Parasites

On-farm internal parasite control: Luck or Design?

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1. Introduction

The need for internal helminth parasite control on deer farms was recognised in the early days of deer farming. The first reports of serious lungworm outbreaks in New Zealand were published by Mason and McAllum (1976). Subsequently there were several reports in the late 1970s and early 1980s describing deer helminth parasite burdens, biology and control (Mason, 1979; Mason, 1980; Wilson, 1981; Wilson and Collier, 1981; Wilson, 1984a, b). At that time one concern was that the chemicals available were not highly efficacious. The realisation that internal parasites, particularly lungworm, could threaten the viability of deer farming caused a shiver to traverse the spine of the industry.

The early generation benzimidazoles and levamisole were poorly effective and the old anthelmintic diethylcarbamazine became a popular choice in the 1970s and early 1980s. By the mid-1980s it was well established that lungworm in weaners could be controlled by anthelmintic treatment late summer/early autumn, reducing the potential autumn peak. The new generations of benzimidazoles, including albendazol, fenbendazol and oxfendazol, were proven more efficacious and more recently the ivermectin/milbemycin chemicals have been proven effective. A wide range of control programmes were in practice (Wilson and Collier, 1981; Mason and Gladden, 1983; Wilson, 1984b). Some farmers treated up to 17 times per year and others did not treat at all. We now have a range of chemicals effective against internal helminth parasites in deer and a reasonable knowledge of how to treat, control and prevent parasitism on deer farms.

While anecdotal observations suggest that clinical parasitism is no longer common, animal health laboratory reports and feedback from final year veterinary students undertaking deer project work as part of their undergraduate curriculum, confirm that sporadic clinical losses due to internal parasitism, particularly lungworm, still occur. It is therefore highly probable that subclinical parasitism also occurs. Thus, a re-evaluation of parasitism is warranted to ask why clinical and subclinical parasitism is still occurring on deer farms. We also need to ask if we yet have accurate and effective tools for the diagnosis of parasitism in deer, and good means of predicting the cost-effectiveness of treatment. Also questionable is whether our vigilance as veterinarians in keeping deer farmers informed of parasitism is adequate, or whether we have been lulled into a false sense of security through our own knowledge, in a belief that everyone else's knowledge is equivalent and that everything is happening as it should.

This paper presents some perspectives on internal parasitism in deer followed by a description of data collected as part of the broader Deer Herd Health and Production Profiling study undertaken by the authors (Audigé, 1995).

2. Clinical and subclinical effects of parasitism

Mortalities due to lungworm are obvious. Clinical signs of lungworm and gastrointestinal parasitism are usually routine to diagnose by thorough case workup, excluding other differential diagnoses. Subclinical parasitism is more difficult and has achieved little attention. Research at Massey University (Hoskins *et al.*, unpublished) showed a significant decrease in weight gain in undrenched deer initially without clinical signs. Clinical signs developed with coughing and respiratory distress shortly after. No larvae were observed in faeces. Anthelmintic treatment resulted in an immediate cessation of clinical signs and a rapid return to normal weight gain. Immature parasitism was the cause. Many farmers and veterinarians would have had similar observations on commercial deer farms, although few would have the weight data to quantify the effect.

A number of trials (Mason and Beatson, 1985; Wagner and Mackintosh, 1992; Waldrup *et al*, 1994) have shown weight gain responses to anthelmintic usage. However, the burden needed to cause subclinical reductions in weight gain is not known. Recently observations in the South Canterbury Deermaster Project (unpublished) have shown some herds with high pepsinogen concentrations. Protocols are now being implemented to investigate possible subclinical parasitism in herds with high and low pepsinogen concentrations.

3. Diagnosis

Confirmation of a diagnosis of early outbreaks was by postmortem observation of huge parasite burdens in the lung. The rôle of faecal egg and larval counts came into focus as a tool for diagnosis and evaluation of effectiveness of treatment. However, there are only two reports of a relationship between faecal egg counts and worm burdens (Wilson, 1981; Anderson, 1983). Anderson showed a statistically significant regression relationship between parasite count and egg count. However, that data must be viewed with caution since it was grouped largely around two clusters, one with low counts/low burdens, and a second with high counts/high burdens. Also, a number of deer with mature and immature worms, not unexpectedly, had no eggs in faeces. Furthermore, both egg and parasite counts were not high by sheep or cattle standards. Those data were collected from healthy deer at slaughter so no information was available on subclinical effects.

While a relationship has been stated, no data has been published to show the relationship between faecal lungworm larval counts and lungworm burdens. Logic would suggest a relationship should exist, although several confounding variables would contribute including food intake, parasite maturity and epidemiology of the parasite.

Baseline pepsinogen was measured by Wilson and Pauli (1983) but was not correlated with worm burdens or egg counts. Waldrup *et al* (1994) measured pepsinogen concentrations but found no relationship with internal parasite burdens or weight gains. Connan (1991) reported higher pepsinogen in deer with abomasal lesions resembling Type II ostertagiosis of cattle in a small number of slaughtered deer. While numbers were insufficient to provide conclusive evidence, levels were in the range reported in our herd health and production study (see Section 4.3.4). Johnstone *et al* (1984) reported no elevation of pepsinogen concentrations after artificial inoculation of deer with gastrointestinal parasite larvae.

Thus the use of faecal egg and larval counts is largely a qualitative measure and must be considered in conjunction with clinical signs, weight gains, available feed and previous anthelmintic treatments. Both animal prevalence and absolute counts must be considered together. Indeed, Audigé *et al* (1997) describe an index of parasitism in weaners which employs this concept (see Section 4.2).

More research needs to be conducted to determine:

- relationship between egg count and worm burden;
- relationship between larval count and lungworm burden;
- numbers of worms causing subclinical/clinical effects;
- species of parasite present;
- the value of pepsinogen as a diagnostic aid;
- other means of diagnosis of clinical and subclinical parasitism.

4. Deer herd parasite profile

This section summarises data of the two-year deer herd health and production profiling study involving data collection from 15 commercial red deer farms in the lower half of the North Island. The general methodology used has been published in earlier Deer Branch NZVA conference proceedings (Audigé *et al*, 1993).

Data is presented to give an up-to-date descriptive analysis of current parasite control practices and other observations related to parasitism in commercial farmed deer.

4.1 Parasite-related data recording

Over 180 anthelmintic treatment events were recorded by date, class of animal, anthelmintic type and formulation, and dose. The observations spanned from weaning 1992 to weaning 1994, ie: 2 years with 3 sets of data for treatment related to weaning.

Faecal egg and larvae counts were obtained from samples collected per rectum from 10 weaner, yearling and adult hinds and stags (5 from each sex) up to 4 times per year (March, June, September, November), and serum pepsinogen activity measured at strategic times as detailed in Table 8 and Figure 3.

4.2 Analyses

Descriptive data are presented. The following animal and herd indices of parasites were included in the statistical analysis of association with various productivity outcomes:

Animal-level factors:
- faecal egg count
- faecal larval count
- faecal egg count > 0
- faecal larval count > 0
- serum pepsinogen activity

Farm-level factors:
- No. of deer with faecal egg counts > 0
- No. of deer with faecal larval counts > 0
- Farm calf faecal lungworm larval index = geometric mean lungworm larval count x number of calves (out of 10 with counts >0)
- mean time interval between two drenches (days)
- late August drench (yes/no)
- number of anthelmintics during a given period of analysis
- Anthelmintic treatment at various seasons
- Geometric mean serum pepsinogen activity

The indices that were statistically significantly associated with various outcomes were incorporated in multivariable stepwise regression analyses. The method and results are published in full elsewhere (Audigé, 1995). Only parasite-specific associations will be discussed here.

4.3 Results and Discussion

4.3.1 Weaning anthelmintic treatments

A summary relating anthelmintic treatments with weaning management practices is presented in Table 1.

Five of 16 farmers drenched deer before weaning on at least one year, one as early as January 15. All farmers drenched deer sometime during the first autumn, but one farm one year delayed commencement of drenching until mid-April. Most farmers treated in the first 10 days of March.

4.3.2 Weaning to yearling (3-15 months)

Anthelmintic treatments given to weaner deer are described in Table 2 and faecal egg and lungworm counts for individual farms are described in Table 3, with a summary in Table 4.

The number of treatments for weaners ranged from 1-5 during the autumn, 0-3 during winter and from 0-2 in spring, ranging from 3-9 annually. The anthelmintic used most commonly was oxfendazol, possibly linked to the veterinary practice servicing those deer farms which markets its own brand of oxfendazol. In order of frequency of usage, oral ivermectin, pour-on ivermectin, oral moxydectin, and pour-on moxydectin were also used. On one occasion a combination fenbendazol/levamisol drench was used.

Faecal egg and larvae counts (Table 3) varied between farms and the time of year. Data from weaning 1993 and 1994 are largely pre-drench data whereas June, September and November data are taken from animals undergoing an anthelmintic programme. Prior to commencement of anthelmintic treatment 22.7, 24.9 and 21.1% of 313 calves shed 50, 100-150, and 200 or more parasite eggs in the faeces, respectively. The percentage of these calves shedding lungworm larvae was 93.9% with a range 0.25-1807.5 larvae per gram. The second highest faecal larval count was 855 per gram. No calves showed clinical signs of internal parasite infestation. There was no significant difference between stag and hind calves. Geometric means of positive faecal larval counts ranged from 1.6-165 lpg, with a mean 30 lpg. These geometric means were significantly higher prior to commencement of treatment in 1992 than in 1993.

At the June visit the proportion of weaners shedding gastrointestinal parasite eggs and lungworm larvae was considerably reduced, and in general, counts were lower. This trend continued through the September and November samplings. Many of those deer, of course, had been treated shortly before sampling. There was no significant reduction in the number of weaners shedding eggs in their faeces if they were sampled within 21 days post-treatment compared with other weaners (chi-square test), but there was a significant reduction in weaners shedding lungworm larvae. On one farm, however, the geometric mean of positive faecal larval count was 19.7 lpg three days after anthelmintic treatment. In that case a dose of oxfendazol recommended for 15 kg animals was used whereas their bodyweights on average were 48 and 54 kg for hinds and stags, respectively.

A clear example of underdosing with the expected result!

During spring, again the number of weaners sampled with lungworm larvae were reduced but the number with eggs in faeces was not reduced. This could suggest that natural immunity to lungworm was greater than natural immunity to gastrointestinal burdens.

4.3.3 Yearling and adult deer

The anthelmintic programme and chemicals used in adults and yearlings are presented in Table 5. Farm data of egg and larval counts presented for stags and hinds, respectively, are presented in Tables 6 and 7I. Summary data is presented in Figures 1 and 2.

There are considerable differences in treatment regimes between farms. Over two years all but one farm treated adult and/or yearling stags or hinds. Most treatments were given late winter. It would appear that stags receive more anthelmintic treatments than hinds.

The prevalence of faecal egg counts was generally low and no more than 11% of stags shed more than 100 eggs per gram of faeces. The proportion of sentinel hinds shedding eggs in their faeces and with higher counts significantly increased ($p < 0.01$) from March to September, and a similar observation was made in sentinel stags from November to June. These data suggest that parasite burdens may be higher in yearling and adult animals during winter and early spring. It is interesting that Table V shows the majority of anthelmintic treatments given to stags are given late winter/early spring. The observation of higher counts in June could suggest that an earlier anthelmintic treatment may be warranted, or be more effective than a later drench. This requires further investigation, although the difficulties associated with treating stags near the rut must be considered..

There was no significant difference in FLC between yearling and adult hinds. The number of sentinel hinds with positive FLC was significantly higher ($p < 0.01$) in March 1993 than in March 1992, but there was no significant difference between years at the September visit and between March and September both years combined (chi-square test). The maximum FLC observed in hinds was 22 lpg in March and 32 lpg in September.

In contrast, yearling stags had significantly higher FLC than adult stags at each visit. However, the geometric mean of FLC from both ages within farms at each visit was 3.9 lpg. The maximum FLC observed in yearling and adult stags was 37 and 95 lpg in June and 4 and 3 lpg in November/December, respectively. A higher proportion of yearling stags but not adult stags had positive FLC in June 1993 than in June 1994, although the overall geometric mean of FLC was lower in1993. Significantly higher proportions ($p< 0.01$ chi-square test) of both yearling and adult stags had positive FLC in June than in November/December.

4.3.4 Pepsinogen

Means, standard deviations and geometric means of pepsinogen concentrations in weaners, yearlings and adults are presented in Table 8 and Figure 3. These data show lowest levels at weaning with a steady increase to late winter/spring. Levels in adult hinds and stags are higher than those in weaners at weaning. Thus deer seem to reach adult levels at approximately 6-9 months of age. The significance of the higher levels in older deer is not known.

Relationships between individual animal pepsinogen concentrations and liveweight gain, and farm geometric mean pepsinogen levels and liveweight gain during summer, and are shown in Figure 4. Those herds with higher geometric mean pepsinogen concentrations had lower growth rates. This data suggests more

research into the diagnostic significance of herd mean pepsinogen concentration as a measure of subclinical parasitism is warranted.

4.3.5 Statistical associations

Statistical analyses of indices of parasitism resulted in inclusion into regression models of association with several outcome variables. A full description is presented elsewhere (Audigé, 1995).

Analysis of the weaner lungworm larval index showed a significantly lower weight at weaning when the index was high. This could indicate that subclinical effects of parasitism may occur in young deer before weaning.

There was also an association between the number of anthelmintic treatments prior to weaning and weaning weights, such that for each drench prior to weaning a stag was 2.34 kg and a hind 3.35 kg heavier, although this effect was partly confounded by weaning date. There was a negative relationship of using ivermectin/albemycin-based anthelmintics compared with benzimidazole-based anthelmintics on autumn growth rate. There was also a negative relationship between the number of anthelmintics and weaner growth rate during autumn for weaner stags. However, neither of those variables were significantly related to autumn growth of weaner hinds. The latter observation, and the lack of a plausible biological explanation, could suggest the observation in males was spurious. No indice of parasitism was associated with growth rate during winter.

During spring it was observed that hinds and stags drenched during the latter part of August grew on average 10 and 26 g/d faster, respectively. Furthermore, the later an anthelmintic treatment was given in spring, the lower the spring bodyweight gain. Combined, if no anthelmintic was given in August and a spring treatment was delayed, rising 1-year-old hinds and stags grew 16 and 27.4 g/d slower, respectively, during spring.

There was a significant inverse relationship (Figure 4) between individual serum pepsinogen concentrations of 1-year-old stags and their individual growth rates during summer (r^2 = -0.11, P <0 .001). This relationship was similar but failed to reach significance for 1-year-old hinds (r^2 = 0.06, P = 0.07). The geometric mean of pepsinogen concentration from sentinel adult hinds was significantly negatively associated with weaning rates within each farm (r^2 = 15.8; P = 0.022). The biological explanation of this association is unclear.

There were no direct or indirect statistical associations between indices of parasitism and velvet antler production from two-year-old or adult stags. There may, however, be an indirect effect of parasitism and the risk of yersiniosis in weaners, because models showed lower body weight to increase the risk of yersiniosis, and that lower bodyweights were associated with parasitism.

5. Conclusions

This paper presents a substantial amount of baseline data on parasite control strategies on commercial deer farms, faecal egg and larval counts, and pepsinogen concentrations. It has highlighted significant variation between farms and between deer, and has allowed a range of analyses of the potential effect of parasitism against production outcomes.

The following are the major conclusions that can be drawn from this study:

- The anthelmintics chosen by deer farmers are efficacious;
- Programme start dates at weaning are generally satisfactory but data suggests further evaluation of the relationship between pre-weaning drench, date of onset of drenching programme and weaning date is needed.
- The variability in drenching programmes during the first 12 months is considerable, with some drenching intervals being inappropriate for parasite control;
- Weaners drenched late winter had higher spring growth rates;
- Farms with higher indices of parasitism generally have lower weaner growth and survival of calves to weaning;
- Adult anthelmintic programmes appear to be *ad hoc* and vary considerably between and within farms from year to year. It is probable that drenching is in response to poor condition rather than based on sound technical justification;
- Stags in their second winter appear to be at risk of subclinical parasitism;
- Higher egg and larvae counts in rising 2-year-olds and adults late winter suggest that drenching should be undertaken earlier than it is currently;
- Egg and larval counts are prevalent and vary considerably amongst all age groups. This data is similar to that reported in the early 1980s.
- Pepsinogen concentrations and relationships suggest subclinical parasitism is present and affecting both weaner growth and calf survival to weaning. Further investigation of these relationships is warranted;
- No deer farms undertook faecal sample monitoring as part of a management programme.

The data contained in this paper and these conclusions would suggest that there is a significant opportunity for veterinarians to advise on parasite programmes and to implement monitoring. This would have the following potential advantages:

- reduction of anthelmintic usage
  - lower cost
  - reduction of risk of resistance
  - marketing image
  - low chemical usage, reduced residue risk
- more efficacious and cost-effective programmes can be devised
- the economic relationship between lower anthelmintic cost and monitoring cost should favour monitoring in all but smaller herds. In future, integration of other

grazing management practices, pasture species etc., will become more important to the deer industry.

Acknowledging these points, veterinarians have an acutely important rôle to play in advising farmers on parasite control strategies to minimise cost and to maximise response and future marketing position.

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Table 1. Anthelmintic treatment date relative to weaning on survey farms over three years

		Date											
Farm	Year	Jan			Feb			Mar			Apr		
		1-10	11-20	21 -	1-10	11-20	21 -	1-10	11-20	21 -	1-10	11-20	21 -
1	1							AW		A			
	2							AW		A			A
	3							W					
2	1									AW	A		A
	2							W					
	3							AW					
3	1							AW			A		
	2							AW			A		
	3					A			AW				
4	1				A		AW			A		A	
	2			A			AW		A			A	
	3						AW			A		A	
5	1								AW				
	2							W		A		A	
	3								AW				
6	1									AW		AW	
	2									A	AW	A	
	3										AW		
7	1							AW			A		
	2									AW	A		
	3									AW		A	
8	1								AW				A
	2							AW			A		
	3							AW					
9	1		A					W	A		A		
	2				A			W			A		
	3							AW					
10	1							AW				A	
	2							AW		A			A
	3						AW						
11	1								AW		A		
	2								AW			A	
	3							AW			A		
13	1							AW	W				A
	2								AW				
	3									AW			
14	1		A							AW		A	
15	1											AW	
	2										AW		
	3										AW		
16	1									AW			A
	2									AW			
	3									AW			

A = Anthelmintic treatment Year 1 = 1992, 2 = 1993, 3 = 1994
W = Weaning

Table 2. Anthelmintic treatments given to weaner deer (3-15 months), and anthelmintic used

Farm	Year	Month											
		Mar	*Apr*	*May*	*June*	*July*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*	*Jan*	*Feb*
1	1 2	I(2) I(2)		I	I I	I I	I I	I I	I				
2	1 2	OIP	I IO	IP	 O	O				 IP			
3	1 2	O I	IP O	O I	O I	 IP	O IP	O IP	 IP	O	IP	 MP	MP
4	1 2	O O	I O	O O	O O	 O							
5	1 2	IP IP	O		IP								
6	1 2	O O	O O	 O	O O					O FL			
7	1 2	O O	I O	I O(2)					 O	O			O
8	1 2	O M	O O	 O	M O	 O	M(2)	 M					
9	1 2	O O	O	 O	O M	O M				O			
10	1 2	O O(2)	O O	O	O O	O O	O 0 0	O O					
11	1 2	O O	O O	O O	O	O		O					
13	1 2	O I	O	O O(2)	O	 IP				 O			
14	1 2	O -	O -	O -	O -	 -	 -	 -	O -	O -	 -	 -	
		Mar	*Apr*	*May*	*June*	*July*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*	*Jan*	*Feb*

Table 2. Anthelmintic treatments given to weaner deer (3-15 months), and anthelmintic used													
Farm	Year	Month											
15	1 2		O O	O	O		O(2) O	O M	O				
16	1 2	O NR	O I		I,IP			I	I	M		I	M

NOTE: **Each alphabetical symbol denotes one treatment, except where followed by (2) when two treatments were given that month**

Year 1 = 1992, 2 = 1993. 0 = Oxfendazole.. M = Moxidectin. I = Ivermectin Oral. IP =Ivermectin pour-on. MP = Moxydectin pour-on. FL =Fenbendazole/Levamazole combination

Table 3: Summary of anthelmintic treatment practices on hinds and stags (> 15 months)

Farm	Year	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
1	1							YH,YS (I)					
	2							YS(I)					
2	1			YS, AS (I)									
	2												
3	1												
	2	YA,YS (I)						YS,AS (IP)				AS(IP)	
4	1									YH/AH (O)			
	2									YH/AH (O)			
5	1												
	2							YS AS(IP)					
6	1								AH(A)				
	2						YS AS(IP)			YH (FL)			
7	1	YS(I)					YS(I), AH(O)						
	2		YS(O)				AS(O)						
8	1				AS(IP)								
	2												
9	1												
	2												
10	1						AS(O)						
	2												
11	1						AS(O)						
	2												

Farm	Year	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
13	1	YS, AS, YH(O)											
	2												
14	1												
	2												
15	1				AS,YS, AH(IP)				YS,AS, HY,AH (I)				
	2												YS(IP)
16	1							YS,AS,A H(IP)					
	2				YS,AS, AH(IP)		YS,AS,A H(IP)						

Year 1 = 1992. Year 2 = 1993

I = Ivermectin Oral. IP = Ivermerctin pour-on. O = Oxfendazole. M = Moxidectin oral. FL = Fenbendazole/Levamisole combination. A = Albendazole

Table 4 Faecal egg and lungworm larval counts (/g) from weaners (3-15 months) on each survey farm.

Farm code	Date of sampling	Time after last drench (days)	Number of deer sampled	Number of deer with FEC *				Faecal larval counts >0			
				0	50	100 150	>=200	Number of deer positive	Geometric mean	Min	Max
FEBRUARY - MARCH											
Year 1992											
1	17-Mar	16	10	10	-	-	-	0	-	-	-
2	2-Mar		10	3	2	1	4	10	32 7	5 5	93 0
3	4-Mar		10	7	3	-	-	8	1 5	0 3	3 8
4	26-Feb	18	10	6	3	1	-	0	-	-	-
5	12-Mar		10	5	1	3	1	9	7 8	1 5	72 0
6	19-Mar		10	6	1	2	1	10	24.0	0 3	162.0
7	24-Mar	15	10	6	4	-	-	1	0 3	0.3	0 3
8	18-Mar	2	10	6	2	2	-	10	25 2	3 0	148 0
9	10-Mar	24	10	5	3	1	1	9	18 9	2 0	72 8
11	3-Mar		10	2	1	5	2	10	19 1	4 0	141 3
13	11-Mar	7	10	10	-	-	-	1	0 3	0 3	0 3
14	9-Mar	54	10	5	2	1	2	8	4 5	0.3	19 5
15	23-Mar		9	4	3	1	1	9	25 5	6.3	83 5
Year 1993											
1	5-Mar		10	2	4	3	1	10	33 4	11 8	274 5
2	3-Mar		10	2	3	4	1	10	106 3	47 5	1807.5
3	16-Mar		10	2	2	5	1	10	165 4	63 0	855 8
4	28-Jan		9	8	1	-	-	6	4 4	0 8	26 0
5	3-Mar		10	-	2	5	3	10	14 4	0 3	155.5
6	18-Mar		10	1	2	1	6	10	72 0	10 8	797 3
7	22-Mar		10	6	3	1	-	10	114 9	47 5	416 5
8	4-Mar		10	2	4	3	1	10	23 6	1 5	131 5
9	2-Mar		10	6	3	1	-	9	25 3	0.8	300 0
10	30-Mar	27	10	6	4	-	-	9	1 5	0.3	7 8
11	2-Mar		10	6	2	1	1	10	31 8	4 8	262 3
13	6-Apr	22	10	-	-	-	-	0	-	-	-
15	29-Mar		10	2	4	3	1	10	35 2	4 5	157 5
16	25-Mar		10	4	3	3	-	9	29 4	1 3	196 3
Year 1994											
1	2-Mar		10	-	2	2	6	10	58 6	13 8	299 3
2	9-Mar		9	1	2	1	5	10	10 3	2 8	101.5
3	11-Mar		10	4	-	5	1	8	5 4	1 0	32 0
4	25-Feb		10	4	-	-	6	9	16 5	1 3	48 5
5	18-Mar		10	-	2	3	5	10	7 6	2 5	25 8
6	31-Mar		10	2	2	5	1	10	9 9	0 5	81 8
7	24-Mar		8	1	2	2	3	9	2 9	0 3	17 3
8	8-Mar		9	1	-	3	5	8	24 0	5 0	74 3
9	8-Mar		10	6	2	2	-	2	1 8	1 0	3 3
10	1-Mar		10	2	3	3	2	10	37 2	3 8	283 8
11	9-Mar		10	3	3	1	3	10	13 0	2 0	101 5
13	23-Mar		10	1	5	3	1	9	5 8	0 3	51 0
15	9-Mar		9	2	2	4	1	9	7 2	0 3	36 5
16	30-Mar		10	3	2	2	3	10	13 3	2 3	85.8
JUNE											
Year 1992											
1	28-May	27	9	6	2	1	-	0	-	-	-
2	27-May	4	10	10	-	-	-	0	-	-	-

Farm code	Date of sampling	Time after last drench (days)	Number of deer sampled	Number of deer with FEC *				Faecal larval counts >0			
				0	50	100 150	>=200	Number of deer positive	Geometric mean	Min	Max
3	3-Jun	1	11	5	2	1	1	8	1.3	0 3	4 8
4	2-Jun	28	10	9	1	-	-	6	1 1	0 3	2 3
5	23-Jun	8	10	7	3	-	-	1	0 3	-	-
6	24-Jun	22	10	10	-	-	-	6	3 1	1 8	10 3
7	8-Jun	37	9	6	3	-	-	6	1 6	0 3	6 3
8	18-Jun	10	10	8	2	-	-	0	-	-	-
9	15-Jun	66	10	5	2	1	2	4	0 7	0 3	2 0
10	16-Jun	1	10	7	3	-	-	4	0 5	0 3	2 3
11	4-Jun	1	10	10	-	-	-	9	3 9	0 5	22 0
13	30-Jun	22	10	7	3	-	-	8	1 2	0 3	6 0
14	22-Jun	40	10	2	-	6	2	1	1 0	-	-
15	29-Jun	3	10	9	1	-	-	10	19 7	3 0	113 5
16	1-Jul	30	10	8	1	1	-	10	10 2	1.0	576 5
JUNE											
Year 1993											
1	31-May	26	10	3	3	3	1	6	0 9	0 3	3 3
2	1-Jun	47	10	8	1	1	-	0	-	-	-
3	3-Jun	2	10	3	-	6	1	1	0 5	0 5	0 5
4	1-Jun	27	9	5	4	-	-	8	2 0	0 3	6 5
5	8-Jun	54	10	3	3	4	-	7	8 0	0 3	41 0
6	2-Jun	33	10	7	1	1	1	10	7 2	0 5	173.3
7	7-Jun	15	10	6	3	1	-	0	-	-	-
8	26-May	9	10	10	-	-	-	0	-	-	-
9	25-May	12	10	10	-	-	-	0	-	-	-
10	9-Jun	28	10	8	1	1	-	9	1 4	0 3	20 5
11	27-May	12	10	8	2	-	-	0	-	-	-
13	24-May	21	10	8	1	1	-	10	3 4	0 8	29 3
15	13-Jun	30	10	7	3	-	-	10	7 9	2 0	44 5
16	10-Jun	4	10	-	6	4	-	7	0 9	0 3	3 0
SEPTEMBER											
Year 1992											
1	2-Sep	3	10	1	-	-	-	1	0 3	-	-
2	30-Sep		10	6	4	-	-	8	1 2	0 3	4.3
3	15-Sep	41	10	7	2	-	1	10	6 6	0 5	53 0
4	17-Sep		10	7	2	1	-	9	2 6	0 3	9 5
5	9-Sep	12	10	6	3	1	-	0	-	-	-
6	5-Oct		10	8	2	-	-	10	11 0	1 0	31 8
7	14-Sep	37	10	9	1	-	-	4	1 7	0 3	11 0
8	8-Sep		10	9	-	1	-	7	4 1	0 5	108 5
9	24-Sep		10	10	-	-	-	10	2 8	0 5	13 5
10	10-Sep	31	10	7	3	-	-	7	4 7	1 3	38 5
11	7-Sep	4	10	7	1	2	-	10	2 1	0 5	5 3
13	24-Sep		10	4	5	1	-	9	7 4	1 0	63 0
14	28-Sep		10	8	-	2	-	5	5 5	4 0	9 0
15	21-Sep	34	10	7	2	1	-	10	6 3	0 3	86 3
16	9-Sep		10	5	3	1	1	6	4 5	0 3	21 5
Year 1993											
1	15-Sep	42	9	8	1	-	-	4	0 7	0 3	3 3
2	31-Aug	19	10	9	1	-	-	0	-	-	-
3	13-Sep	3	10	8	2	-	-	0	-	-	-
4	31-Aug	17	9	5	2	2	-	5	0 7	0 3	1 8
5	14-Sep		10	7	1	2	-	0	-	-	-

				Number of deer with FEC *				Faecal larval counts >0			
Farm code	Date of sampling	Time after last drench (days)	Number of deer sampled	0	50	100 150	>=200	Number of deer positive	Geometric mean	Min	Max
6	16-Sep	21	10	8	1	1	-	4	1 4	0 5	6 3
7	5-Sep	8	10	7	3	-	-	0	-	-	-
8	20-Sep	11	10	10	-	-	-	0	-	-	-
9	21-Sep		10	10	-	-	-	0	-	-	-
10	2-Sep	23	10	5	-	4	1	5	1 1	0 3	2 5
11	8-Sep		10	5	2	2	1	9	4 0	0 3	28 0
13	7-Sep	33	10	8	2	-	-	1	0 3	-	-
15	6-Sep	25	10	9	1	-	-	8	2 2	0 3	30 5
16	1-Sep		10	9	1	-	-				
NOVEMBER 1992											
1	18-Nov	35	10	10	-	-	-	0	-	-	-
2	18-Nov		10	9	1	-	-	1	0 3	0 3	0 3
3	1-Dec	27	10	9	1	-	-	1	0 5	0 5	0 5
4	1-Dec		10	8	2	-	-	3	0 8	0 3	3 0
5	19-Nov		10	8	1	1	-	4	1 1	0 5	5 0
6	24-Nov	15	10	7	3	-	-	0	-	-	-
7	30-Nov	2	10	9	1	-	-	0	-	-	-
8	25-Nov		10	8	1	1	-	9	1 4	0 3	5 8
9	25-Nov	13	10	8	2	-	-	0	-	-	-
10	26-Nov		10	8	2	-	-	9	2 4	0 5	11 8
11	23-Nov		10	9	1	-	-	8	1 8	0 3	7 5
13	2-Dec		10	8	2	-	-	9	2 1	0 3	60 3
14	2-Dec	28	10	10	-	-	-	1	0 3	0 3	0 3
15	23-Nov	33	10	10	-	-	-	4	0 5	0 3	1 8
16	3-Dec		10	10	-	-	-	0	-	-	-

Table 5 **Percentage of sentinel weaners shedding faecal parasite eggs and lungworm larvae, and mean and range of geometric means (larvae/g) of positive faecal larval counts at each visit in 1992, 1993 and 1994**

Year and visit	Number of weaners	Weaners with FEC>0 (%)			FLC>0	Geometric mean FLC>0		
		50	*100-150*	*>=200*	*%*	*Mean*	*Min*	*Max*
February/March								
1992†	129	19.4	13.2	9.3	65.9	14.5	0.3	162.0
1993‡	119	27 7	25 2	12 6	95 8	54.7	0 3	1807.5
1994‡	135	21.6	28 8	33 6	99.2	15.2	0 3	299 3
June								
1992	149	15.4	6 7	3.4	49 0	3 7	0 3	576 5
1993	139	20 1	15 8	2.2	48 9	3.6	0 3	173.3
September								
1992	150	18.7	6.7	1.3	70 7	4.3	0 3	108.5
1993	138	12.3	8.0	1.4	26 1	1 5	0 3	30.5
November								
1992	150	11.3	1 3	0.0	32 7	1 1	0.3	60 3

† 7 farmers had drenched their 10 sentinel calves before sampling
‡ Calves were sampled before the commencement of anthelmintic treatment
FEC = faecal egg count (egg per gram), FLC = faecal larval count (larvae per gram)
Min = minimum; Max = maximum

Table 6: Faecal egg and lungworm larval counts (/g) from yearling and adult hinds* on each survey farm.

Farm code	Date of sampling	Days after last drench**	Number of deer sampled	Number of deer with FEC ***				Faecal larval counts >0			
				0	50	100	>=150	Number of deer positive	Geometric mean	Min	Max
MARCH											
Year 1992											
1	17-Mar		10	8	1	1	-	6	10	03	38
2	2-Mar		10	7	1	1	1	0	-	-	-
3	4-Mar		5	3	1	1	-	1	03	-	-
4	26-Feb		10	6	2	-	2	1	33	-	-
5	12-Mar		10	9	1	-	-	7	06	03	18
6	19-Mar		10	10	-	-	-	5	12	03	148
7	24-Mar		10	7	2	1	-	7	14	03	43
8	18-Mar		10	8	2	-	-	7	10	03	25
9	10-Mar		10	10	-	-	-	7	09	05	28
11	3-Mar		10	10	-	-	-	3	05	03	13
12	27-Feb		10	7	2	-	1	0	-	-	-
13	11-Mar	1	10	10	-	-	-	2	04	03	05
14	9-Mar		10	8	1	1	1	2	04	03	05
15	23-Mar		10	8	2	-	-	2	22	18	28
Year 1993											
1	24-Mar		10	9	1	-	-	5	07	03	33
2	23-Mar		10	8	2	-	-	3	06	03	13
3	16-Mar		10	10	-	-	-	3	08	05	15
4	15-Mar		10	10	-	-	-	7	07	03	20
5	3-Mar		10	5	4	-	1	6	10	03	45
6	18-Mar		10	6	3	-	1	8	13	03	58
7	22-Mar		10	9	1	-	-	7	19	03	53
8	10-Mar		10	10	-	-	-	7	26	03	55
9	8-Mar		10	7	2	1	-	10	31	05	218
10	30-Mar		10	7	2	1	-	6	11	03	78
11	2-Mar		10	9	1	-	-	7	15	03	55
13	6-Apr		10	10	-	-	-	10	11	03	93
15	29-Mar		10	10	-	-	-	7	12	03	28
16	25-Mar		10	7	2	1	-	3	04	03	13
SEPTEMBER											
Year 1992											
1	2-Sep		10	9	1	-	-	6	09	03	35
2	30-Sep		10	7	1	1	1	2	23	20	28
3	15-Sep		7	5	2	-	-	4	12	08	20
4	17-Sep		10	5	1	1	3	7	19	05	68
5	9-Sep		10	5	3	-	2	5	37	18	155
6	5-Oct		10	6	3	-	1	8	32	03	308
7	14-Sep	29	10	8	1	-	1	9	21	03	50
8	8-Sep		10	4	6	-	-	8	11	03	75
9	24-Sep		10	8	2	-	-	8	26	05	180
10	10-Sep		10	8	2	-	-	6	17	03	65
11	7-Sep		10	10	-	-	-	3	90	45	150
13	24-Sep		10	8	2	-	-	7	19	08	53
14	28-Sep		10	8	2	-	-	3	05	03	08
15	21-Sep	87	10	7	3	-	-	3	03	03	05
16	9-Sep	9	10	10	-	-	-	0	-	-	-
Year 1993											
1	15-Sep		10	9	-	1	-	2	18	13	25

Farm code	Date of sampling	Days after last drench**	Number of deer sampled	Number of deer with FEC ***				Faecal larval counts >0			
				0	50	100	>=150	Number of deer positive	Geometric mean	Min	Max
2	31-Aug		10	6	4	-	-	4	0 7	0 3	1 8
3	13-Sep		10	4	2	3	1	7	1 9	0 3	13 5
4	31-Aug		10	2	-	5	3	5	0 7	0 3	1 5
5	14-Sep		10	4	6	-	-	5	1 3	0 5	3 0
6	16-Sep		10	4	3	2	1	5	0 9	0 3	2 8
7	5-Sep		9	5	4	-	-	2	1 4	0 5	3 8
8	20-Sep		10	8	2	-	-	6	2 5	0 3	8 3
9	21-Sep		10	4	3	3	-	6	3 4	1 3	31 5
10	2-Sep		10	6	4	-	-	4	1 1	0 5	3 5
11	8-Sep		9	8	1	-	-	4	2 5	1 0	6 0
13	7-Sep		10	6	3	-	1	5	1 1	0 3	2 5
15	6-Sep		10	6	2	1	1	5	0 8	0 3	3 3
16	1-Sep	31	10	9	1	-	-	0	-	-	-

* FEC and FLC were not statistically significantly different (using Chi-square test and T-test, respectively, P>0 05) between yearling and adult hinds, so data were pooled for presentation

** Farm 13 drenched yearling hinds only in March 1992, Farm 7 drenched adult hinds only in August 1993
Farms 15 and 16 drenched adult hinds in June 1992, and in August 1993, respectively
Drenching programs implemented on each farm are presented in Table 3 13

*** FEC = faecal egg count

Table 7: Faecal egg and lungworm larval counts (/g) from yearling 15-28 months) and adult (>28 months) stags on each survey farm.**

Farm code	Date of sampling	Days after last drench	Number of deer sampled		Number of deer with FEC *				Adult stags with FLC >0**				Yearling stags with FLC >0**			
			Adult	Yearling	0	50	100	>=150	Number of deer positive	Geometric mean	Minimum	Maximum	Number of deer positive	Geometric mean	Minimum	Maximum
JUNE																
Year 1992																
1	28-May		5	5	7	2	1	-	5	1 3	0 3	6 3	4	6 9	3 0	24 5
2	27-May	4	0	5	4	1	-	-	Deer not sampled				0	-	-	-
3	3-Jun	79	6	1	5	-	-	1	3	2 7	0 3	28 0	0	-	-	-
5	23-Jun		4	4	1	5	1	1	4	1 3	0 3	5 5	4	6 4	0 8	37 5
6	24-Jun		5	5	4	2	1	3	3	6 0	1 0	95 3	4	8 7	3 5	44 8
7	8-Jun	71	4	5	7	2	-	-	2	0 6	0 3	1 3	1	0 3	0 3	0 3
9	15-Jun		5	5	4	3	-	3	4	1 8	0 8	7 0	5	3 8	1 5	12 5
10	16-Jun		5	5	10	-	-	-	4	1 1	0 3	3 3	4	0 9	0 3	5 5
11	4-Jun		5	5	8	2	-	-	3	0 7	0 3	2 5	4	0 9	0 3	2 8
13	30-Jun	111	4	4	7	1	-	-	3	1 6	0 8	4 5	2	2 9	1 5	5 8
14	22-Jun		5	0	2	2	1	-	2	0 7	0 3	1 8	Deer not sampled			
15	29-Jun	25-14	5	5	10	-	-	-	0	-	-	-	0	-	-	-
16	1-Jul		5	5	4	2	4	-	4	1 8	0 5	8 3	4	4 3	1 0	33 8
Year 1993																
1	31-May		5	5	8	2	-	-	1	4 5	4 5	4 5	4	2 7	1 3	13 5
3	3-Jun		5	5	7	3	-	-	1	0 8	0 8	0 8	4	2 7	0 8	6 3
5	8-Jun		4	5	7	2	-	-	3	1 3	0 5	2 8	3	1 5	0 5	4 3
6	2-Jun		1	5	2	3	-	1	0	-	-	-	3	0 5	0 3	0 8
7	7-Jun	65	5	5	9	1	-	-	1	0 3	0 3	0 3	3	0 9	0 5	1 8
8	26-May		0	5	5	-	-	-	Deer not sampled				4	9 6	6 0	15 3
9	25-May		5	5	7	2	1	-	1	0 5	0 5	0 5	5	2 8	0 5	13 3
10	9-Jun		5	5	5	3	2	-	3	0 9	0 5	1 3	5	4 5	2 3	16 3
11	27-May		5	5	8	2	-	-	4	4 0	0 5	29 8	3	4 6	1 8	8 3
13	24-May		4	5	9	-	-	-	1	1 0	1 0	1 0	5	2 0	0 8	4 5
15	13-Jun		5	5	10	-	-	-	5	1 5	0 3	3 3	4	1 4	0 3	9 0
16	10-Jun		5	5	7	1	1	1	3	0 5	0 3	1 0	4	1 9	0 8	5 8
NOVEMBER 1992* **																
1	18-Nov	81	5	5	10	-	-	-	2	0 4	0 3	0 5	1	1 3	1 3	1 3
2	18-Nov		0	5	5	-	-	-	Deer not sampled				0	-	-	-
3	1-Dec		5	0	5	-	-	-	2	0 4	0 3	0 5	Deer not sampled			
5	19-Nov		5	5	9	1	-	-	1	2 0	2 0	2 0	0	-	-	-

Farm code	Date of sampling	Days after last drench	Number of deer sampled		Number of deer with FEC *				Adult stags with FLC >0**				Yearling stags with FLC >0**			
			Adult	Yearling	0	50	100	>=150	Number of deer positive	Geometric mean	Minimum	Maximum	Number of deer positive	Geometric mean	Minimum	Maximum
6	24-Nov		0	5	5	-	-	-	Deer not sampled				0	-	-	-
7	30-Nov	120	5	5	8	1	-	1	1	20	20	20	4	20	08	40
10	26-Nov	93	3	3	6	-	-	-	2	06	03	15	2	11	10	13
11	23-Nov	101	5	0	3	2	-	-	1	08	08	08	Deer not sampled			
13	2-Dec		5	5	9	1	-	-	1	03	03	03	2	10	03	38
14	2-Dec		5	0	5	-	-	-	3	08	05	15	Deer not sampled			
15	23-Nov		5	5	6	4	-	-	1	30	30	30	2	06	03	15
16	3-Dec	81	2	0	1	1	-	-	0	-	-	-	Deer not sampled			

* Faecal egg counts (FEC) were not statistically significantly different (using Chi-square test, P>0 05) between yearling and adult stags, so data were pooled for presentation

**Positive faecal larval counts (FLC) were statistically significantly different (using t-test, P<0 01) between yearling and adult stags

***Stags were not sampled in November-December 1993

Note Actual dates of anthelmintic treatment are presented in Table 3 13

Table 8: Geometric mean, range and SD of serum pepsinogen concentration (mU Tyrosine/L) from weaner, yearling and adult deer (data pooled over all farms and both years)

	MARCH					JUNE					SEPTEMBER					NOVEMBER				
Sex	n	mean	min	max	SD	n	mean	min	max	SD	n	mean	min	max	SD	n	mean	min	max	SD
WEANER																				
M	140	154	0	628	104	145	330	0	1490	235	144	429	47	1309	233	69	492	152	1528	255
F	139	177	0	581	105	141	370	0	1351	229	139	502	140	2609	327	69	531	152	1375	221
YEARLING AND ADULT																				
M						307	550	0	3334	419										
YEARLING																				
F	131	269	18	1522	527						127	373	0	2310	660					
ADULT																				
F	282	278	0	2719	403						142	365	0	2368	558					

M = male
F = female

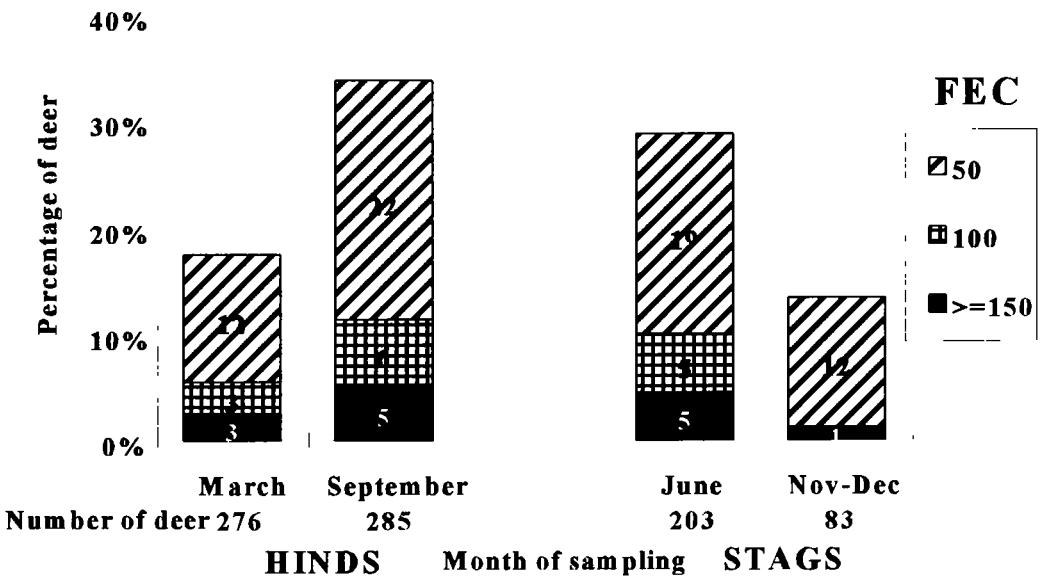


Figure 1. Distributions of faecal egg count (FEC in eggs/g) of sentinel hinds in March September and of sentinel stags in June and in November/December. Data from 1882 and 1993 combined.

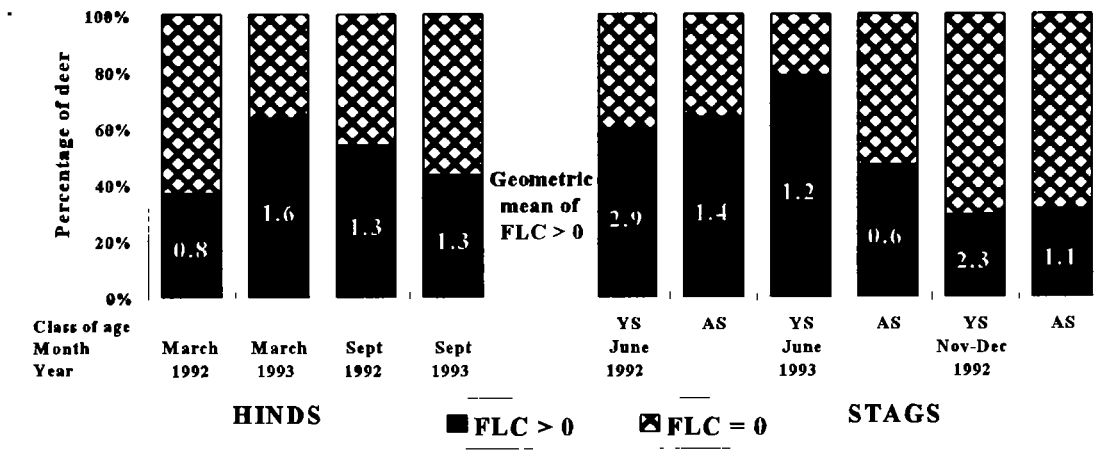
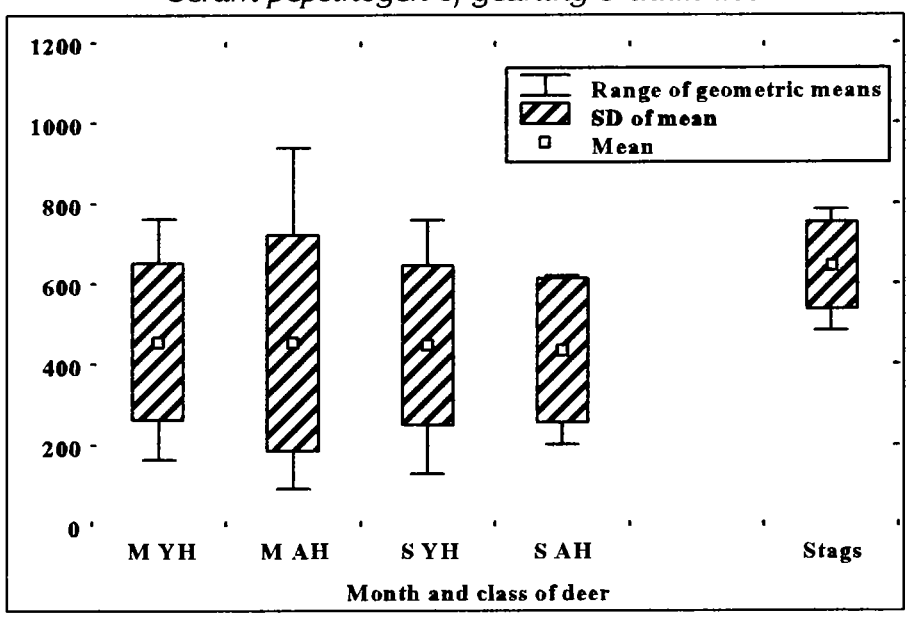


Figure 2. Percentage of sentinel hinds in June and September and stags in June and November-December with positive faecal lungworm larval count (FLC) and respective overall geometric means of FLC all farms combined.

Figure 3. Means, standard deviations (± SD) and ranges of geometric mean pepsinogen (mUTyrosine/L) of 10 weaners, yearling and adults within farms.

Serum pepsinogen of yearling & adult deer



WS = weaner stag. WH = weaner hind
YH = yearling stag. AH = adult hind
M = March. J = June.
S = September. N = November

Serum pepsinogen of weaners

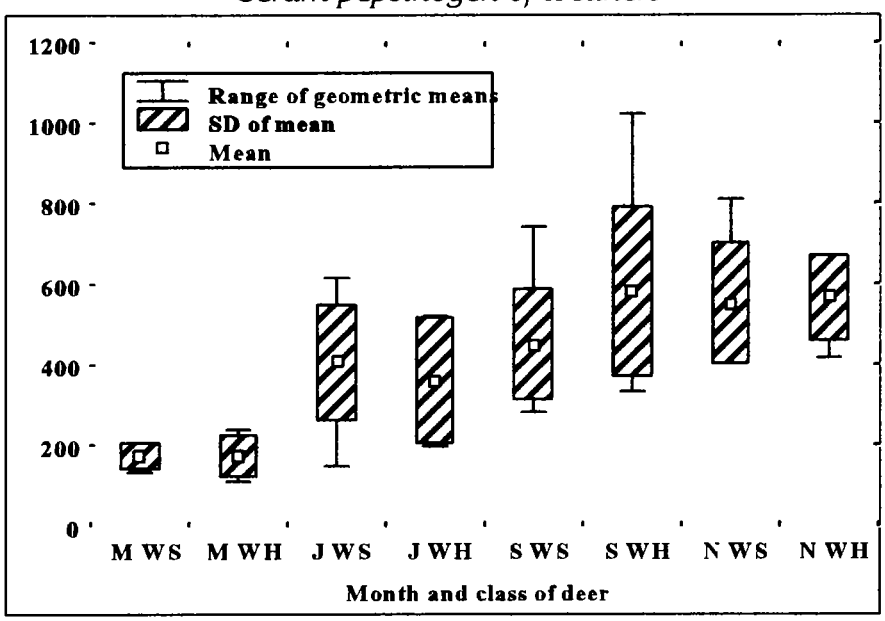
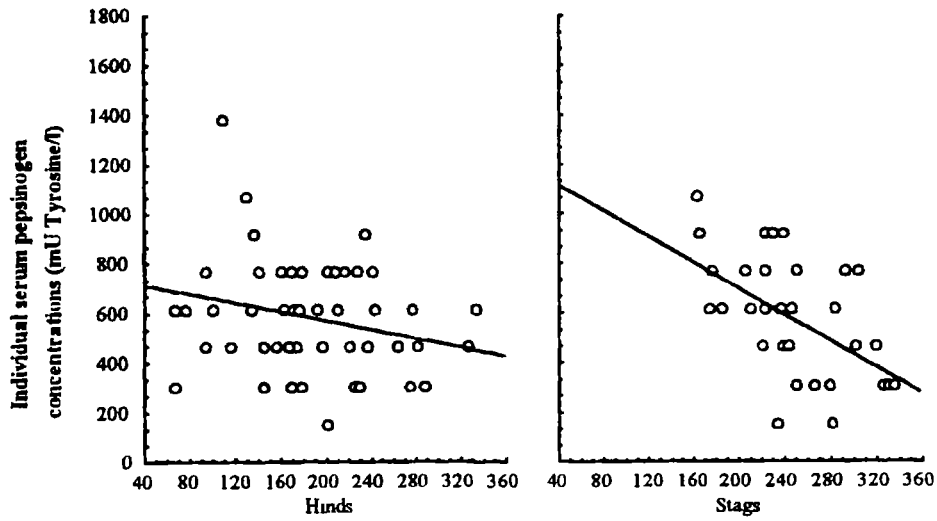


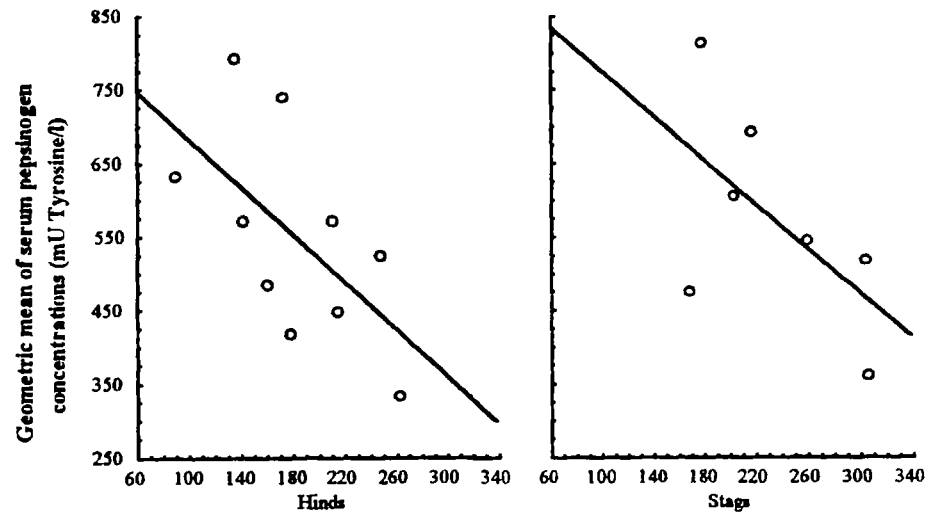
Figure 4. Relationships between individual (a) and mean (b) weaner stag and hind summer growth rates (g/d) and serum pepsinogen concentrations (mU Tyrosinine/L) from 10 weaners (5 hinds and 5 stags) randomly selected on each survey farm and sampled in November.

a. Individual deer serum pepsinogen concentrations



Individual weaner summer growth rates (g/d)

b. Geometric farm mean serum pepsinogen concentrations



Mean weaner summer growth rates (g/d)