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## EIMERIA SP. (APICOMPLEXA: EIMERIIDAE) FROM WYOMING GROUND SQUIRRELS (*SPERMOPHILUS ELEGANS*) AND WHITE-TAILED PRAIRIE DOGS (*CYNOMYS LEUCURUS*) IN WYOMING

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**ABSTRACT.**—Six species of the coccidian genus *Eimeria* (*E. larimerensis* [prevalence = 17%], *E. bilamellata* [12%], *E. beecheyi* [34%], *E. morainensis* [43%], *E. callospermophili* [21%], and *E. spermophili* [5%]) were recovered from Wyoming ground squirrels (*Spermophilus elegans elegans*) collected during 1983, 1984, 1985, and 1986. Infected ground squirrels were found to harbor from one to five species simultaneously. The 1007 hosts examined were collected from two different habitats: (1) a xeric desert shrub-steppe and (2) an irrigated alfalfa-brome field. All species of *Eimeria* occurred at each study site during all years, although the prevalence of each species varied between years. This is the first report of these congeries of species infecting this host. In a second study of sympatric populations of Wyoming ground squirrels and white-tailed prairie dogs (*Cynomys leucurus*), we found three species of *Eimeria* present in both host populations (*E. beecheyi* [white-tailed prairie dog prevalence = 83%, Wyoming ground squirrel = 52%], *E. morainensis* [22%, 52%], and *E. bilamellata* [17%, 10%]). This is the first report of these three species infecting white-tailed prairie dogs. *Eimeria larimerensis* was found in Wyoming ground squirrels but not in prairie dogs.

Levine and Ivens (1990) recently reported 17 species of *Eimeria* from ground squirrels of the genus *Spermophilus*. In most cases these species of *Eimeria* were described from small samples of hosts collected from restricted geographic locations, and only 1 or 2 species were recovered from the limited sample population of squirrels. They listed no species from the Wyoming ground squirrel, *Spermophilus elegans* Kennicott, 1863.

Additionally, Duszynski (1986) has reported that the host specificity of the coccidian genus *Eimeria* may be rather broad. For example, *Eimeria bilamellata* Henry, 1932 has been reported in nine species of ground squirrels (*Spermophilus* spp.) (Levine and Ivens 1990); and *E. larimerensis* Vetterling, 1964 has been found in five ground squirrel species, white-tailed prairie dogs (*Cynomys leucurus* Merriam, 1890) (Todd and Hammond 1968a), and black-tailed prairie dogs (*C. ludovicianus* Ord, 1815) (Vetterling 1964). Cross-transmission experiments with oocysts from prairie dogs inoculated into ground squirrels have been successful (Todd and Hammond 1968a, 1968b, Todd et al. 1968).

The purpose of this paper is to report the prevalence of six eimerian species in two

populations of Wyoming ground squirrels occurring in two habitats and to report the eimerian parasites of sympatric populations of Wyoming ground squirrels and white-tailed prairie dogs.

### METHODS

As part of an ongoing study on the life history of the Wyoming ground squirrel, 1007 individuals were examined for the presence of coccidian parasites of the genus *Eimeria* over a four-year period. These hosts were collected from two habitats: (1) xeric cold desert shrub-steppe, 14 km north of Baggs, Wyoming (107°45'W, 41°17'N) and (2) an irrigated alfalfa-brome field, 10 km south of Laramie, Wyoming (105°33'W, 41°12'N).

In late June and early July of 1983 and 1986 ground squirrels were snap-trapped in both study areas using three 40 × 50 trapping grids (0.6 ha) with traps set every 5 m (240 total traps). In 1984 and 1985 squirrels were randomly shot within the study sites throughout their summer active season (April–August). All squirrels were weighed, sexed, and necropsied. Fecal material was obtained during necropsy from the lower large intestine.

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The second study was initiated in conjunction with a white-tailed prairie dog study conducted by Menkens and Anderson (1989). The study area, located 11 km south of Laramie, Wyoming (105°40'W, 41°20'N), contained populations of both *C. leucurus* and *S. elegans* as well as a small population of 13-lined ground squirrels (*S. tridecemlineatus* Mitchell, 1821). A trapping grid of 11.3 ha containing 176 National live traps was established. Traps were baited with oats and opened before daylight each morning. After a four-hour trapping period the traps were closed for the remainder of the day. Trapped animals were weighed, sexed, and released; feces were collected from each trap following the animal's release. Trapping occurred over a five-day period, 3–7 July 1987.

All fecal samples collected in both studies were placed in 2% potassium dichromate solution at room temperature (25 C) for two to three weeks to allow oocyst sporulation for species identification. Sporulated oocysts were isolated by flotation in saturated sucrose flotation solution (specific gravity = 1.2) and identified at 100X objective with an Olympus (CH) compound microscope.

## RESULTS

In the first study 613 ground squirrels were collected from the irrigated site and 394 from the xeric site. Six species of *Eimeria* were found infecting both populations. For the entire sample, 26% of the squirrels harbored one eimerian species, 26% had two species, 13% had three species, 2% had four, and only two animals were infected with five species simultaneously.

During the four-year sampling period, 168 of 1007 (17%) *S. elegans* examined were infected with *E. larimerensis*. Significantly more hosts were infected in the irrigated study site (23%) than in the xeric site (6%) ( $\chi^2$ ,  $p \leq .01$ ) (Table 1).

*Eimeria bilamellata* was found infecting 11% of the squirrels examined. The prevalence of *E. bilamellata* varied among years and sites but there were never more than 21% of the hosts infected at any site during any year (Table 1). Overall, there was no significant difference in prevalence between the two sites over the four years ( $\chi^2$ ,  $p \leq .10$ ).

*Eimeria beecheyi* Henry, 1932 was the second most prevalent species found during the study (34%), and for the four-year period the prevalence was higher in the alfalfa field (38% vs. 27%), but the difference was not significant ( $\chi^2$ ,  $p \leq .10$ ) (Table 1).

*Eimeria morainensis* Torbett, Marquardt, and Carey, 1982 was the most prevalent species found during the study (43%). Significantly more hosts were infected with this species at the irrigated site (55% vs. 25%) during the four years ( $\chi^2$ ,  $p \leq .01$ ) (Table 1).

*Eimeria callospermophili* Henry, 1932 was found infecting 21% of the squirrels examined. It was present in both populations, but no difference in prevalence was found between the two study sites over the four years ( $\chi^2$ ,  $p \leq .10$ ) (Table 1).

*Eimeria spermophili* Hilton and Mahrt, 1971 was the least common species found during this study (5%). It occurred in only a few hosts from each study site, and no significant difference in prevalence occurred between the two sites ( $\chi^2$ ,  $p \leq .10$ ) (Table 1).

In the second study a total of 69 *S. elegans*, 18 *C. leucurus*, and one *S. tridecemlineatus* were trapped over the five-day period. Of these, 47 *S. elegans* (68%) and 17 *C. leucurus* (94%) were positive for the presence of *Eimeria* oocysts. Thirty-six *S. elegans* (52%) and 15 *C. leucurus* (83%) were infected with *E. beecheyi*. Similarly, 36 *S. elegans* (52%) and 4 *C. leucurus* (22%) harbored *E. morainensis*. Three *C. leucurus* (17%) and 7 *S. elegans* (10%) were infected with *E. bilamellata*. *Eimeria larimerensis* infected 3 *S. elegans* (4%) and none of the 18 *C. leucurus*. Up to three eimerian species were found co-occurring in individual hosts.

## DISCUSSION

*Eimeria larimerensis* was first described from *C. ludovicianus* from Larimer County, Colorado (Vetterling 1964). In 1968 this eimerian was reported by Todd and Hammond from an additional seven species of *Spermophilus*, including *S. armatus* Kennicott, 1863 from Utah and Montana; *S. variegatus* Erxleben, 1777 from Utah; *S. tridecemlineatus* from Wyoming; *S. lateralis* Say, 1823 from Utah; *S. beecheyi* Richardson, 1829 from California; *C. leucurus* Merriam, 1890 from Wyoming (Todd and Hammond 1968b); and



TABLE 1. Number and percentage of Wyoming ground squirrels (*Spermophilus elegans*) infected by *Eimeria* sp. by year. Samples ( $N = 1007$ ) were taken from two habitats in Wyoming. Animals may be infected simultaneously by more than one species of *Eimeria*.

Species of <i>Eimeria</i>	1983				1984				1985			
	Mesic ( $N = 314$ ) <sup>a</sup>		Xeric ( $N = 212$ )		Mesic ( $N = 34$ )		Xeric ( $N = 72$ )		Mesic ( $N = 86$ )		Xeric ( $N = 74$ )	
	No. of squirrels infected	%	No. of squirrels infected	%	No. of squirrels infected	%	No. of squirrels infected	%	No. of squirrels infected	%	No. of squirrels infected	%
<i>larimerensis</i>	53	17	12	6	10	29	8	11	8	9	4	5
<i>bilamellata</i>	35	11	7	3	2	6	8	11	17	20	1	1
<i>beecheyi</i>	45	14	26	12	7	21	22	31	37	43	45	61
<i>morainensis</i>	128	41	34	16	13	38	28	39	52	60	25	34
<i>callospermophili</i>	83	26	33	16	16	47	30	42	18	21	17	23
<i>spermophili</i>	19	6	4	2	6	18	2	3	2	2	8	10

  

Species of <i>Eimeria</i>	1986				Total			
	Mesic ( $N = 179$ )		Xeric ( $N = 36$ )		Mesic ( $N = 613$ )		Xeric ( $N = 394$ )	
	No. of squirrels infected	%	No. of squirrels infected	%	No. of squirrels infected	%	No. of squirrels infected	%
<i>larimerensis</i>	72	40	1	3	143	23	25 <sup>b</sup>	6
<i>bilamellata</i>	37	21	1	3	91	15	26	7
<i>beecheyi</i>	143	80	13	36	232	38	106	27
<i>morainensis</i>	143	80	12	33	336	55	99 <sup>b</sup>	25
<i>callospermophili</i>	16	9	0	0	133	22	80	20
<i>spermophili</i>	8	4	0	0	35	6	14	4

<sup>a</sup>Number of squirrels examined.

<sup>b</sup>Significant,  $p < .01$ .

*S. spilosoma* Bennett, 1833 from Colorado (Broda and Schmidt 1978). Experimentally, Todd and Hammond (1968b) inoculated what they called *S. richardsonii* Sabine, 1822 with *E. larimerensis*. Although all eight individuals developed "severe diarrhea" three to four days post-inoculation, no oocysts were recovered. *Spermophilus richardsonii* from Wyoming has since been elevated to specific status, *S. elegans*, by Zegers (1984).

*Eimeria bilamellata* was first described from *S. lateralis* in California (Henry 1932). It has been reported from *S. citellus* Linnaeus, 1766 in Hungary and Czechoslovakia (Pellerdy and Babos 1953), *S. franklinii* Sabine, 1822 from Iowa (Hall and Knipling 1935), *S. armatus* from Utah and Wyoming, *S. beecheyi* from California, and *S. variegatus* from Utah (Todd et al. 1968). Todd et al. (1968) were unable experimentally to infect *S. richardsonii* (syn. *S. elegans*) from Wyoming with sporulated oocysts from any of the above donor hosts.

*Eimeria beecheyi* was originally described from *S. beecheyi* collected in California

Henry 1932). Since its first report, it has been found only in *S. relictus* in the USSR (Abenov and Svanbaev (1982).

*Eimeria morainensis* was first described by Torbett et al. (1982) from *S. lateralis* collected in northern Colorado. This is only the second report of the occurrence of *E. morainensis*.

*Eimeria callospermophili* was first described from *S. lateralis* in California (Henry 1932). More recently it has been reported from that same host in northern Colorado (Torbett et al. 1982). This species is widespread both in its host and geographical distribution, having been reported from *S. fulvus* Lichtenstein, 1823 and *S. maximus* Pallas, 1778 in the Soviet Union (Levine and Ivens, 1990), *S. spilosoma* from Mexico (Levine et al. 1957), *S. beldingi* Merriam, 1888 from California (Veluvolu and Levine 1984), *S. columbianus* Ord, 1815, *S. franklinii*, and *S. richardsonii* in Alberta, Canada (Hilton and Mahrt 1971). In addition, Todd and Hammond (1968a) found this species in six species of *Spermophilus* and *C. leucurus* (*S. armatus*



from Utah and Montana, *S. richardsonii* from Montana and Wyoming [syn. *S. elegans*], *S. beecheyi* from California, *S. lateralis* and *S. variegatus* from Utah, and *S. tridecemlineatus* and *C. leucurus* from Wyoming).

*Eimeria spermophili* was first described by Hilton and Mahrt (1971) from *S. richardsonii* collected in Alberta, Canada. They also found this species in *S. franklinii* from the same area.

This is the first report of these six eimerian species infecting *S. elegans* and the first of *E. beecheyi*, *E. morainensis*, and *E. bilamellata* in *C. leucurus*.

In the first study, although the number of infected ground squirrels changed from year to year, the same species were present at both locations throughout the four-year period. The large sample collected from different habitats over a four-year period indicates that a single ground squirrel population can be infected with several species of *Eimeria*. With a few exceptions, the results of this study suggest that if intensive sampling were conducted with any of the other species of *Spermophilus*, more species of *Eimeria* would be found (Parker et al., in review).

Moreover, the known species of *Eimeria* may be considerably more widespread in their host distribution. As noted above, several reports of sharing of coccidian parasites between species within a genus and between different genera of sciurid hosts exist (Todd and Hammond 1968a, 1968b, Todd et al. 1968, Duszynski 1986). Veluvolu and Levine (1984) stated that an individual eimerian species may infect at least 11 host species. However, most previous coccidian surveys of host populations have reported a low species richness of the parasite community. Todd and Hammond (1968b) reported the presence of *E. larimerensis* in 5 species of *Spermophilus* and *C. leucurus*. They did not find this species in *S. elegans*, nor could they experimentally establish an infection in this species. This contrasts with the results of our first study in which we found 18% of the ground squirrels infected with this species. *Eimeria bilamellata* was also reported from a variety of ground squirrels by Todd et al. (1968), although they did not find this species in wild populations of *C. leucurus* or *S. richardsonii* (syn. *S. elegans*). These results also differ from ours in that we found 14% of 1007 *S. elegans* infected

with this species. However, Shults (1986) could not experimentally establish infections in this host even after immunosuppression with corticosteroids for seven days prior to inoculation.

*Eimeria morainensis* and *E. beecheyi* are two of the most common protozoan parasites infecting *S. elegans*, but neither species has been previously reported from *C. leucurus*.

It is interesting to note that of the species of *Eimeria* originally described from *C. ludoviciani* by Vetterling (1964) (*E. ludoviciani*, *E. cynomysis*, *E. larimerensis*), and which have also been identified from *C. leucurus* in northwestern Wyoming (Seville and Williams, 1989), none were found in *C. leucurus* from our site.

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