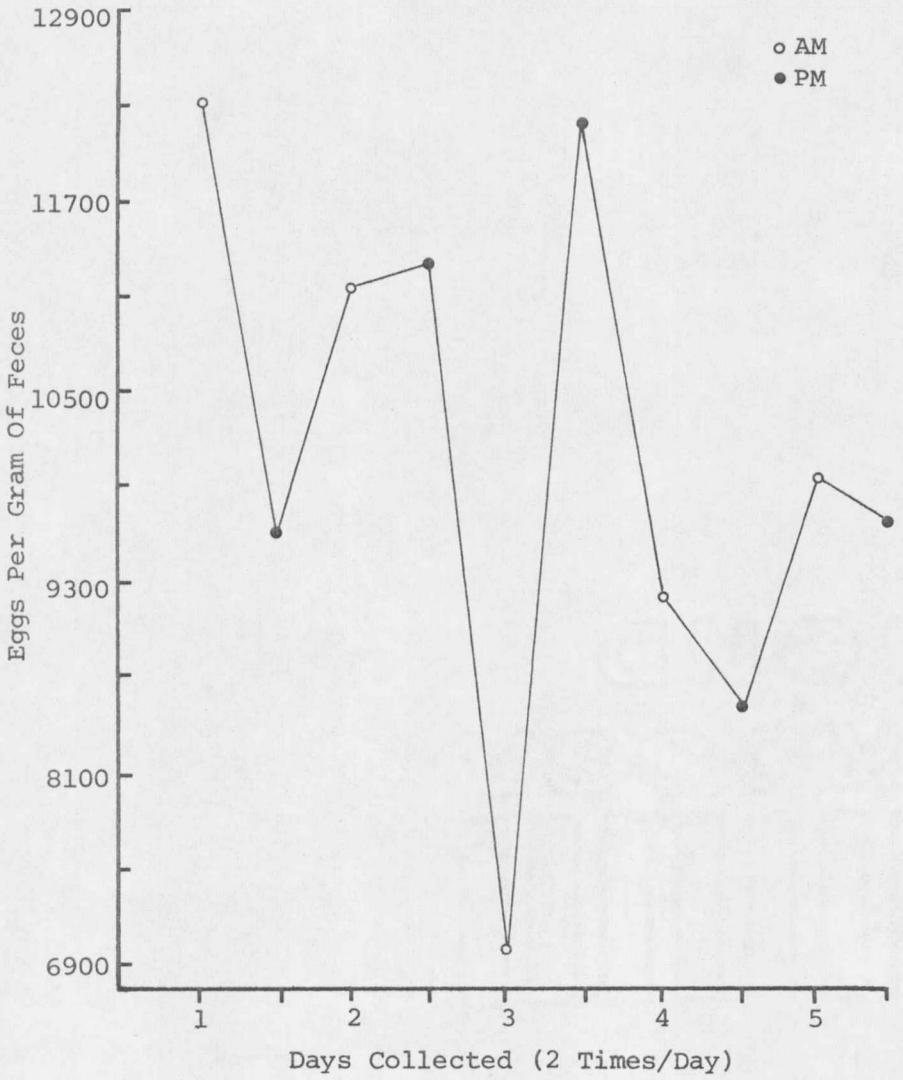

Figure 7. Passage of *Parascaris equorum* eggs by foal 2 during a five day period.

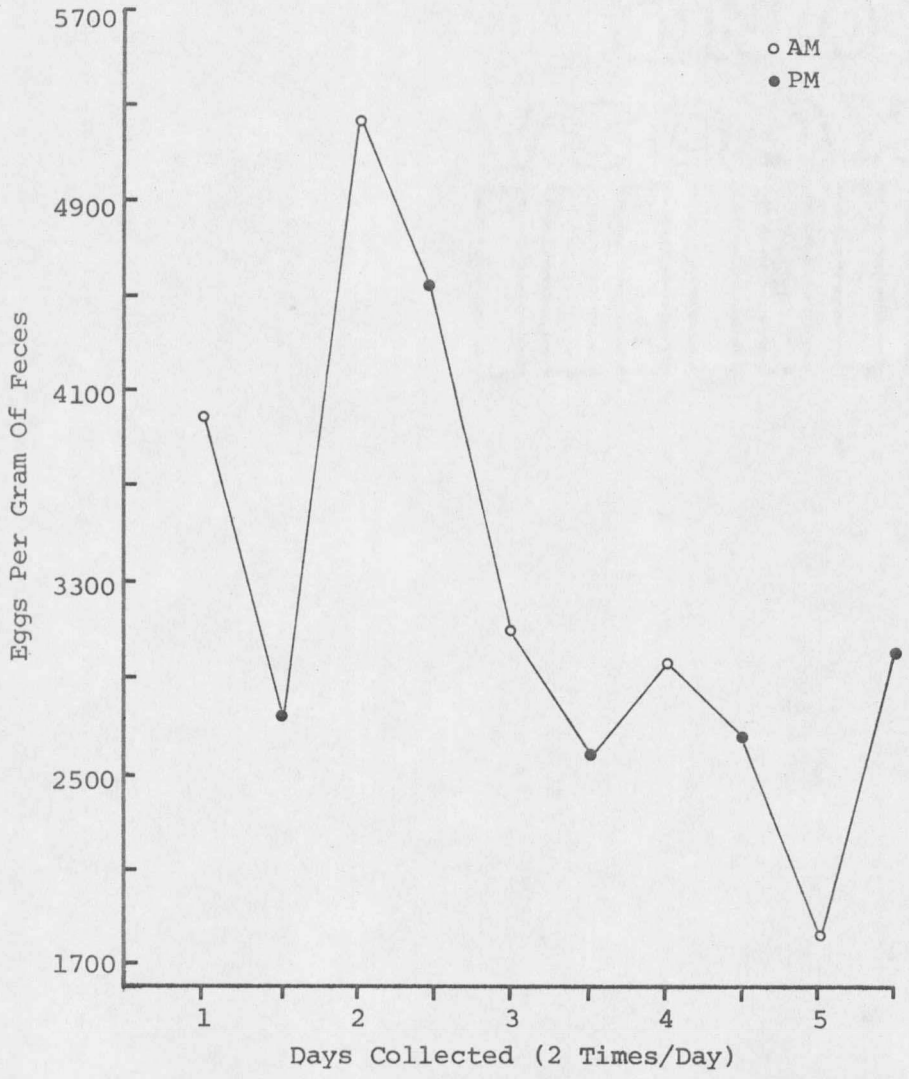

Figure 8. Passage of *Parascaris equorum* eggs by foal 3 during a five day period.

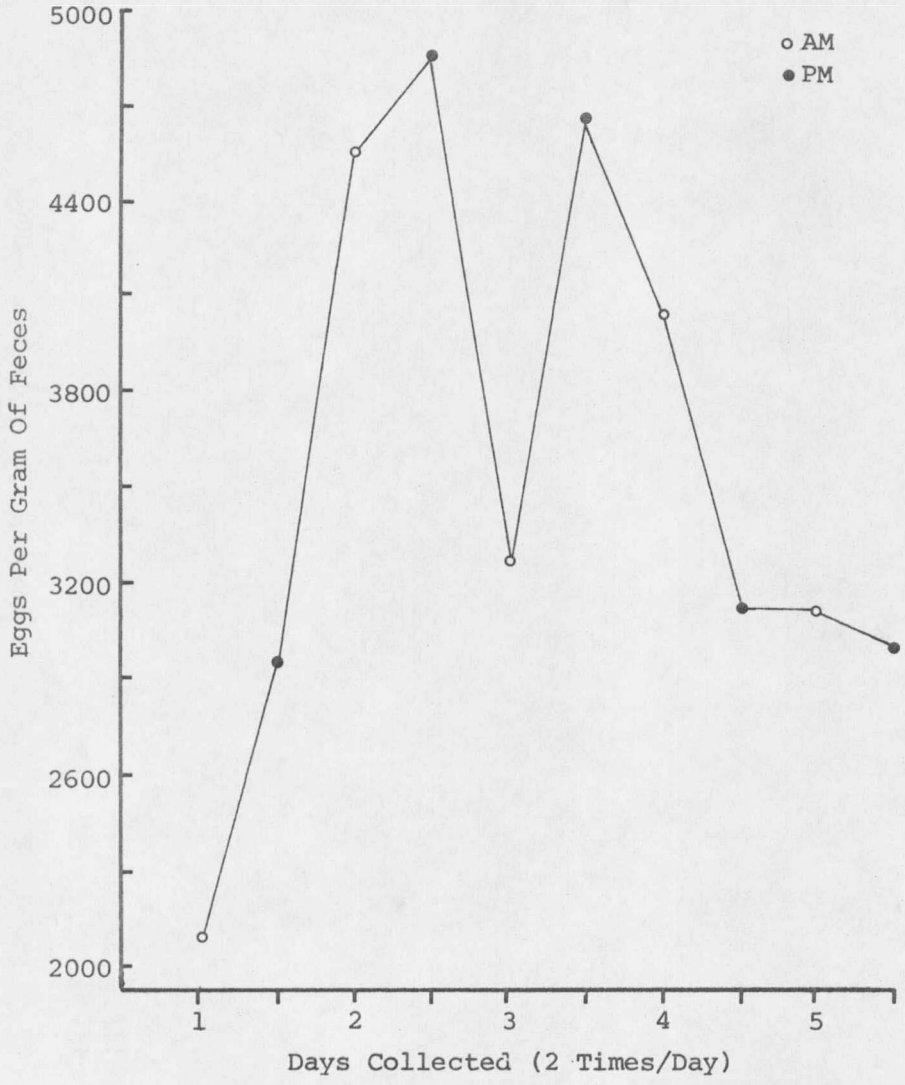

Figure 9. Passage of *Parascaris equorum* eggs by foal 4 during a five day period.

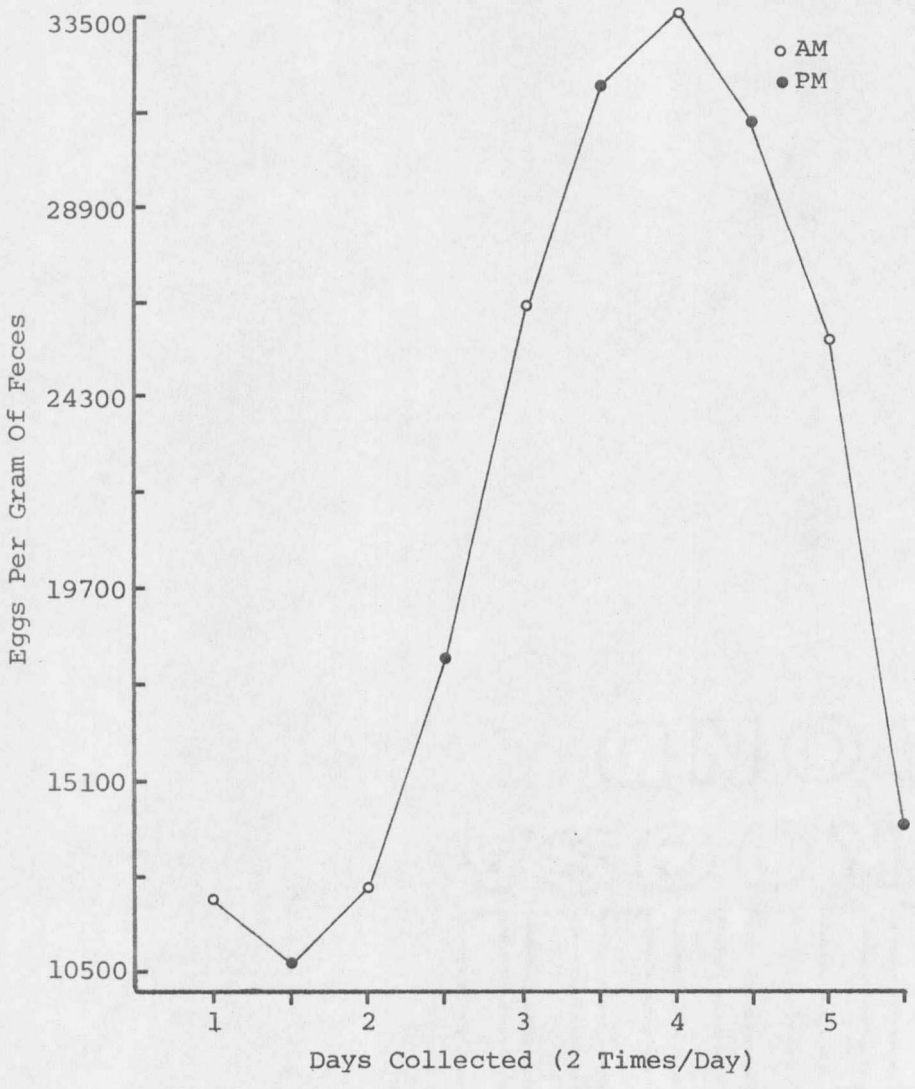

Figure 10. Passage of *Parascaris equorum* eggs by foal 5 during a five day period.

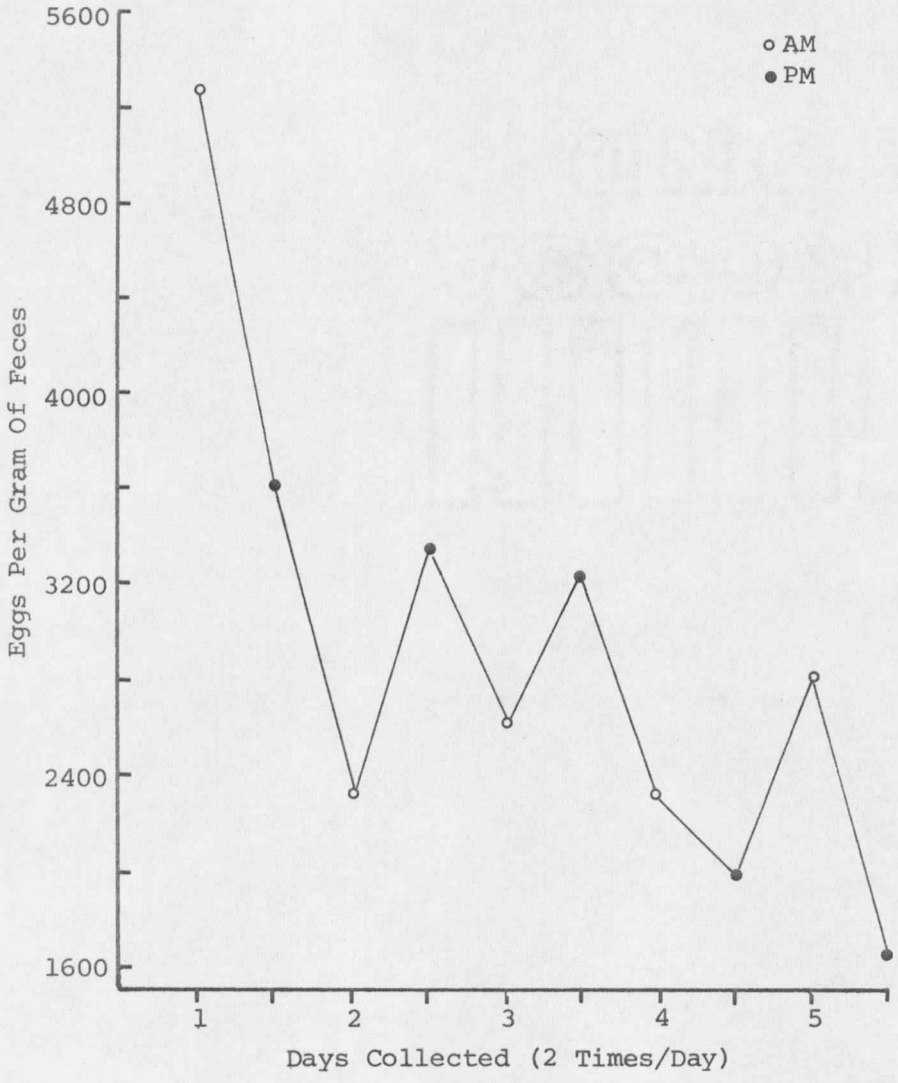

Figure 11. Passage of *Parascaris equorum* eggs by foal 6 during a five day period.

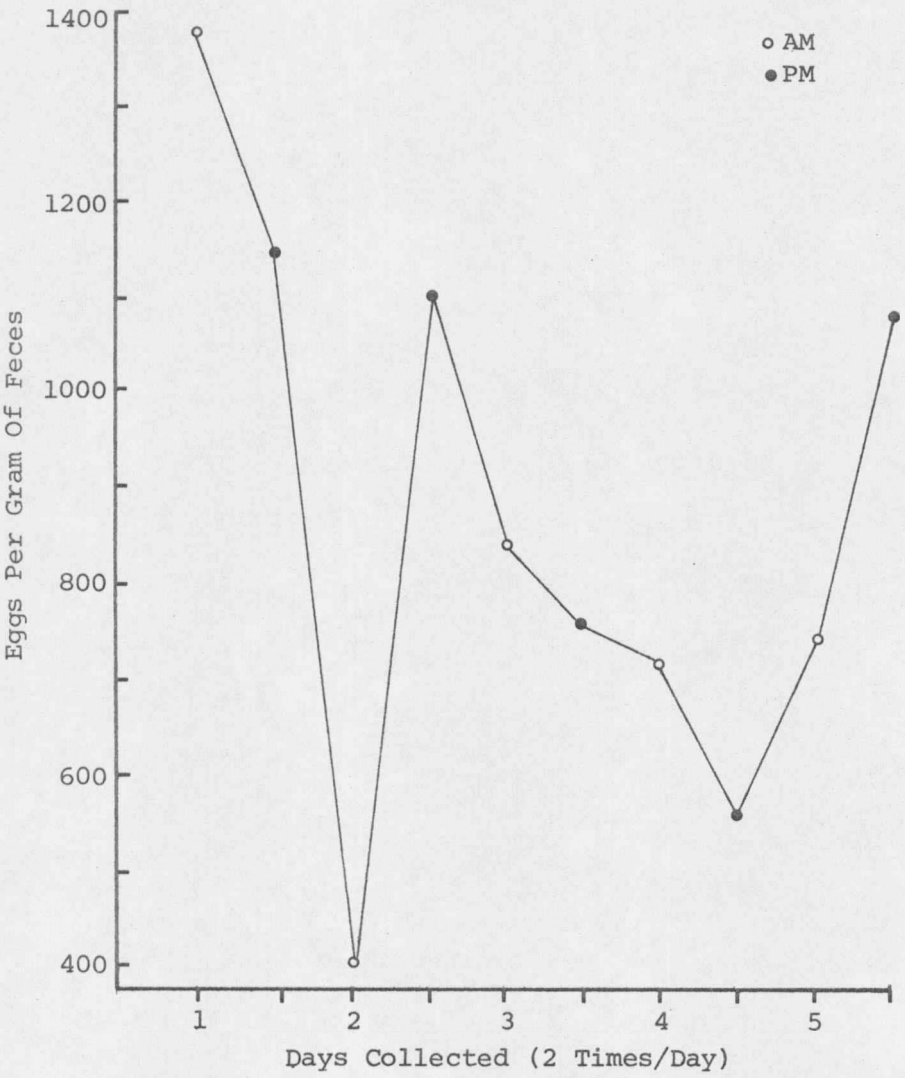

Figure 12. Passage of *Parascaris equorum* eggs by foal 7 during a five day period.

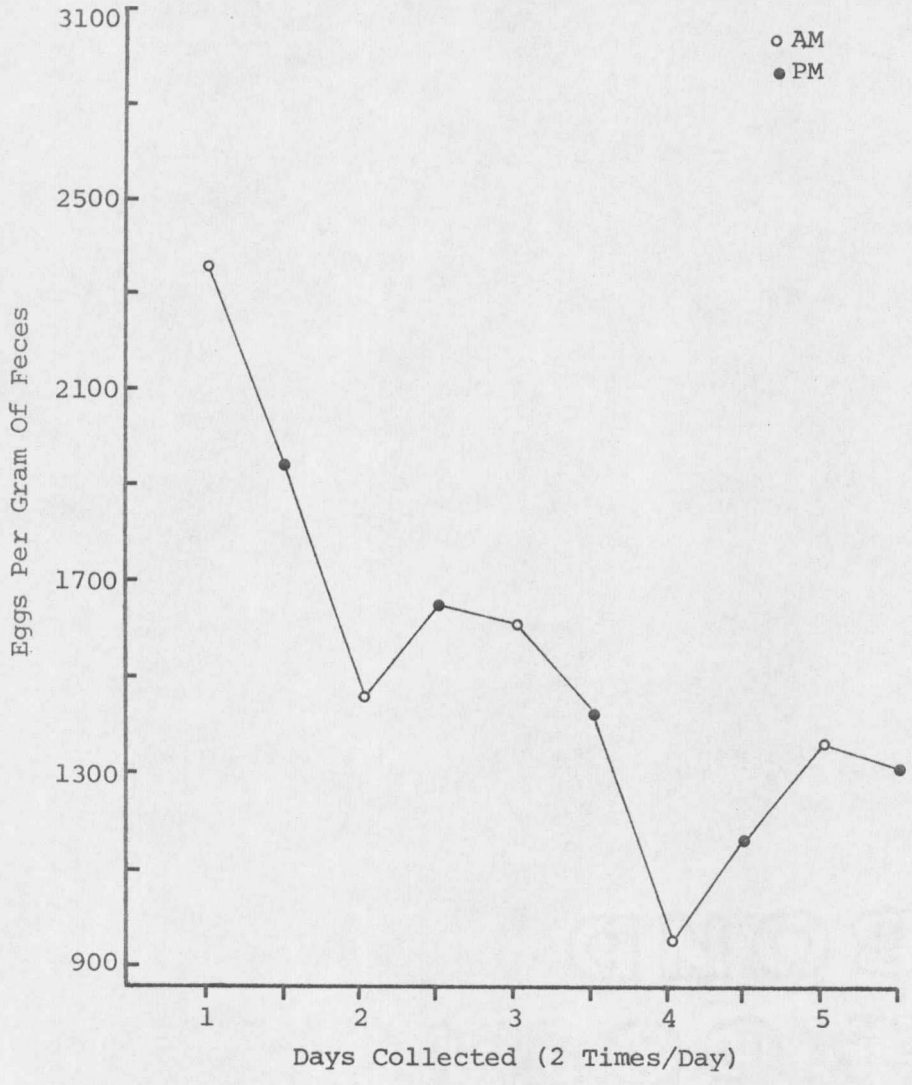

Figure 13. Passage of *Parascaris equorum* eggs by foal 8 during a five day period.

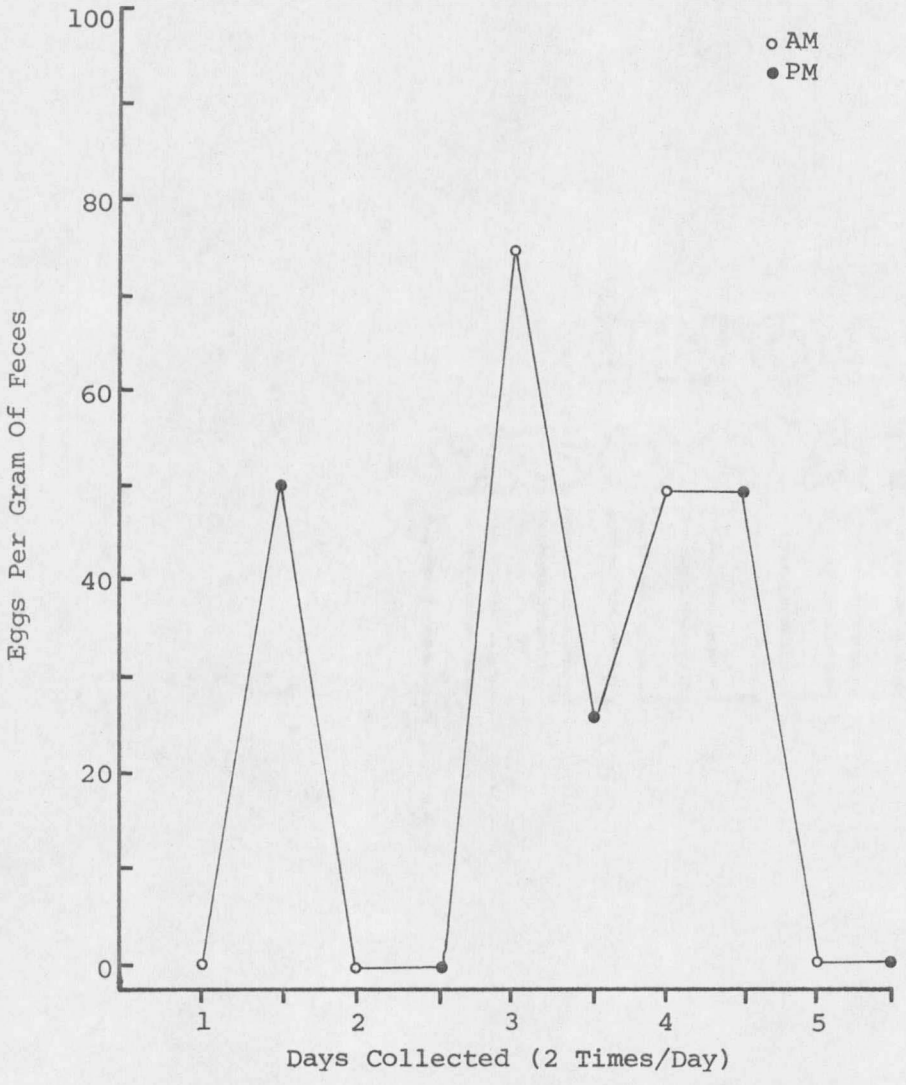

Figure 14. Passage of *Parascaris equorum* eggs by foal 9 during a five day period.

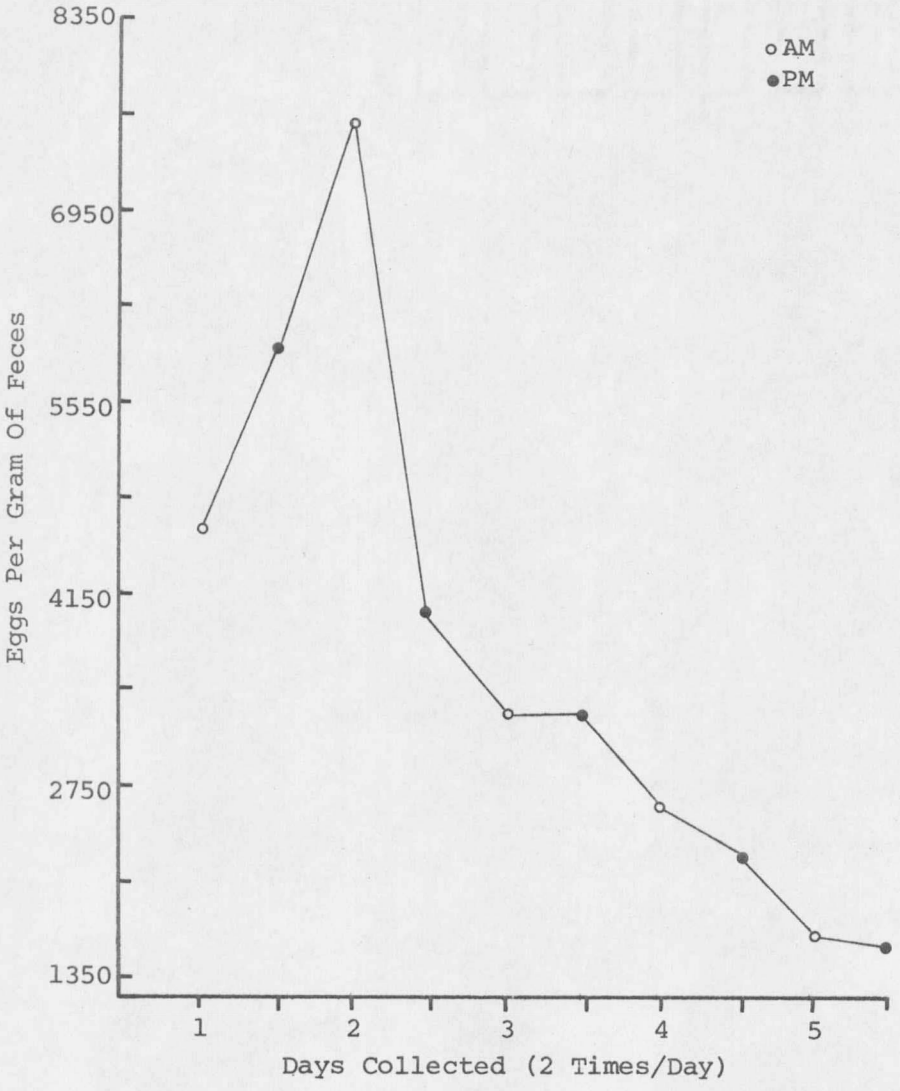

Figure 15. Passage of *Parascaris equorum* eggs by foal 10 during a five day period.

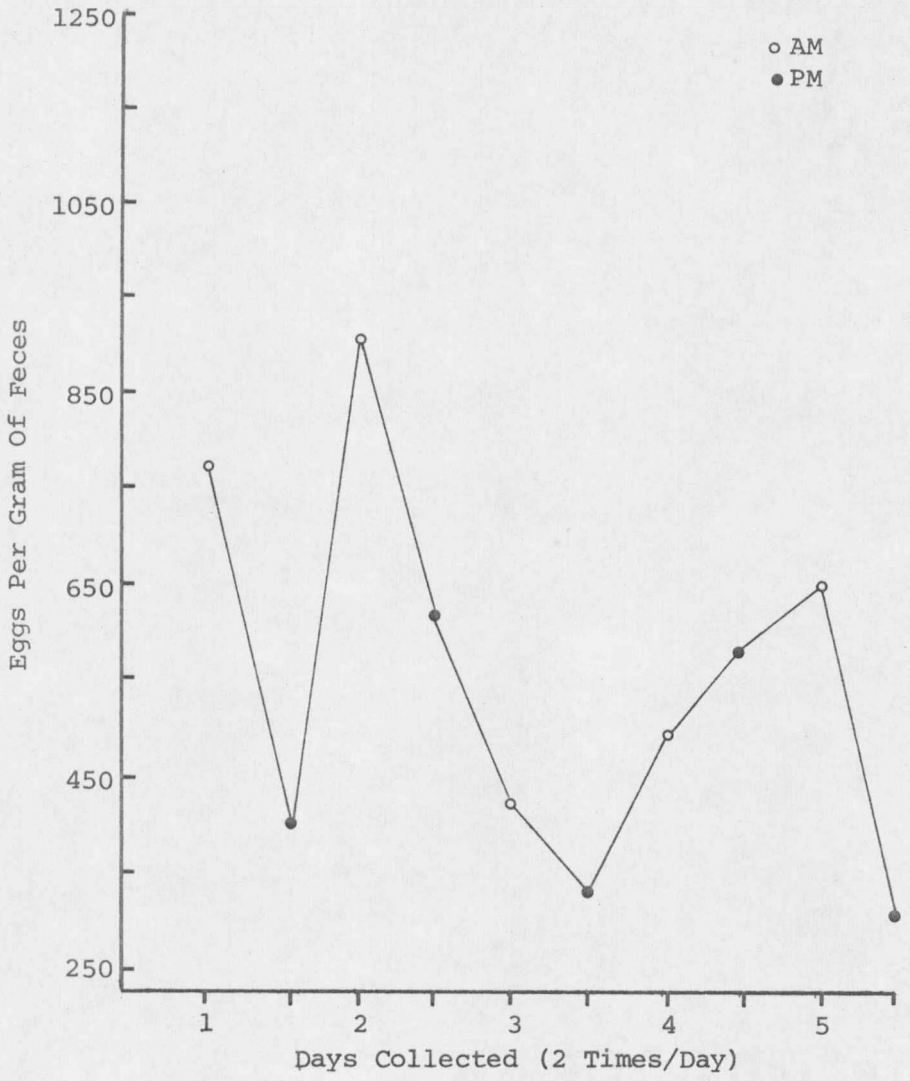

Figure 16. Passage of *Parascaris equorum* eggs by foal 11 during a five day period.

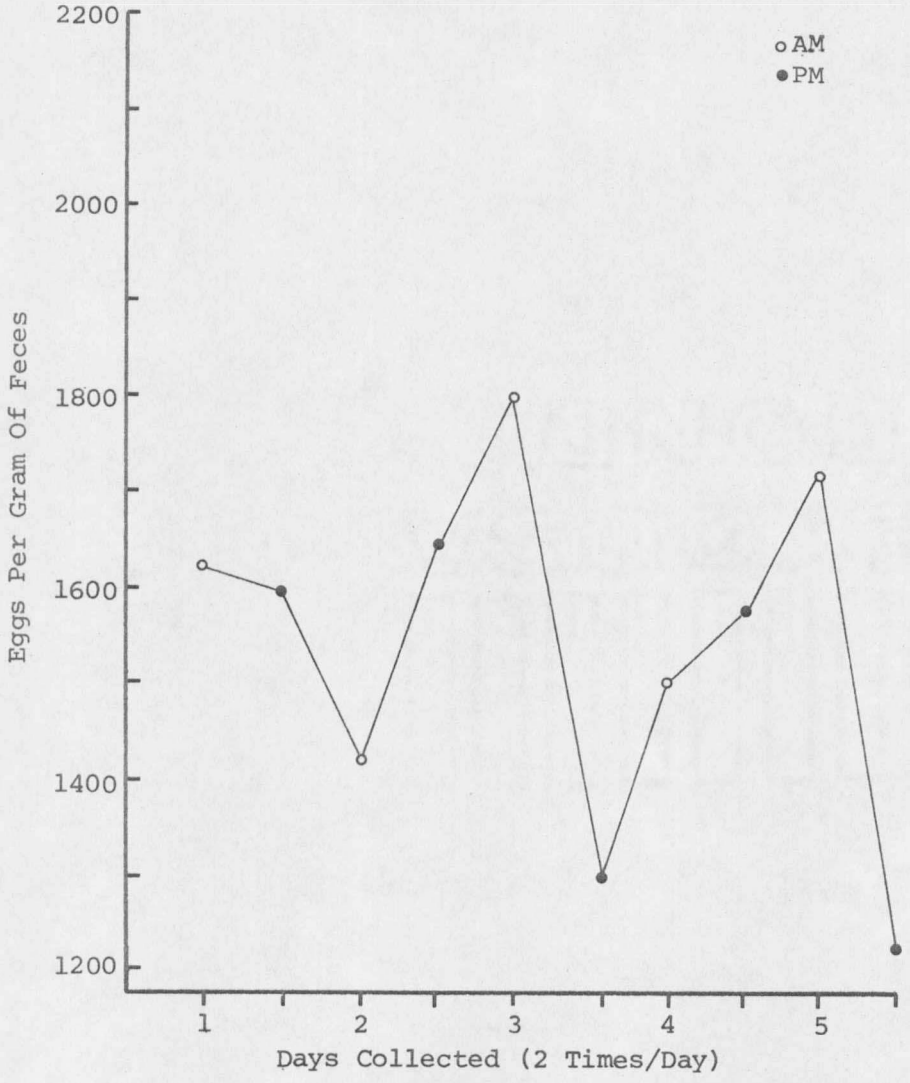

Figure 17. Passage of *Parascaris equorum* eggs by foal 12 during a five day period.