Endoparasitism in Wild Ruminants on a Wisconsin Game Farm

by

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Endoparasitism in elk on a Wisconsin game farm

INTRODUCTION

The elk, or wapiti, (Cervus canadensis Erxleben, 1777) was once probably the most widespread of the hoofed species of North America. A favorite target of hunters and photographers, this magnificent animal has become a symbol of American wilderness and insurance companies alike.

Technically, the word elk describes the European moose. Wapiti is the more proper term although its usage is not widespread. Wapiti means "white deer" or "light colored deer" in Shawnee, in reference either to the light rump of the animals or to the bleached color of the winter coat by spring (Madson 1966). The word elk will be employed in this paper as being the term commonly used in the United States.

In the 18th and early 19th centuries, the range of the elk extended from the Pacific Coast to the Atlantic savannah lands and from Arizona to British Columbia. The advance of civilization and the increase in hunting impinged upon their range and population (Madson 1966). At one time there were probably 10 million elk in North America (Seton 1937), where today fewer than one-half million remain. However, they are a very tolerant and adaptable species and are found in areas as diverse as the north woods of Michigan, the rain forests of Washington, the arid and hot mountains of Arizona, New Mexico and Oklahoma, and the high, cold Rocky Mountains of the United States and Canada. The majority of the elk today live in Yellowstone and Rocky Mountain National Parks and on National Forest Service land in western North America. By far the largest herd, numbering over 15,000, lives on the National Elk Refuge near Jackson, Wyoming.

Today, elk have been transplanted as far east as Florida and Virginia (Cross 1950) and have been successfully reintroduced to the

Wichita Mountains of Oklahoma and the Black Hills of South Dakota (Boddicker and Hugghins 1969).

Since the 1930's elk have become common game farm animals as the concept of game farming has increased in popularity. Game farming is a valuable enterprise which is appropriate to the rapidly changing economic environment and the inadequate world food supply. The need to develop and expand available sources of protein can be met in part by game farm production, since wild ruminants are efficient in their conversion of native vegetation into meat (Novakowski 1972). A successful and well managed game farm can be a valuable research, educational and recreational facility.

It is not possible to make appropriate management decisions on game farms without knowledge of the diseases and parasites infecting the animals. Parasitism can influence the health and behavior of a herd, which may in turn affect its population dynamics. Stress due to change from the natural environment may induce the development of clinical parasitisms (Choquette 1956). Parasitic infections contribute to a decrease in the economic value of the animals as well as possibly rendering them undesirable to the sportsman. Game farm animals must be considered as possible reservoirs of diseases of man and domestic animals (Worley et al. 1969).

In the wild, elk are fairly resistant to the effects of parasitism unless they are simultaneously stressed or weakened. Boddicker and Hugghins (1969) noted that there appeared to be little harmful effect from parasitisms in wild elk in South Dakota, which included infections with two genera of tapeworms, several gastro-intestinal nematodes and one species of lungworm. However, in a penned herd of elk in Minnesota, a single species of nematode, Trichostrongylus axei, was responsible for the death of two animals (Eveleth 1955). Parasitisms usually function indirectly, compounding the effects of environment and physical stress on animals. Infections are often assisted by conditions facilitating parasite dissemination, such as supplementary winter feeding (Stelfox 1962), a practice that is used on the study area.

Elk are host to a variety of parasites, many of which are shared with domestic livestock and other wild ruminants. The great majority of the parasitiological studies which have been done on elk have been concerned with wild elk, but the extent and significance of parasitism has not been established in game farm animals. This study was undertaken to determine the endoparasitisms of one herd of captive elk and to determine the seasonal variations in the parasite populations in the elk. Limited behavior data were collected on one bull elk and are included in the appendix.

Description of study area

The study area is located on a private game farm, owned by Ellwyn West, in Waupaca County, Wisconsin (Fig. 1). A herd of approximately 30 elk occupies a 320 acre pasture which consists of 160 acres of the SW section 20, TWN 21 North, Range 12 East and 160 acres of NW section 20, TWN 21 North, Range 12 East. The land has not been farmed since the mid-1950's, when wild game were first stocked on the area.

The pasture area is approximately one-half open rangeland with a large marshy area, and one-half oak (Quercus sp.) and poplar (Populus sp.) woods. Bluestem (Calamgrotis canadensis) is the predominant grass in the lowland areas, with numerous other species scattered throughout (Appendix, Table 1). Most of the wooded area is on two hills on either

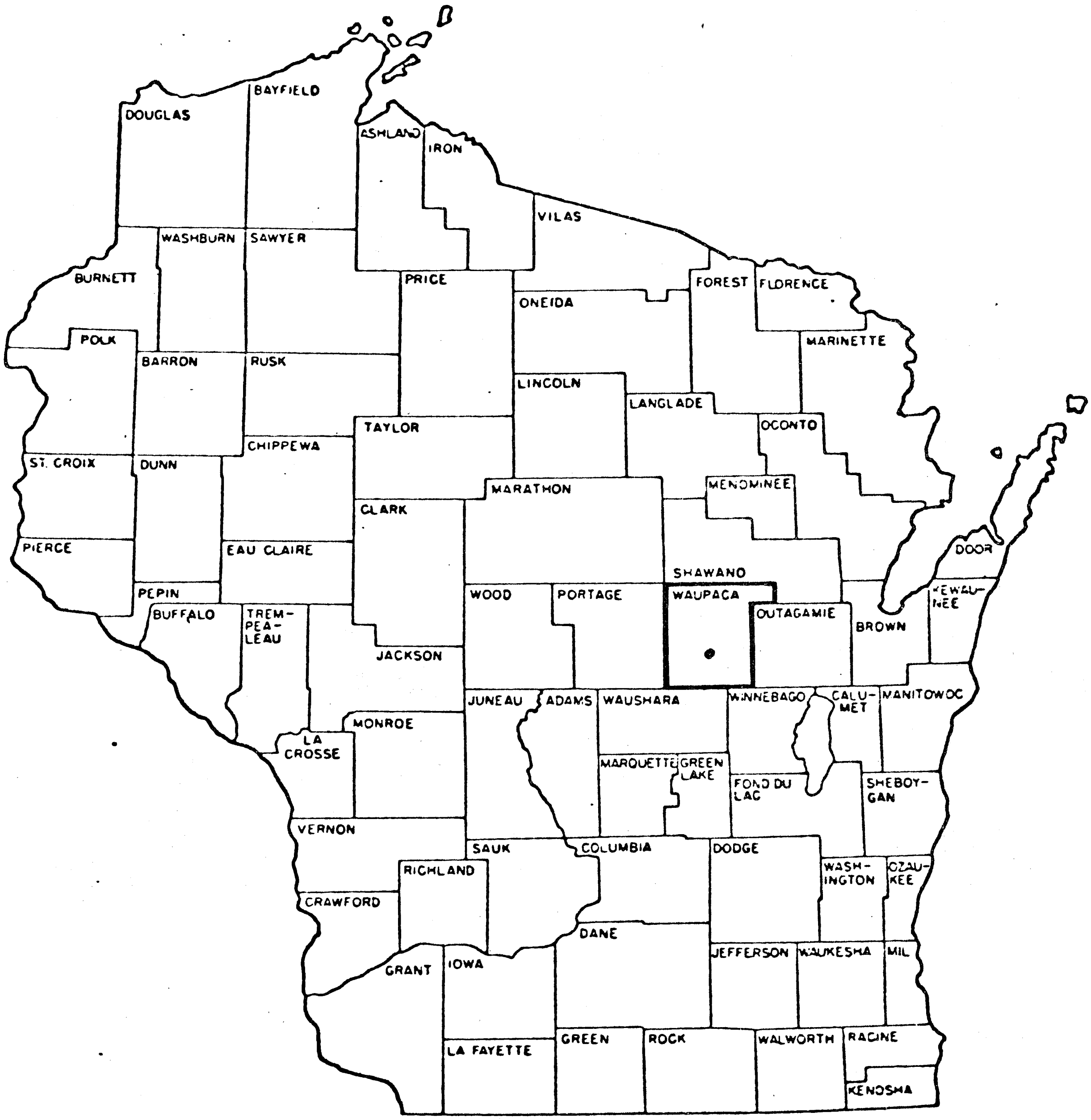

Fig. 1. Location of the study area in Waupaca County, Wisconsin

side of the lowland. The elk have browsed the woods heavily and there is little undergrowth remaining. The water source for the herd is a man-made ditch that runs through the pasture areas. It is fed by a small spring and is generally open through the winter. The water is fairly stagnant and murky in appearance during the summer.

The elk at various and irregular times of the year share the pasture with approximately 30 bison (Bison bison). The bison are usually kept in a separate pasture during the summer months but are contained with the elk between October and May. All of the animals are fed hay and silage during these months, on a common feeding ground.

There are also approximately 15 white-tailed deer (Odocoileus virginianus) that share the pasture with the elk and bison. They are fed corn and other grain feed throughout the year in special enclosures which are inaccessible to the elk or bison. The parasites of the bison and deer are discussed in Section II of the study.

METHODS

Two methods are generally employed to determine the parasitisms of animals. One method is the systematic necropsy of the animal, examining for the presence of adult worms. The other method is the microscopic examination of fecal samples for the presence of parasite eggs, larvae and oocysts. Examination of the feces allows comparatively rapid analysis of many animals in a short period of time and is simple, convenient and fairly efficient. It is a useful technique in estimating the parasitic populations of a large number of animals and does not require that any animals be sacrificed. However, certain parasites cannot be detected by fecal flotation (Soulsby 1965; Samuel and Trainer 1969) and necropsy often becomes necessary for the verification of parasite egg identification. Necropsy is a long and involved process (Robinson 1964; Samuel and Beaudoin 1966), and the acquisition of a suitable dead animal is often difficult in a game farm situation where every animal represents tangible income.

Parasites detected in an individual animal at necropsy do not necessarily reflect the parasitisms of the entire herd. Certain parasites are too small to be detected in the necropsy procedure, making it necessary to use both methods to reveal an accurate sample of the parasitism of a herd of animals.

Sampling procedure

Fecal samples were collected from 15 elk each month from June 1974 through March 1976. The best collection method proved to be approaching the herd while it was lying down. Approach caused a few animals to stand and defecate, as is the usual habit of elk within one or two minutes of rising. By carefully sighting the spot it was possible to collect fresh fecal samples. Further approach would cause the remaining animals to stand, move off and defecate. Thus it was possible to collect fecal samples from 15 different animals without duplication. Individual samples from the adult bull elk were collected, marked and identified in this manner.

Fecal flotation

The fecal flotation method has often been used to detect the parasitisms of domestic livestock (Levine et al. 1960) and has proven to be equally effective with wild ruminants. In this study, a modified sugar centrifugation-flotation technique, modelled after that of Benbrook and Sloss (1965) and Samuel and Trainer (1969), was used for the concentration of parasite eggs, larvae and oocysts in the feces. Fecal samples were preserved in 10 per cent formalin solution to prevent development of the immature parasite stages in the feces. Formalin preservation is the most efficient method for long-term storage, although some degree of distortion of the parasite eggs does occur (Foreyt 1969). Centrifugation also causes some egg rupture and distortion, making positive identification of some of the parasites difficult without having adult worms for verification.

A small portion of fecal material from each sample collected was mixed with approximately 25 ml of water and comminuted with a spatula. This mixture was passed through a tea strainer with 9-12 meshes per centimeter. The coarse material remaining in the strainer was pressed with a spatula to remove most of the water, and then discarded. Equal amounts of the filtrate were poured into two 15 ml centrifuge tubes and spun at 1500 rpm for ten minutes. At this stage, the immature parasite stages are heavier than the water and settle to the bottom of the tubes during centrifugation. Next, the supernatant was poured off from each tube and approximately 10 ml of the flotation solution added to the sediment and mixed well. The flotation solution consists of 454 g. of sugar to 355 ml of water and has a specific gravity of 1.270. The solution is heavier than the immature parasite stages, causing them to float to the top of the tubes when centrifuged. Additional flotation solution was then added until a positive meniscus formed above the lip. A cover slip was placed on the meniscus and the tubes spun at 1500 rpm for another ten minutes. The cover slips, with a drop of flotation solution containing any immature parasite stages adhering to them, were quickly removed, placed on microslides and examined in their entirety under 60X magnification.

Parasite eggs, larvae and oocysts were identified by characteristics described by Shorb (1939), Yamaguti (1961 a,b), Soulsby (1965), Samuel and Trainer (1969), Moose (1973), and Samuel and Gray (1974). Specimens were checked and confirmed by Dr. William Foreyt, Department of Veterninary Science, University of Wisconsin, Madison.

RESULTS

Elk herd

Based on fecal examination, six genera and one general category of parasites were detected in the elk. Individual parasite prevalence varied considerably and in some cases seasonal fluctuations were present. All of the parasites detected in the game farm elk have been previously reported in wild elk populations.

Nematoda

The eggs of the stomach worms that are found in ruminants are very difficult to identify and distinguish from each other in preserved fecal samples. Although 10 per cent formalin is the most effective preservative for period over 100 days, a certain amount of egg shell distortion and breakage does occur (Foreyt 1969) and the centrifugation process contributes further distortion. These factors alter the morphological characteristics of the eggs, making it difficult to measure and identify them accurately. They have therefore been grouped together and classified here as "stomach worms".

Five genera of nematodes were considered stomach worms in this study: 1) *Haemonchus* spp. Cobb, 1898; 2) *Ostertagia* spp. Ransom, 1907; 3) *Cooperia* spp. Ransom, 1907; 4) *Trichostrongylus* spp. Cobbold, 1879; and 5) *Oesophagostomum* spp. Molin, 1861.

Stomach worm infections were detected in all of the elk during most of the months sampled (Table 1). During the other months, 14 out of 15 animals were positive for stomach worms. Spring and summer samples contained greater numbers of eggs than did fall and winter samples.

Nematodirus sp., although technically stomach worms, are easily

ELK

Month	Prevalence (Per Cent)		
	1974-1975	1975-1976	Average
June	100	100	100
July	93	100	96.5
August	100	100	100
September	100	93	96.5
October	100	100	100
November	93	100	96.5
December	93	100	96.5
January	100	100	100
February	93	100	96.5
March	100	100	100
April	100		
May	100		
Average	97.6	99.3	98.45

Table 1. Monthly comparison of the prevalence of stomach worms, based on fecal examination, in 15 elk.

recognized and identified in fecal samples by their large and characteristically shaped eggs (Appendix, Fig. 1). A low level of infection by Nematodirus sp. existed in the elk during the first year of the study, with one to four animals shedding eggs (Fig. 2). The percentage of infection rose in the second year of sampling, with as many as six animals shedding eggs during some months.

Lungworm infections (Dictyocaulus viviparous) were detected in the elk throughout the sampling period. The fecal samples of infected animals contain the first stage larvae of the parasite rather than the eggs (Appendix, Fig. 1). Three to six elk were shedding larvae throughout the first summer of sampling and only one or two animals were during most of the remainder of the sample year (Fig. 3). The rate of infection was higher during the second sample year, averaging 28.4 per cent as opposed to 18 per cent for the first year (Table 2). Again the highest rates occurred in the summer months, with as many as seven elk shedding larvae in July. There was a steady decline in the infection rate until the winter months.

The prevalence of Trichuris ovis in the elk fecal samples was sporadic but showed a general increase in the fall and winter during both sample years (Fig. 4).

The prevalence of Capillaria sp. in the elk was very low and egg shedding was confined to the autumn months during the first year of the study (Fig. 5). The distribution of the infections was somewhat different during the second year of sampling, although the prevalence was similar. One to two animals shed eggs throughout the summer and fall and then egg shedding ceased for the remainder of the year.

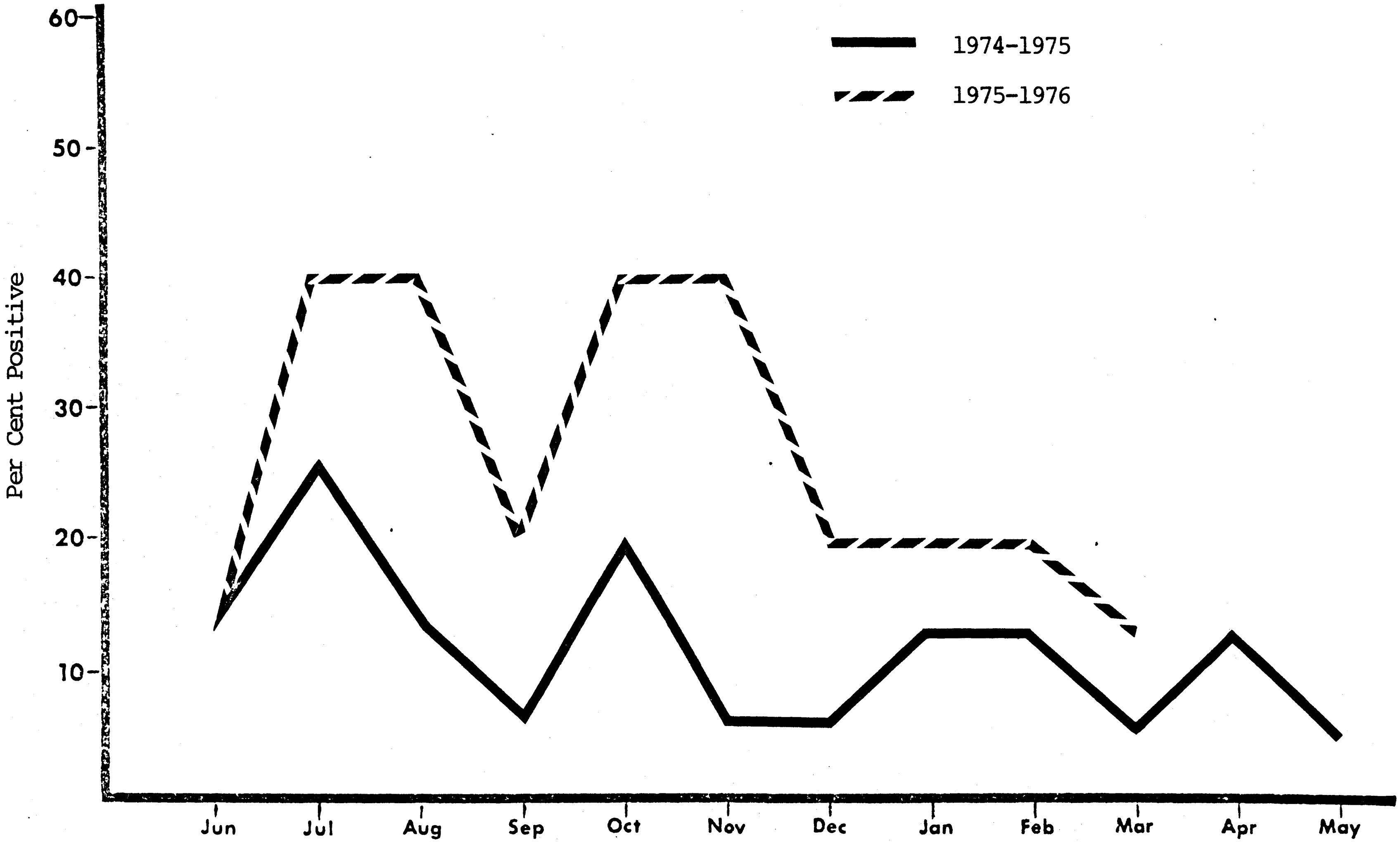

Fig. 2. Comparison of prevalence of *Nematodirus* sp., based on fecal examination, in 15 elk.

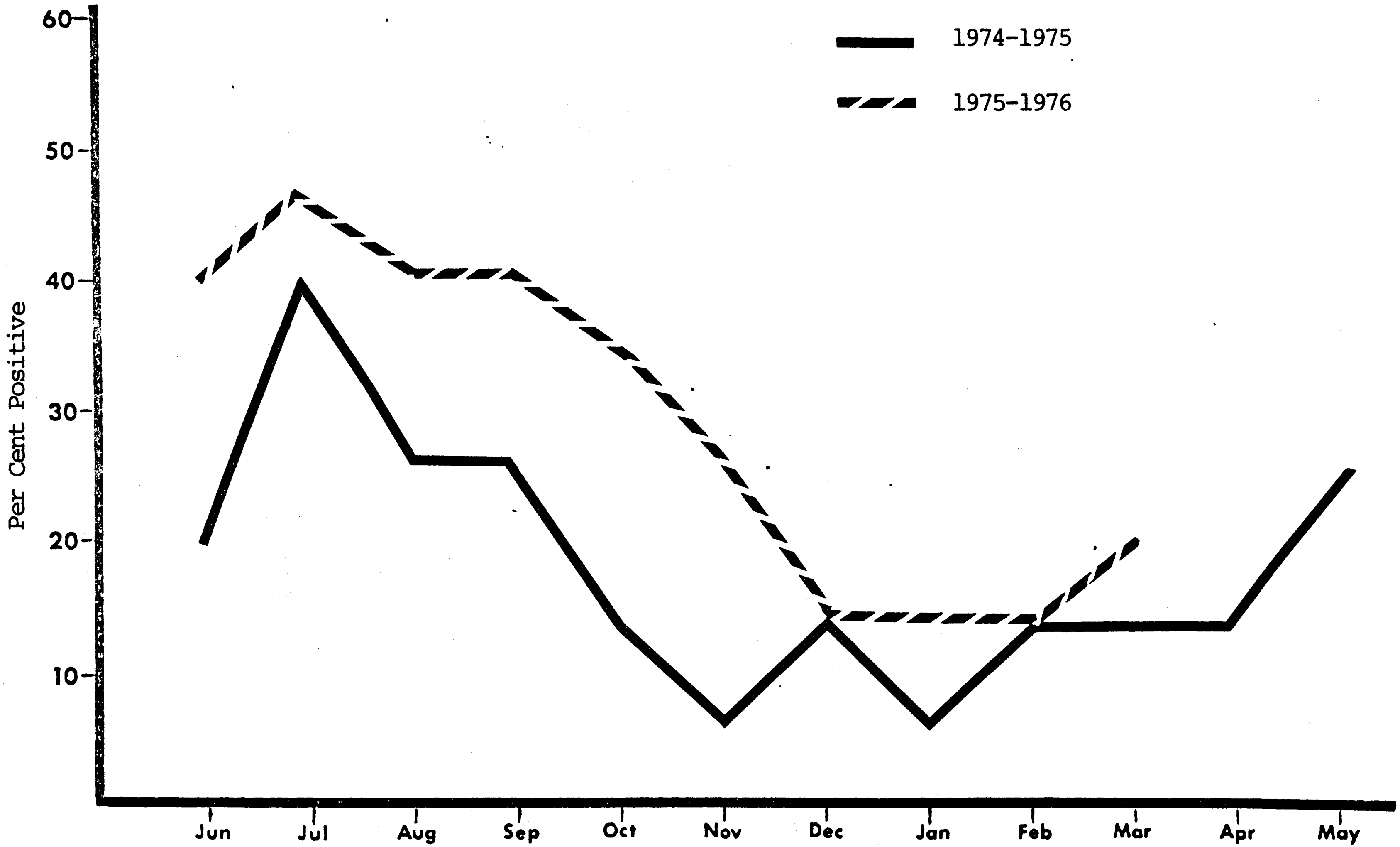

Fig. 3. Comparison of prevalence of Dictyocaulus viviparous, based on fecal examination, in 15 elk.

Parasite	Prevalence (Per Cent)		
	1974-1975	1975-1976	Average
Stomach worms	97.6	99.3	98.45
Capillaria sp.	2.73	4.58	3.65
Dictyocaulus viviparous	18.0	28.4	23.2
Eimeria sp.	16.5	21.7	19.1
Moniezia benedeni	22.0	15.7	18.85
Nematodirus sp.	12.0	26.6	19.3
Trichuris ovis	13.0	17.7	15.35

Table 2. Average prevalence of parasites, based on fecal examination, in 15 elk.

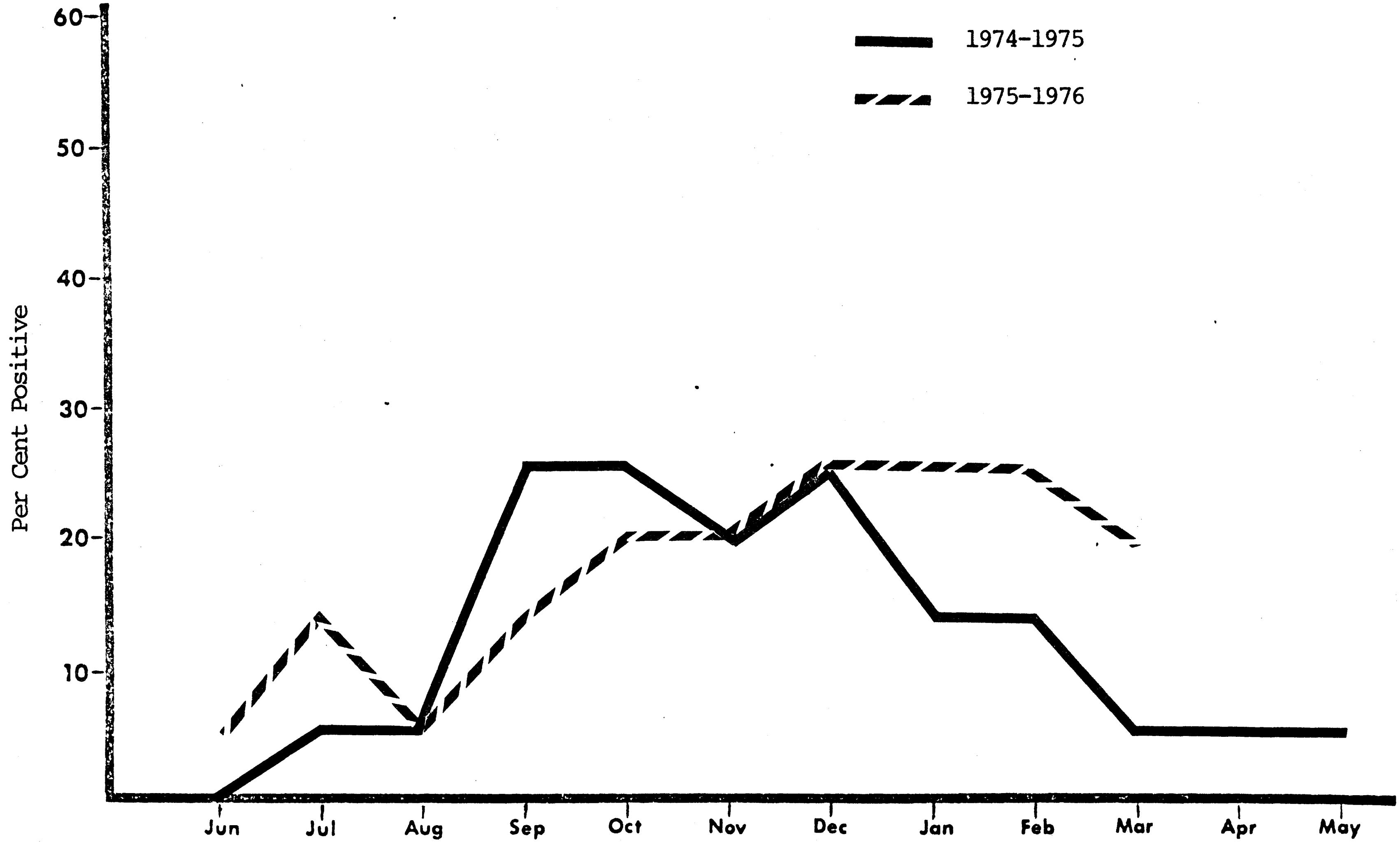

Fig. 4. Comparison of prevalence of <u>Trichuris ovis</u>, based on fecal examination, in 15 elk.

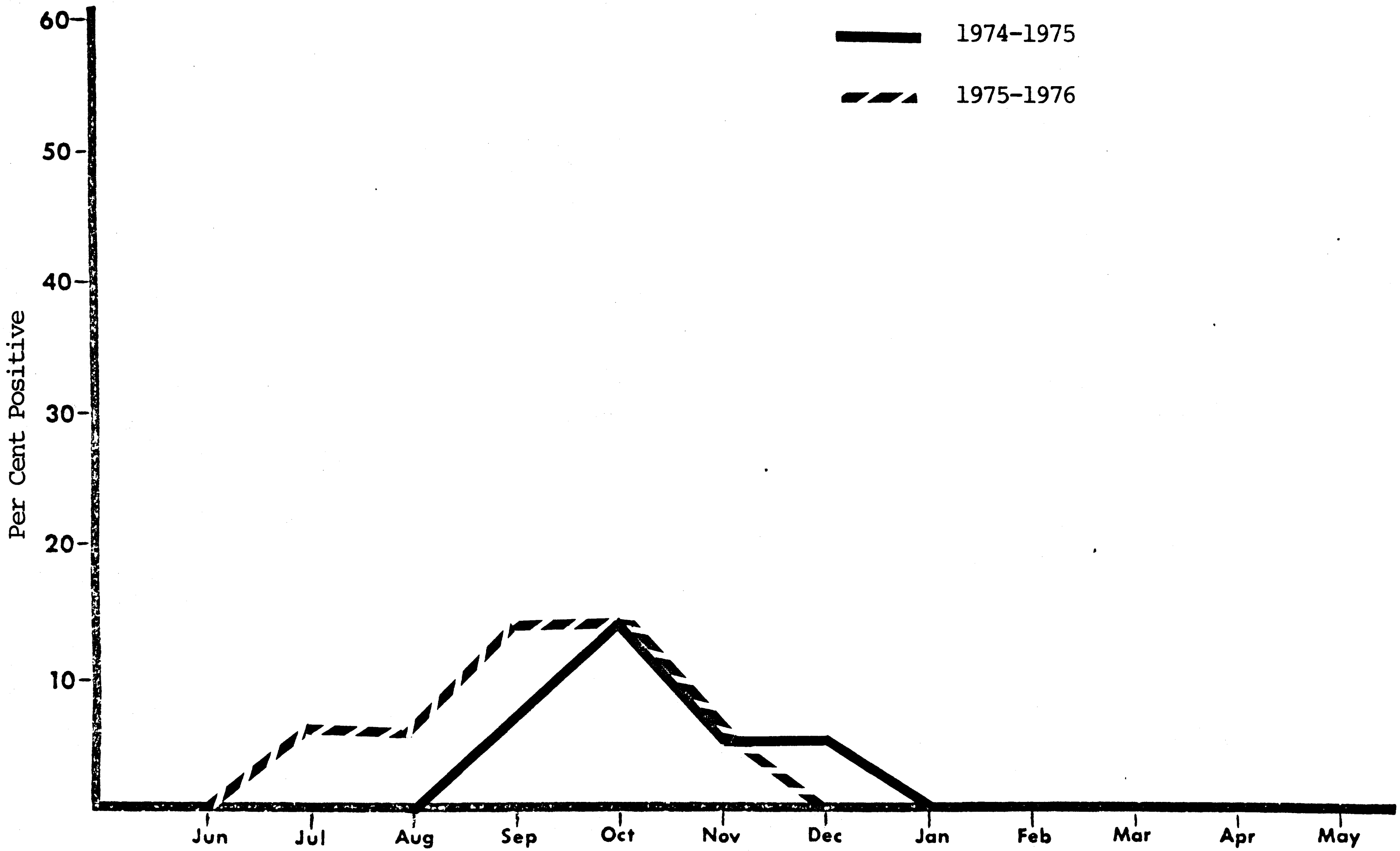

Fig. 5. Comparison of prevalence of Capillaria sp., based on fecal examination, in 15 elk.

Cestoda

The highest rate of infection by the broad tapeworm, *Moniezia benedeni*, occurred during the summer in both sample years, when four to five elk were shedding eggs (Fig. 6). There was a general decrease in the early fall until the rate leveled off in the winter.

Coccidia

During the first year of sampling the infection rate by *Eimeria* sp. was highest during the summer when almost half of the animals sampled were shedding eggs (Fig. 7). One to two animals were infected throughout the fall and winter. In the second year the highest rate of infection occurred in November and was usually low during the rest of the year.

Bull elk

Parasite infection rates for the individual bull elk were followed throughout the 22 month sampling period. Individual differences in antler structure and peculiar body markings provided excellent means for recognition and field identification of each bull. The bulls were given numbers for ease of identification.

All of the bulls carried stomach worm infections throughout the sampling period (Table 3).

Bull #1 was an 11-year-old with a rack of seven points on the right side and six points on the left. He was the herd bull, the one that did most of the mating, for at least three years. He was infected with *D.viviparous* in 14 out of the 22 months sampled and had a *T. ovis* infection from September through February of the first

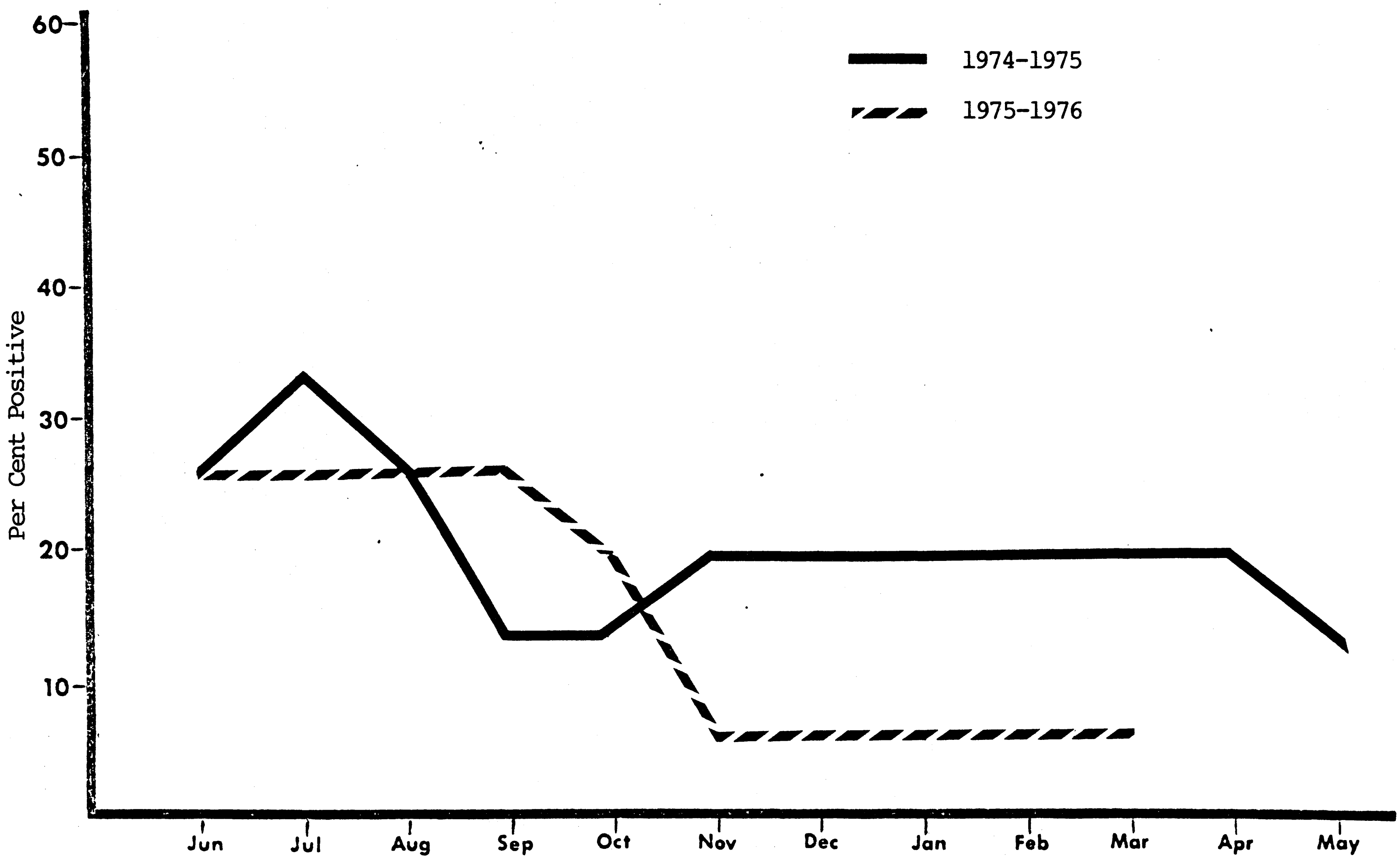

Fig. 6. Comparison of prevalence of Moniezia benedeni, based on fecal examination, in 15 elk.

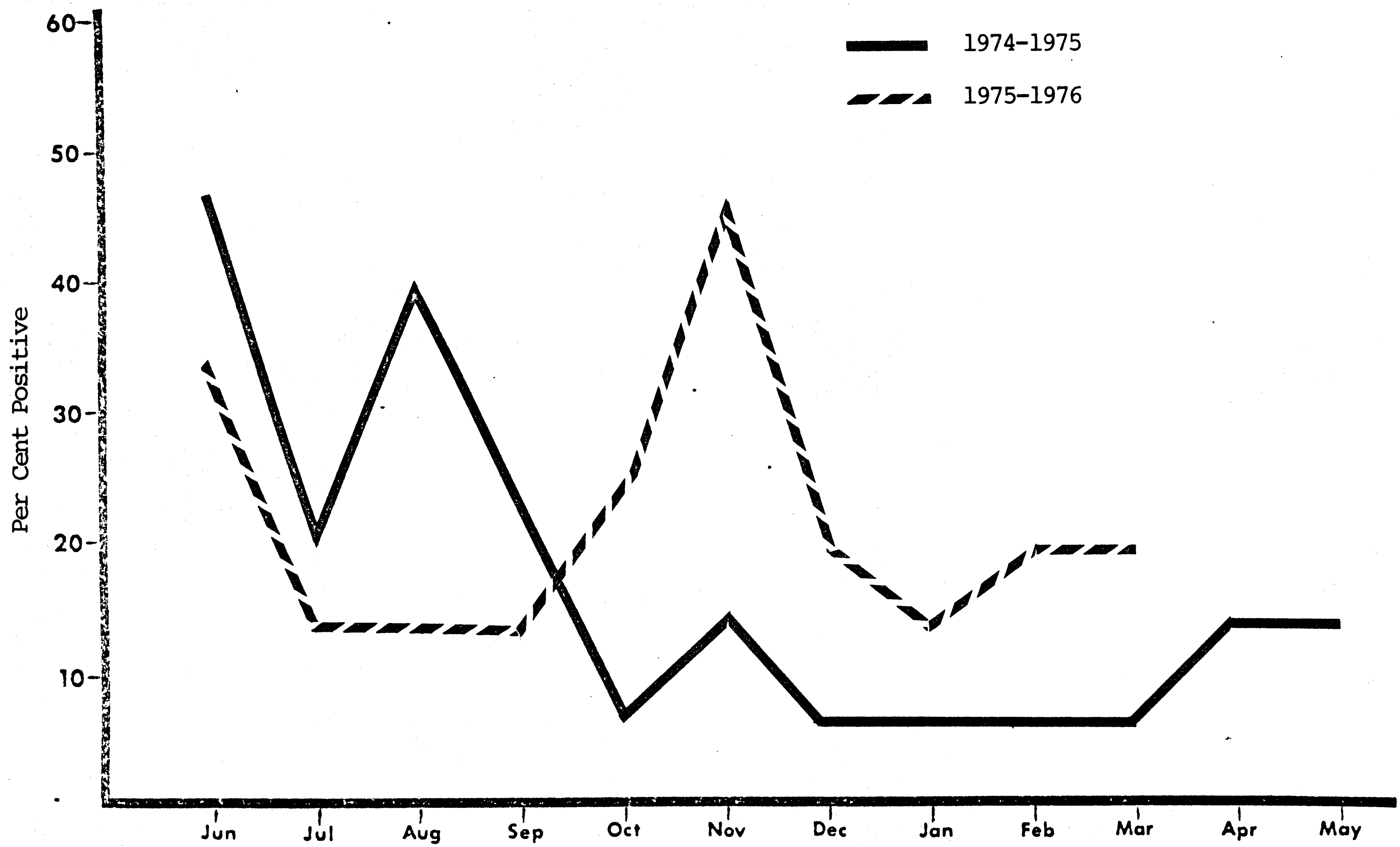

Fig. 7. Comparison of prevalence of Eimeria sp., based on fecal examination, in 15 elk.

Parasite	Prevalence (Per Cent)		
	1974-1975	1975-1976	Average
Stomach worms	100	100	100
Capillaria sp.	12.5	12.5	12.5
Dictyocaulus viviparous	41.6	45.0	43.3
Eimeria sp.	12.5	10.0	11.25
Moniezia benedeni	6.25	10.0	8.13
Nematodirus sp.	27.0	12.5	19.75
Trichuris ovis	25.0	30.0	27.5

Table 3. Average prevalence of parasites, based on fecal examination, in four adult bull elk.

year of sampling (Table 4). He was intermittently infected with Nematodirus sp.

Bull #2 was a six point bull with the herd for only ten months of the first year of sampling before he was moved to another area. He was infected with D. viviparous during the summer but showed no evidence of other parasitisms during the study.

Bull #3 was a 4-year-old with a six point rack. He was the most heavily parasitized of the bulls and was in poorer condition than the others, losing his antlers earlier and keeping his winter coat longer into the summer. He had Capillaria sp., Nematodirus sp., D.viviparous, T.ovis and Eimeria sp. infections simultaneously through much of the first year. He was in much better condition during the second year, having rid himself of the Nematodirus sp., D.viviparous and Eimeria sp. infections (Table 5). He continued to shed Capillaria sp. and T.ovis eggs sporadically.

Bull #4 was four years old, with an irregular rack of five points. He was sold in early January 1976 to a Chicago meat packing company. He was lightly parasitized during the first year of sampling. During the second year of sampling he had a M.benedeni infection for four months and D. viviparous for three months.

Bull #5 was nine years old, had a seven point rack and replaced Bull #2 in March 1975. He arrived at the game farm with a stomach worm infection, but picked up lungworms as early as May and carried them through November (Table 5). He shed Eimeria sp. eggs from June through September and T.ovis eggs from December through March 1976.

	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Stomach worms	*1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
Capillaria sp.				3	3 4	3	3			3
Dictyocaulus viviparous	3	1 2 3 4	1 2 3	2 3 4	3		1	1	1	1
Eimeria sp.	3		3				3	3	3	3
Moniezia benedeni									1 4	
Nematodirus sp.	1 3	3	1 3	3	3	3	3		3	3
Trichuris ovis				1 3	1 3	1 3	1 3	1 3	1 3	

Table 4. Monthly comparison of the parasitisms of individual bull elk, based on fecal examination. 1974-1975.

*#1 represents Bull #1.

	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
Stomach worms	*1 5 3 4	1 5 3 4	1 5 3 4	1 5 3 4	1 5 3 4	1 5 3 4	1 5 3 4	1 5 3 4	1 5 3 4	1 5 3 4
<u>Capillaria</u> sp.				3	3	3	3	3		
<u>Dictyocaulus viviparous</u>	1	1 5 4	1 5	1 5	1 5	1 5 4	1 5 4	1 5 4		
<u>Eimeria</u> sp.			5	5	5	5				
<u>Moniezia</u> <u>benedeni</u>	4		4		4	4	4			
<u>Nematodirus</u> sp.	1	1	1		5	1 5	1			
<u>Trichuris</u> <u>ovis</u>			3			3	3	3	5 3	5 3

Table 5. Monthly comparison of the parasitisms of individual bull elk, based on fecal examination. 1975-1976.

*#1 represents Bull #1

Gross examination of elk viscera

Three elk were examined by necropsy for the presence of parasites. An adult male elk was determined to be missing from the herd at feeding time in January 1975. However, a massive snowstorm at that time and continued heavy snowfalls through the remainder of the winter prevented success at locating him until 30 March 1975. He was located at that time in a decomposed state and only a portion of the gastro-intestinal tract could be recovered. Only one adult worm was found, and identified as *Cooperia* sp. by Dr. William Samuel, University of Alberta, Edmonton. The cause of death was not determined.

An adult female elk died in September 1975 and only the gastro-intestinal tract was recovered from the carcass. The animal had shown signs of malnutrition and had been emaciated throughout the summer. She had been wormed two days before her death. The cause of death was not determined but was probably due in part to the stress of worming added to the already poor condition of the animal. No evidence of parasitism was found.

A yearling cow elk died in April 1976 after exhibiting signs of illness, including circling and torticollis, for approximately 24 hours. The head and body had no wounds or bruises. The brain had no meningeal worms (*Odocoileostrongylus tenuis*) but was inflamed and abnormal in appearance, with the vessels enlarged and prominent. No pathology was evident in the lymph glands, spleen or mesenteries. The liver had no evidence of the giant liver fluke (*Fascioloides magna*).

The intestines, abomasum, cecum and lungs were examined grossly and then washed and the washings examined for parasites. The mucosal surfaces were examined under 20X magnification. Infections of *T.ovis* and Oesophagostomum sp. were detected in the cecum. Haemonchus sp. and Ostertagia sp. were present in the abomasum and D.viviparous in the bronchioles. Capillaria sp. and Eimeria sp. were not found in gross examination but were detected in fecal flotation. The abdominal worm Setaria yehi was not located in the visceral washings and no cysterci of Echinococcus granulosus were detected on the lungs.

DISCUSSION

Elk Herd

By far the most common of the parasites infecting the elk herd was the group of stomach worms. During the 22 month study period, 98.45 per cent of the elk were infected with stomach worms, or abomasal trichostrongyles (see Table 1). There was no seasonal prevalence detected, although it has been reported that under natural conditions transmission of infective larvae occurs primarily throughout the summer months (Foreyt 1969). This is especially true in areas where heavy summer grazing brings animals in close contact with the infective stages in the grass. However, the game farm feeding area provides an excellent site for constant re-infection of parasitisms. Throughout the year the elk feed and defecate in a concentrated area. Throughout the winter there is a large buildup of fecal material and feed, with the feed being contaminated quickly after being distributed. This allows eggs and infective larvae to be reacquired throughout the year, masking the usual summer and fall increases in prevalence such as are seen in Texas deer (Samuel 1969). Spring and summer samples from the game farm elk had generally larger numbers of eggs than did fall and winter samples. The number of eggs shed in the feces is not a direct reflection of the number of adult worms in the host but is only an indication of the egg producing activities of the female worms at that time (Foreyt 1969).

Soulsby (1965) reported that older animals develop immunity and resist gastro-intestinal worm infections. However, this mechanism appears to break down where there is continuous, long-term exposure to the nematodes, as is the case with the elk. The animals are continuously infected and re-infected with the stomach worms. Although there have been reports of stomach worms contributing to the debilitation of wild ruminants (Van Volkenberg 1943; Esch et al. 1975), this game farm herd was in excellent condition and seemed to suffer no ill effects from the stomach worm infections.

Nematodirus sp. infection in the elk was most prevalent in the summer and fall months (Appendix, Table 3). In the second year the rates were higher than during the first, possibly reflecting milder weather and therefore increased egg survival and higher re-infection rates. New infections are generally acquired during the warmer months when the eggs are able to survive and develop to the infectious stage, and infections are often retained through the winter. However, since embryonated *Nematodirus* sp. eggs are able to survive short periods of freezing (Samuel and Gray 1974), it is possible that the elk acquired new infections during the winter months. Adult worms may be expelled in the spring, thus reducing the number of animals infected, or they may be held until fall and then shed (Thomas 1959). In September of both years of sampling there was an abrupt decrease in the prevalence of *Nematodirus* sp., probably the result of the elk having shed the adult worms and not yet having acquired a new worm burden. The fairly erratic infection rates may also be a reflection of the different animals sampled each month.

Worley et al. (1969) considered *D. viviparous* the most important of the parasites infecting wild elk, being potentially the most pathogenic. It is more pathogenic in young animals than in adults, although in a host of any age the adult worms may group together and cause blockage of the bronchioles.

On the game farm the highest rate of D.viviparous infection occurred during the summer months, with a decrease in the fall (Appendix, Table 4). This fall decrease is attributed to an increase in larval mortality, as lungworm larvae are susceptible to dessication and freezing once passed in the feces. Barrett and Worley (1966) reported that the incidence and worm burden of D.viviparous in elk in winter varied directly with range conditions and use. A depleted range resulted in decreased host resistance and increased winter infections. However, on the game farm the range is supplemented with hay and peak re-infection rates occur in the winter when contamination of feed by fecal material, and therefore infectious larvae, is at a maximum. This results in the highest infection rates being detected in the summer after the parasites have completed their life cycles and the first stage larvae are actively being released. High temperatures in the summer of 1974 decreased larval survival and resulted in a lower rate of infection in the fall. The rate of infection was higher during the second year, probably due to mild weather allowing greater survival of infectious larvae.

The prevalence of T.ovis infection in the elk was highest in the fall and winter months, a trend which coincides with reports in the literature (Foreyt 1969; Samuel 1969). In both sample years the months September through March had the highest infection rates (Appendix, Table 5). The seasonal increase in prevalence is explained by the fact that T.ovis requires two months to develop from egg to adult in the host. Most infections are acquired in the summer when egg survival is the most efficient, and new adults begin producing eggs in the fall. Although infections may be carried through the winter, many are dropped, resulting in the lowest rate of infection occurring in the spring. Overall prevalence of T.ovis in the elk was low and it is unlikely that any pathogenic conditions resulted from the infections.

Capillaria sp. infections were evident in the elk only in the summer and fall months, with the highest prevalence occurring in October (Appendix, Table 6). These worms are closely related to Trichuris sp. and follow similar developmental patterns in the host. This results in an increase in prevalence in the fall and a decrease in the spring. Capillaria sp. are more easily detected in fecal flotation than in necropsy because the adults are extremely small and difficult to locate.

The tapeworm M. benedeni was detected in 18.9 per cent of the elk, with the highest rate of infection occurring during the summer months (Appendix, Table 7). The summer peak in infection rates coincides with the presence of the mites which serve as intermediate hosts for the parasite. Ruminants become infected by ingesting mites carrying the cysticercoid stage of the parasite. The greatest exposure to these mites occurs during the summer. The drop in the infection rate in the fall is due to the disappearance of the mites and to the development of host resistance to the worms (Kates 1965). The relatively high infection rate found in the winter on the game farm was probably due to re-infection from the contaminated feeding ground area. Full development of the parasite is not possible without the intermediate hosts, so eggs were apparently being ingested, passed through the digestive system without any development taking place and passed again in the feces. This provided a sort of false positive reading to the fecal samples, influencing the infection rate and making it impossible to determine which animals were actually infected with adult M. benedeni.

M. benedeni has been mentioned only rarely in the literature as a parasite of elk (Boddicker and Hugghins 1969; Flook and Stenton 1969). The tapeworm Thysanosoma actinoides has been reported more frequently as a parasite of elk (Hall 1930; Dikmans 1939; Alderson 1949; Jacobson et al. 1969; Worley et al. 1969). Flook and Stenton (1969) found adult M. benedeni in only one of 1380 elk examined, while T.actinoides was present in many. These worms are generally not found together in the same regions of the country and it appears that M. benedeni is the dominant tapeworm in the area of the game farm.

Eimeria sp. infections were detected in 19.5 per cent of the elk fecal samples examined, with the highest prevalence in the summer and fall (Appendix, Table 8). In the fall of 1975, mild weather allowed increased egg survival and development to the infectious stage, resulting in increased infection rates. These data are in conflict with those of Samuel (1969), who detected a peak in prevalence during the winter in white-tailed deer in Texas. However, the mild winter temperatures of Texas favor oocyst survival. Prevalence of Eimeria sp. in the game farm elk was at a low level each winter, as winter temperatures in Wisconsin inhibit oocyst sporulation and prevent re-infection. The intermittent pattern of infection in the elk indicates that lasting infections were not occurring. Eimeria sp. are fairly host specific (Levine 1963) and the lack of long-term infections indicates that the species of Eimeria was probably one that is abnormal in elk and that it was unable to complete its life cycle in them (Levine and Ivens 1970). There were several white-tailed deer on the game farm that were probably the normal hosts for the Eimeria sp. present. They were probably transmitting the parasite to the elk via the contaminated feed ground.

There is some evidence that elk develop immunity to *Eimeria* sp. within weeks of being infected (Alderson 1949). The *Eimeria* sp. infections in the game farm elk were probably self-limiting and not maintained long enough to be pathogenic.

The summer increase in the prevalence of some parasitisms was probably due to the onset of the calving season. The stress of calving often produces a massive release of parasite eggs and and increase in the parasitic fauna in the cows (Foreyt pers. comm.).

Parasitisms normally fluctuate in prevalence over a period of time, but certain factors aid in their dissemination. An important management practice to aid in controlling the spread of parasitism on the game farm would be the elimination of ground feeding in the winter. The constant contamination of the feed is resulting in continual re-infection of the animals. By feeding above ground, in bins or racks, fecal contamination of the feed could be prevented and the possibility of winter re-infection by parasites minimized. It will be important to monitor the diseases and parasites of the animals on a continuing basis.

Bull elk

In the wild situation the bull elk would ordinarily isolate themselves from the cows during much of the year. On the game farm the conditions regulated and altered their behavior patterns. The winter supplemental feeding program required that the herd remain together at a time when the bulls would usually run as a bachelor herd. The bulls left the herd only when grazing was possible and the calving season arrived. They joined the cows and calves with the onset of the rut in September.

These changes in herd composition influenced the pattern and types of parasitisms in the animals (Esch et al. 1975). The bulls and cows picked up infections from each other during the months they were together and either continued or dropped the infections while they were separated. The infection rates were higher in the fall and winter months when there was a more continuous re-infection process taking place. However, many of the worms do not release eggs until spring, resulting in a seemingly higher infection rate at that time. It has also been noted that fighting and other acts of social aggression decrease the resistance of an animal to parasitism, probably through the action of corticosteroids (Weinman and Rothman 1967). This may contribute to a higher infection rate in the fall when the bulls are in rut.

Overall, the stomach worms were present in both the bulls and cows with approximately equal frequency.

The primary foci of D.viviparous infection was in the bulls (Appendix, Table 2). It is possible that, while they re-infected each other regularly during the spring and summer when they were separated from the cows, they did not pass larvae to the cows except sporadically during the winter feeding season and during the rut. Larval survival is much less successful at these times and the cows probably were not easily infected. However, winter was the time of greatest concentration of larvae and the cows that did become infected probably did so at that time. Adult worms developed and began producing larvae by the summer months, resulting in the higher rate of infection in the cows.

The rate of T.ovis infection in the bulls was 25 per cent. The prevalence increased in the fall, reflecting the life cycle of the parasite. The two bulls that were periodically infected with T.ovis were the two most aggressive animals. They probably acquired the infections from the more heavily parasitized cows and then began shedding eggs in the late summer and fall.

Only two bulls were infected with Capillaria sp. in the first year of study; none of the cows showed any evidence of infection. The bulls were infected only during the rutting season, when the greatest degree of interaction occurs between the bulls and the cows. However, neither of the infected bulls was a breeder and therefore not in close contact with the herd, minimizing the rate of cross-infection. In the second year of study, one bull retained the Capillaria sp. infection while the other shed it. Only one cow was infected at this time, probably having acquired the infection from one of the bulls.

Nematodirus sp. infection was generally limited to one bull, which shed eggs almost continuously in the first year of study while the other bulls showed only intermittent infections. The others were probably ingesting eggs and shedding them again without actually harboring adult worms or any adult worms present may have been releasing eggs only sporadically. Bull #3 was in poor condition and was unable to repel the infection.

Eimeria sp. infections were evident in two of the bulls. Each carried the infections for several months in a row. However, Eimeria sp. are fairly host specific and it is unlikely that this species, which probably originated in the deer in the area, was retained in the bulls long enough to complete its life cycle or to become pathogenic.

Infection by M.benedeni was usually limited to one bull, which showed an irregular pattern of infection. The longest continuous infection was three months in the late summer and early fall of 1975. He probably built up a partial immunity to the parasite by fall and repelled the infection then. The absence of the mite intermediate hosts in the fall also resulted in a decrease in M.benedeni infection.

SUMMARY

Prevalence data for parasites detected by fecal examination were compared for fifteen game farm elk each month from June 1974 through March 1976. Five bull elk were individually followed in their parasitisms.

In the elk herd parasite seasonality was difficult to detect because of the variation in animals sampled each month. The general increase in parasitism that was evident in June and July was probably due to the effects of the stress of the calving season, which often produces a massive release of parasite eggs and an increase in parasitic fauna in the cows. A seasonal fluctuation in parasite prevalence was evident in the bull elk, with *Dictyocaulus viviparous*, *Nematodirus* sp., *Capillaria* sp., and *Eimeria* sp. being most common in the summer and fall months and *Trichuris ovis* in the winter months. Stomach worm prevalence was consistently high throughout the year.

A complete necropsy was conducted on one cow elk. Infections of *T.ovis* and *Oesophagostomum* sp. were detected in the cecum, *Ostertagia* sp. and *Haemonchus* sp. in the abomasum, and *D. viviparous* in the bronchioles. Fecal flotation revealed that *Capillaria* sp. and *Eimeria* sp. infections were also present. The brain was negative for *Odocoileostrongylus tenuis* and the liver contained no flukes. The cause of death was not determined.

The elk herd was infected by several genera of parasites but no clinical disease was evident. The irregular pattern of association with other ruminants and the contamination of the feed ground produced the possibility of nearly constant re-infection of the animals by the parasites present.

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Section II

Endoparasitism in Game Farm Bison and Deer

INTRODUCTION

In any situation where different species of ruminants share common range, there is the possibility of cross-transmission of diseases and parasites. Certain parasites can be limiting factors to the introduction of new ruminant species to an area (Anderson 1962), while others may present only mild disease threats.

Bison (Bison bison) and white-tailed deer (Odocoileus virginianus) are known to share several of the same parasites in the wild, such as Dictyocaulus viviparous, Moniezia benedeni, and several stomach worms (Boddicker and Hugghins 1969). All of the genera of parasites reported by Dunn (1968) to be present in bison have been reported in deer by Anderson (1962), indicating that the possibility of cross-transmission is high.

Approximately 30 bison were confined to an area on a game farm which has been described previously (See page 4). They shared a pasture with 30 elk (Cervus canadensis) through the fall and winter when supplemental feeding was necessary and then separated during the summer months. The feed ground was an ideal site for fecal contamination, increasing the possibility of cross-transmission of parasites between the bison and elk. Eveleth (1955) suspected bison to be the source of nematode Trichostrongylus axei, which killed two elk after the elk and bison had shared a pasture for a short time, and reported that localized feeding areas on the ground should be avoided if at all possible because of the disease implications. Bison and elk share many of the same parasites (Boddicker and Hugghins 1969), making it important to monitor the parasitisms of a combined or intermixing herd.

Between ten and fifteen white-tailed deer shared the same pasture with the elk and bison and generally appeared to remain within the fenced area, although they were able to get through the fence at one spot if desired. They periodically moved into the feeding area after the elk and bison left, but usually remained in one corner of the pasture. At night they grazed the same areas as did the elk and bison, introducing the possibility of parasite contamination. Deer generally present little parasitic threat to elk other than the meningeal worm, *Odocoileostrongylus tenuis* (*Pneumostrongylus tenuis*). Young elk, caribou and moose are often fatally infected with this parasite, whose natural host is the white-tailed deer, and in whom is produced little or no pathology (Trainer 1973).

This study was undertaken to determine if the deer and bison were sharing parasitisms and to determine if they were transmitting parasitisms to the elk on the farm.

METHODS

Fecal samples were collected from ten bison in June 1974, June and January 1975, and January 1976. Fecal samples from ten white-tailed deer were collected in December 1974 and December 1975. The fecal flotation procedure utilized has been previously described (See page 8).

RESULTS

Bison

The bison had a very high rate of infection by the stomach worm complex, which includes Haemonchus sp., Ostertagia sp., Oesophagostomum sp., Cooperia sp., and Trichostrongylus sp. In both June sampling periods all of the bison sampled were positive for stomach worms (Table 1). January 1975 was the only sample period with less than 100 per cent infection.

D.viviparous was second to the stomach worms as the most prevalent of the endoparasites infecting the bison. Both January samples showed a 30 per cent infection rate. There was a substantial increase to 80 per cent in June 1974 and to 60 per cent in June 1975.

Nematodirus sp. infection was present in the bison in fairly low percentages. Between 20 per cent and 30 per cent of the bison were infected with this parasite during the sampling periods.

Trichuris ovis infection was detected in the bison only in the winter samples. In the first year of sampling 20 per cent were infected and in the second year 40 per cent.

M.benedeni was present in the June samples only. In the first year of sampling, 20 per cent were infected and in the second year only 10 per cent.

Deer

All of the white-tailed deer sampled carried stomach worm infections but none showed evidence of Nematodirus sp., T.ovis, or M.benedeni.

In 1974, 33 per cent of the deer were infected with Eimeria sp.,

Parasite	Prevalence (Per Cent) 1974-1975 June	1974-1975 Jan.	1975-1976 June	1975-1976 Jan.	Average
Stomach worms	100	80	100	100	95
Dictyocaulus viviparous	80	30	60	30	50
Nematodirus sp.	20	30	30	30	27.5
Trichuris ovis	0	20	0	40	15
Moniezia benedeni	20	0	10	0	7.5

Table 1. Comparison of prevalence of parasitism, based on fecal examination, in ten bison.

while 20 per cent were in 1975 (Table 2).

D.viviparous was present in 10 per cent of the deer.

The meningeal worm, O.tenuis, was present in 25 per cent of the deer, which are the normal hosts for this parasite.

Parasite	Prevalence (Per Cent) 1974 December	1975 December	Average
Stomach worms	100	100	100
Eimeria sp.	33	20	26.5
Dictyocaulus viviparous	10	10	10
O.tenuis	20	30	25

Table 2. Comparison of prevalence of parasitism based on fecal examination, in ten white-tailed deer.

DISCUSSION

Bison

One hundred per cent of the bison were infected with stomach works in all but one sample period. Swales (1933) and Dunn (1968) also reported high levels of stomach worm infections in bison. It is unlikely that those animals not actively shedding eggs during the one sample period were actually free of worms. More probably, the adult worms in the animals were not producing eggs at the time of sampling. Egg production varies considerably from time to time and may cease at certain times (Foreyt 1969). The rate of infection in the other sampling periods (100 per cent) indicates that the bison were being continually parasitized by the stomach worms. The high rate also found in the elk (98 per cent) indicates that, although the elk and bison were infecting each other while they were feeding together in the winter, both maintained infections among themselves when they were separated.

D.viviparous was the most prevalent of the other endoparasites infecting the bison. This is in agreement with reports by Frick (1951), Lockner (1953) and Meagher (1973). Infections showed a distinct seasonal fluctuation in prevalence, with the rate being higher in the June samples than in the January samples. This corresponds with the seasonal variations in D.viviparous infections in the elk. First stage larvae are shed throughout the year but the maximum transmission potential occurs in the winter when the bison and elk are in close contact with each other, concentrating large numbers of larvae and consuming contaminated feed. D.viviparous larvae are easily killed by dessication (Rose 1956), thereby reducing the possibility of transmission during hot summer months.

Nematodirus sp. infection was consistently low throughout the sampling period. This suggests long-term infections maintained by intermittent re-infections. Most new infections were probably acquired during the fall and winter and were retained through the spring and summer. In most wild populations, Nematodirus sp. infections are generally acquired in the fall by susceptible young and are retained through the winter (Foreyt 1969).

T.ovis infections were evident only in the winter samples. This is a pattern similar to that in the game farm elk. Although the elk continued to shed some T.ovis eggs in summer, the bison were separated from them at that time, reducing the possibility of cross-transmission. The bison probably acquired the infections from the elk during the winter when the animals were concentrated near the feeding site.

M.benedeni was present in the bison only in the June samples. This was due to the presence of the mites which are necessary as intermediate hosts for the parasite. The period of highest infection occurred in the summer when the mites were more numerous and were frequently ingested by the bison. The bison probably developed resistance to the infections by fall and eliminated the worms at that time. M.benedeni is a common parasite of wild bison (Boddicker and Hugghins 1969), and the infection on the game farm probably was initiated in the bison and transmitted to the elk.

Capillaria sp. was not found in the bison, although it was present in the elk. Possibly the low rate of infection and the limited duration Capillaria sp. egg shedding by the elk produced little opportunity for the bison to acquire the parasite. However, the practice of feeding hay on the ground to both the bison and the elk should be eliminated. The site is ideal for the transmission of parasites between the ruminants. Some of the parasites present on the area are potentially pathogenic, and an effort should be made to limit their dissemination.

Deer

The deer were probably the foci of Eimeria sp. infection, transmitting it to the elk. The host specificity of this parasite prevented it from becoming more than a temporary resident in the elk (Levine 1963).

D.viviparous is often found in deer but is generally considered nonpathogenic in them (McDonald 1969). The deer probably acquired the lungworm from the more heavily infected elk and bison.

O.tenuis is common throughout much of North America and is nonpathogenic in deer, its normal host. It is lethal to young moose, caribou and elk (Carpenter et al. 1973) and may establish itself in areas where different species of ruminants intermix. This parasite has been implicated in several unsuccessful attempts to introduce susceptible ruminants into various areas of the United States, including one involving caribou and moose in northern Wisconsin (Trainer 1973).

There have been no apparently successful infections by O.tenuis in the bison. However, three elk died after exhibiting some difficulty walking, circling and other signs similar to those of neurologic disease. The meningeal worm was not located in any of the animals at necropsy and the cause of death was not determined.

Since a fairly low percentage of the deer herd was infected with O.tenuis, a high concentration of animals would be necessary to insure transmission to the elk. The most likely area for this would be on the feed ground, where conditions were more favorable to larval survival. This did not appear to be occurring, possibly because the deer went to the feed ground only after the bison and elk had left and too few larvae were passed at that time. Suitable gastropods are necessary as intermediate hosts for O.tenuis and they may not be present in the area of the feed ground, reducing the possibility of infection originating there. Few deer tended to visit the area at one time, minimizing the amount of contamination. Most of the elk were in excellent condition, minimizing their susceptibility to the parasite. However, the larval stages may survive in the soil for years and the potential exists on the game farm for the meningeal worm to develop into a serious problem, and its presence limits the introduction of certain ruminant species into the area.

SUMMARY

Prevalence data for endoparasites detected by fecal examination were compared for ten game farm bison and ten white-tailed deer. Data also were compared with that from 15 game farm elk.

The bison were parasitized by *Nematodirus* sp., *Dictyocaulus viviparous*, *Moniezia benedeni*, and stomach worms. Infections were primarily acquired in the winter when the bison were in close association with the elk on a feed ground. This resulted in an increase in the rate of infection in June. The bison and elk were probably re-infecting each other continuously during the winter and intermittently during the summer.

The deer had infections of *D.viviparous*, *Eimeria* sp., stomach worms and the meningeal worm *Odocoileostrongylus tenuis*. They were probably the focus of *Eimeria* sp. infection and were periodically infecting, which were unable to retain the infections for long. The deer were the only ruminants sampled on the game farm that carried *O. tenuis*. However, the presence of this parasite is a threat to any young or sickly elk and is a deterrent to the introduction of moose or caribou to the area.

Some of the possible reasons for differences in parasite prevalence within the ruminant species as well as between the species were presented and discussed.

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Appendix I

Common Name	Scientific Name
Blackberry	*Rubus* spp.
Bluestem	*Calamagrotis canadensis*
Boneset	*Eupatorium* sp.
Burdock	*Rumex* spp.
Canada bluegrass	*Poa compressa*
Cattail	*Typha latifolia*
Cinquefoil	*Potentilla palustris*
False buckwheat	*Polygonum cilinode*
Goldenrod	*Solidago* sp.
Hawkweed	*Hieracium* sp.
Horsetail	*Equisetum* sp.
Iris	*Iris versicolor*
Lycopus	*Lycopus* sp.
Marsh bedstraw	*Galium tinctorium*
Marsh fern	*Thelyptra palustris*
Marsh scullcap	*Scutellarius galericulata*
Meadow bluegrass	*Poa palustris*
Meadow rue	*Thalictrum* sp.
Panicum	*Panicum* sp.
Plantain	*Plantago* sp.
Pussytoes	*Antennaria* sp.
Quackgrass	*Agropyron repens*
Redtop	*Agrostis* sp.
Reed canary grass	*Phalaris arundinacea*
Rice cut grass	*Orozomys* sp.
Sedges	*Carex* spp.
Sensitive fern	*Onoclea sensibilis*
Smooth brome	*Bromus inermis*
Steeplebush	*Spirea tomentosa*
Swamp milkweed	*Asclepias incarnata*
Thistle	*Cirsium* spp.
Timothy	*Phleum pratense*
Vetch	*Vicia* spp.
Violet	*Viola* spp.
Watercress	*Nasturtium* sp.
Wild strawberry	*Fragaria vesca*
Wintergreen	*Gaultheria* sp.
Wood sorrel	*Oxalis* sp.
Yarrow	*Achillea millefolium*

Table 1. Principal plants occurring on the West Game Farm, Waupaca Country, Wisconsin.

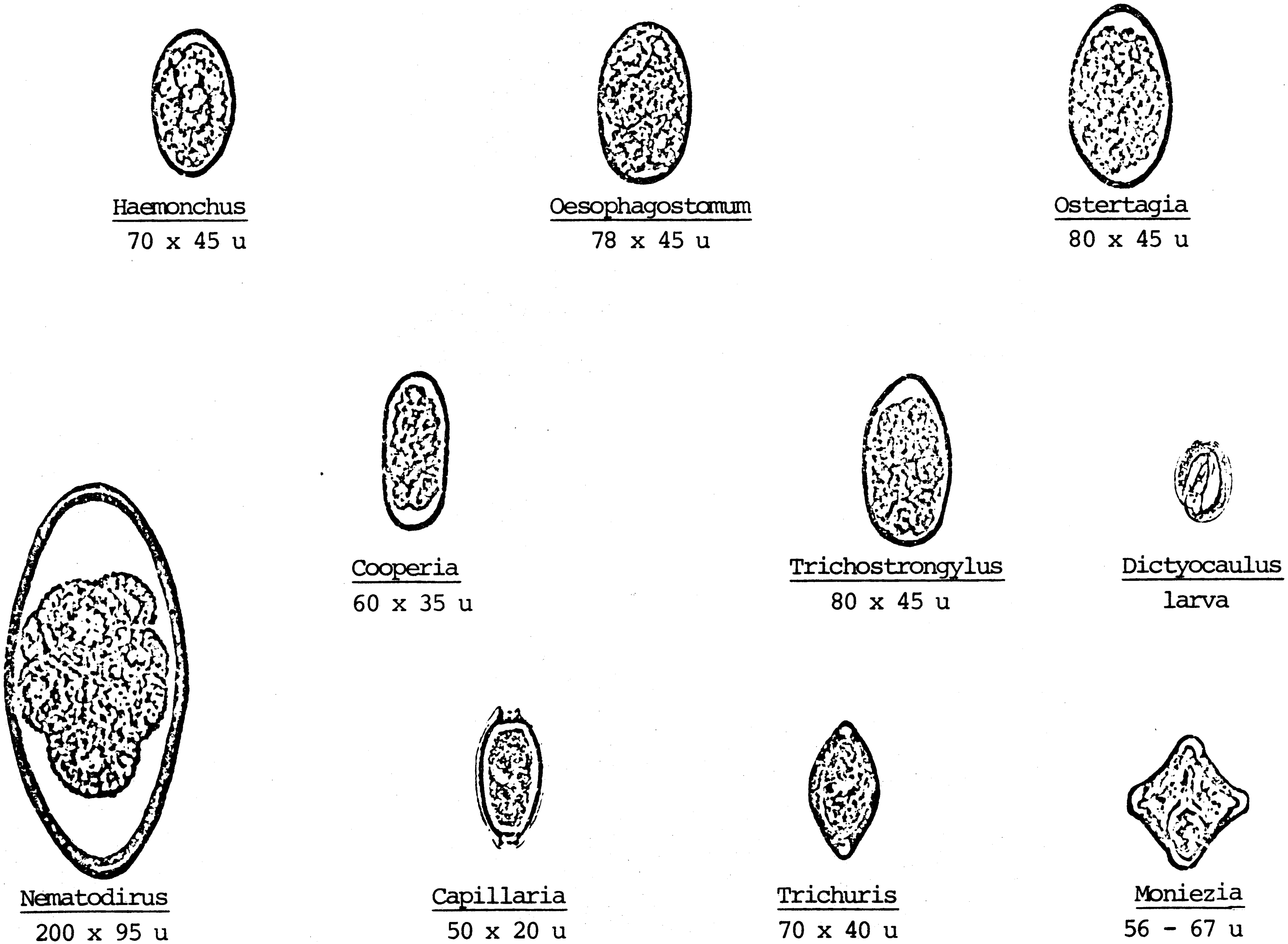

Fig. 1. Some parasite eggs and larva occurring in elk fecal samples.

Benbrook & Sloss, 1965

Month	Prevalence (Per Cent)					
	Nematodirus sp.		*Dictyocaulus viviparous*		*Eimeria* sp.	
	Cows	Bulls	Cows	Bulls	Cows	Bulls
June	0	50	18	25	55	25
July	27	25	18	100	27	0
August	0	50	9	75	45	25
September	0	25	9	75	27	0
October	18	25	9	25	9	0
November	0	25	9	0	18	0
December	0	25	9	25	0	25
January	18	0	0	25	0	25
February	9	25	9	25	0	25
March	0	25	9	25	0	25
Average	7.2	27.5	9.9	40.0	18.1	15.0

Table 2. Comparison of prevalence of selected parasites, based on fecal examination, in cow and bull elk.

Month	Prevalence (Per Cent)		
	1974-1975	1975-1976	Average
June	13	13	13
July	26	40	33
August	13	40	26.5
September	6.6	20	13.3
October	20	40	30
November	6.6	40	26.5
December	6.6	20	13.3
January	13	20	16.5
February	13	20	16.5
March	6.6	13	9.8
April	13		
May	6.6		
Average	12	26.6	19.3

Table 3. Comparison of prevalence of *Nematodirus* sp., based on fecal examination, in 15 elk.

Month	Prevalence (Per Cent)		
	1974-1975	1975-1976	Average
June	20	40	30
July	40	46	43
August	26	40	33
September	26	40	33
October	13	33	23
November	6.6	26	16.3
December	13	13	13
January	6.6	13	9.8
February	13	13	13
March	13	20	16.5
April	13		
May	26		
Average	18	28.4	23.2

Table 4. Comparison of prevalence of *Dictyocaulus viviparous*, based on fecal examination, in 15 elk.

Month	Prevalence (Per Cent)		
	1974-1975	1975-1976	Average
June	0	6.6	3.3
July	6.6	13	9.8
August	6.6	6.6	6.6
September	26	13	19.5
October	26	20	23
November	20	20	20
December	26	26	26
January	13	26	19.5
February	13	26	19.5
March	6.6	20	13.3
April	6.6		
May	6.6		
Average	13	17.7	15.4

Table 5. Comparison of prevalence of *Trichuris ovis*, based on fecal examination, in 15 elk.

Month	Prevalence (Per Cent)		
	1974-1975	1975-1976	Average
June	0	0	0
July	0	6.6	3.3
August	0	6.6	3.3
September	6.6	13	9.8
October	13	13	13
November	6.6	6.6	6.6
December	6.6	0	3.3
Janaury	0	0	0
February	0	0	0
March	0	0	0
April	0		
May	0		
Average	2.73	4.58	3.7

Table 6. Comparison of prevalence of *Capillaria* sp., based on fecal examination, in 15 elk.

Month	Prevalence (Per Cent)		
	1974-1975	1975-1976	Average
June	26	26	26
July	33	26	29.5
August	26	26	26
September	13	26	19.5
October	13	20	16.5
November	20	6.6	13.3
December	20	6.6	13.3
January	20	6.6	13.3
February	20	6.6	13.3
March	20	6.6	13.3
April	20		
May	13		
Average	22.0	15.7	18.9

Table 7. Comparison of prevalence of *Moniezia benedeni*, based on fecal examination, of 15 elk.

Month	Prevalence (Per Cent)		
	1974-1975	1975-1976	Average
June	46	33	39.5
July	20	13	16.5
August	40	13	26.5
September	20	13	16.5
October	6.6	26	16.3
November	13	46	29.5
December	6.6	20	13.3
January	6.6	13	9.8
February	6.6	20	13.3
March	6.6	20	13.3
April	13		
May	13		
Average	16.5	21.7	19.5

Table 8. Comparison of prevalence of *Eimeria* sp., based on fecal examination, in 15 elk.

Appendix II

Behavior in a Game Farm Bull Elk

Wild animals placed in a restricted environment alter their behavior and activity patterns in response to the physical environment as well as to their temperamental states (Esch et al. 1975). As time passes and they adjust, or fail to, to their new surroundings, their behavior changes accordingly. The bull elk (Cervus canadensis) in this study had been confined on the West Game Farm near Waupaca, Wisconsin for ten years and had progressed to a semi-wild state. He was eleven years old with a five point rack in velvet at the time of the study. His fully developed rack was seven points. He spent most of the time with another seven point bull, not intermixing with the cows or calves to any degree.

The statistics and material in this paper were compiled from an ongoing study of elk on the game farm. Data from 60 hours of observation in June 1975 are included here, with most being hours of daylight. Most observations were made without the aid of binoculars, since it was quite easy to work within 50 meters of the animals.

The entire herd of elk, numbering around 30, was generally less alert, less wary and more sedentary than elk in the wild (Altmann 1956; Darling 1963). By observing the behaviour patterns of the various animals in the herd it was possible to distinguish which ones had been confined for several years and which ones were new arrivals from the wild. Although they had lost much of their fear of man, the game farm elk still showed a certain amount of wariness and the basic behavior and activity patterns were present.

Craighead (1973) mentioned that elk movements are often quite localized, especially in the summer. I found this to be true, with almost all activity taking place on less than 123 ha. of land even though the area was large enough to allow considerable freedom of movement. There were only occasional forays onto other parts of the land. The area where the bull spent the majority of his time had an old barn on it. The lower section of the barn was left open for the elk and this is where they spent most of their bedding time since it was somewhat cooler inside.

Behavior Patterns

Ingestive

During four observation periods in June 1975, ingestive behavior was found to be only an intermittent occurrence in the daylight hours. The weather was very hot and humid and the animals tended to do most of their grazing in the cooler evening and night-time hours.

The bull usually grazed for 15 minutes or less at a time during the day and continuously for periods up to 1½ hours at night. He often interrupted his grazing with short visual investigations of the area. He walked continuously while grazing.

The act of grazing consisted of using the lips to guide grasses into the mouth. The grasses were nipped off with a quick jerk of the head, and swallowed every 10-16 bites. The bull generally tended to eat the shorter grasses, nibbling at the taller ones only while preoccupied with something else, such as investigating a deer.

The bull usually drank while standing in the middle of the water ditch. The lips were together and were placed just under the surface of the water while sucking, much in the same manner of a horse drinking. This was often accompanied by sloshing the head back and forth, possibly to splash flies off of his face. Drinking occurred most often in the late evening.

Investigative

Investigatory behavior was a common occurrence although not very time consuming, possibly because these animals were in a relatively safe and stable environment compared to that of the wild. The bull often interrupted his grazing to lift his head and look around. If he spotted something, most often a deer, he raised his nose high in the air and sniffed. From many observations of this pattern, it was apparent that he was constantly listening while grazing, used sight to locate what he heard, and used his olfactory abilities to confirm his investigations. A gunshot at close range was the only sound observed to startle the bull.

The sound of the landowner's truck elicited the most consistent response from the bull. He would stop any activity to come to the truck and examine it for any grain. During the winter when the herd is fed hay and grain, the animals hear the truck up to five minutes before it arrives at the feeding site. The sounds of similar trucks are ignored.

The bull occasionally stopped his grazing to move slowly toward me as I sat watching him. He always had his head stretched out and sniffed audibly. He generally lost interest rapidly and returned to his grazing.

<u>Eliminative</u>

Defecation occurred regularly just after the animal had risen from being bedded down. The tail was lifted to an angle at least 45 degrees to the back, feces were dropped and the tail held up for another 2-5 minutes until more feces were dropped. The tail was then lowered. After a long bedding period this often occurred while the animal was standing or investigating. When defecating after a short rest or during activity, there was less fecal material dropped and it was deposited all at once; even so, the tail was often held upright for a few minutes. Defecation did not interrupt concurrent activities such as grazing, and did not appear to take place in any specific area, although there was a larger accumulation near favored resting areas.

Urination involved stretching the front legs forward and crouching the hindquarters a bit. The bull often actively investigated the area while urinating, possibly because he was in an awkward and vulnerable position. Urination was more frequent during darkness, and the bull was observed twice urinating while standing hock deep in water.

Shelter-seeking

In the case of the bull, shelter-seeking was synonymous with bedding. The favorite place was the barn, where it was dark, cooler and the flies were not so numerous as outside. While inside the barn, the bull laid down and ruminated, especially between 9:00 a.m. and 11:00 a.m. after a night of grazing. By 1:00 p.m. he appeared to have completed rumination, and rested and slept. On hot, sunny days he spent up to six hours at a time inside the barn; on cloudy or rainy days, less than one hour was spent in the barn. Entering and leaving the barn was almost always done in the company of other elk. I observed him entering the barn alone only once, and he turned around and came back out immediately.

Agonistic

Agonistic behavior, since the antlers were in velvet, consisted mostly of making threats and bluffs rather than actual physical combat. The most common action observed was between two bulls as they grazed near each other. When one violated the other's individual distance requirements, they started lowering their heads at each other, then raised their noses and snorted. They often made a crying sound while doing this. The effect was immediate and the transgressor retreated, at least for the moment. According to Scott (1972) the primary function of agonistic behavior "is the regulation of distance between individual animals" and this was obviously the case in the elk. I observed them locking antlers only once and this was for less than ten seconds.

The "antler threat" (McCullough 1969) was observed most often and was very effective in forcing the aggressor to keep his distance. The threat, lowering the head and moving toward the other animal, was observed only against another bull. No threatening acts were observed to be directed at cows.

When the bull approached me as I sat nearby, he usually raised and lowered his head several times, sniffed the air and occasionally ground his teeth when he was within ten feet. The teeth grinding may have been meant as a threat or possibly was an indication of his own tension.

<u>Allelomimetic</u>

Grazing was the only allelomimetic behavior observed in the bull. This was usually done within ten meters of another bull and travels to and from the barn and grazing areas were consistently done in conjunction with another animal's movements. When leaving the shelter of the barn, one animal, usually a young female, acted as an investigator. If she continued out to the grazing areas the others then followed. If she turned back into the barn, all stayed inside. The bull never left the building first if there were cows inside.

No epimeletic, et-epimeletic or sexual behavior was observed during 60 hours in June. The bulls remained separated from the cows and calves for several months each year, including the summer months, and had no part in the care and upbringing of the young. No educational behavior was observed.

Summary of 60 Hours of Activity in June

Activity	June 14		June 15		June 21		June 22	
	Hours	%	Hours	%	Hours	%	Hours	%
Bedding	11:02	78.6	9:20	77.8	10:30	58.3	10:20	64.5
Feeding	1:45	12.6	1:41	14.1	6:13	34.6	4:34	28.6
Standing	:22	2.6	:19	2.6	:21	2.0	:12	1.2
Traveling	:12	1.4	:15	2.0	:24	2.2	:18	1.9
Agonistic	:11	1.4	:14	2.0	:18	1.7	:14	1.5
Grooming	:06	.7	:05	.7	:07	.6	:06	.6
Investigatory	:23	2.7	:06	.8	:07	.6	:16	1.7
TOTAL	14:00	100.0	12:00	100.0	18:00	100.0	16:00	100.0

Bedding-Lying down, usually in the barn, often ruminating.

Feeding-Grazing or drinking.

Standing-Standing still, usually just after getting up.

Traveling-Moving to and from the barn, grazing areas and water.

Agonistic-Threatening or combative motions with another elk.

Grooming-Scratching neck with hind hoof, scratching flanks or back with antlers, biting and rubbing body parts.

Investigatory-Looking around, sniffing, listening alertly.

SUMMARY

A bull elk on the West Game Farm, Waupaca, Wisconsin was observed on four separate occasions in June 1975. He demonstrated behavior and activity patterns consistent with his species but somewhat altered due to the immediate environment. In the wild he would ordinarily have been running with a herd of bulls, separate from the cows and calves. Because he was fed supplemental hay periodically and had abundant food, he probably grazed less than he would have in the wild. He was safer and more secure, investigated less and rested more than animals in the wild. The process of taming lessened his fear of man. The most common activity of the bull was bedding, or resting. The game farm situation had altered the behavior patterns of the bull but he still exhibited many activity patterns similar to wild elk.

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