

***Eimeria* (PROTOZOA: EIMERIIDAE) FROM WHITE-TAILED DEER *Odocoileus virginianus* IN PENNSYLVANIA, TEXAS, AND WISCONSIN, WITH DESCRIPTIONS OF TWO NEW SPECIES<sup>1</sup>**

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**Abstract**

Fecal samples were collected from white-tailed deer, *Odocoileus virginianus*, in Pennsylvania, Texas, and Wisconsin. Four species of *Eimeria* which have not been reported previously from white-tailed deer were found. Two new species, *E. virginianus* and *E. madisonensis* are described, while *E. mccordocki* and *E. odocoilei* are compared with their original descriptions from mule deer, *Odocoileus hemionus*. Oocysts of *E. virginianus* are elongate ovoid to ellipsoidal with micropyle. They have a rough outer wall and measure 42.3 to 55.0 by 26.2 to 42.0 $\mu$ , mean 49.2 by 32.6. Oocysts of *E. madisonensis* are nearly round with a smooth outer wall and measure 14.0 to 19.1 by 12.8 to 16.3 $\mu$ , means 16.1 by 15.5. *Eimeria mccordocki* and *E. odocoilei* were found in deer from all three states, *E. virginianus*, in deer from Pennsylvania and Wisconsin, and *E. madisonensis*, only from Wisconsin deer.

**Introduction**

During the years of 1963 through 1968, 1,201 fecal collections were examined from white-tailed deer, *Odocoileus virginianus* from the Welder Wildlife Foundation, San Patricio County, Sinton, Texas; the Letterkenny Army Ordnance Depot, Franklin County, Pennsylvania; The Pennsylvania State Uni-

versity Experimental Forest, Huntingdon County, Pennsylvania; and from 29 counties in Wisconsin. This paper presents the descriptive results of fecal examinations which showed the presence of oocysts of four species of *Eimeria*, two of which are undescribed.

**Materials and Methods**

The fecal samples from 146 deer from the Letterkenny Ordnance Depot and The Pennsylvania State University Experiment Forest and 372 samples from deer at the Welder Wildlife Foundation were obtained by taking several pellets

from the colon of deer which had been shot. The 683 samples from Wisconsin were obtained by collection from individual deer pellet groups (Samuel and Trainer, 1969) during large-scale spring pellet surveys. Most pellets were placed

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in 10 per cent formalin, others were placed in 2.5 per cent aqueous potassium dichromate, mixed thoroughly, spread in a thin layer in a Petri dish, and kept at room temperature (22-23 C) or incubated at 20 C for one week to allow oocysts to sporulate. Oocysts were concentrated for microscopic examination using a modified sugar centrifugation-flotation technique of Benbrook and Sloss (1965).

Sporulated oocysts were located using a compound microscope equipped with a 100 x achromatic oil immersion ob-

jective. Further examinations were made using a Leitz Ortholux microscope equipped with fluorite and apochromatic oil immersion objectives. The layers comprising the oocyst wall were determined by a method described by Anderson et al. (1968). At least 50 oocysts of each species were measured using an ocular micrometer. Composite drawings were made from measurements and photomicrographs. All measurements are in microns, mean sizes are given in parentheses following the range.

### Results and Discussion

Four species of *Eimeria* were found in the white-tailed deer, two described by earlier writers, and two which did not fit any previous description.

*Eimeria mccordocki* Honess, 1941  
(Fig. 1)

REMARKS: *Eimeria mccordocki* is easily distinguished from *E. virginianus* n. sp. by its smaller size, thinner oocyst wall, and morphological differences in the sporocyst and sporozoites. These two species are the only two with micropyles reported from the host genus of *Odocoileus*. No species reported from cattle fit the descriptions of *E. mccordocki* so it was concluded the species encountered above is the same as that reported by Honess in 1941 and later described by Landram and Honess (1955), (Table 1) even though no drawings or photomicrographs of sporulated oocysts accompanied either paper for *E. mccordocki*.

*Eimeria odocoilei* Levine, Ivens and Senger 1967  
(Fig. 2)

REMARKS: The oocysts encountered from *Odocoileus virginianus* in this study were very similar to those of *E. odocoilei*. There were, however, slight differences in the size and shape of the sporocysts and sporozoites, and the number of layers comprising the oocyst wall recorded in this study and corresponding characters recorded by Levine et al. (1967) (Table 2). For example, Levine

et al. record a single oocyst wall layer, but we definitely observed two layers. We believe these differences to be insufficient to consider our material a new species.

*Eimeria virginianus* sp. n.  
(Fig. 3)

*Morphology*: The sporulated oocysts are elongate ovoid to ellipsoidal. The wall color is yellow brown under high power (1000 x). The rough outer wall (3 $\mu$ ) narrows slightly at the small end; the thin inner wall layer (less than 1 $\mu$ ) is of a uniform thickness. The micropyle measures 2.6-6.0 (3.0). Sixty-four sporulated oocysts measured 42.3 to 55.0 by 26.2 to 42.0 (49.2 by 32.6). The shape index was 1.34-1.95 (1.53). No oocyst residuum or polar body are present. The sporocysts are thin walled, ellipsoidal and pointed at one end. They measure 18.6 to 27.0 by 8.2 to 11.0 (23.6 by 9.7). The shape index is 1.77-2.62 (2.36). A Stieda body is present. The sporozoites are 1) banana-shaped and rounded at both ends, 2) are arranged side by side and overlap one another considerably, and 3) usually contain four large refractile globules.

*Sporulation time*: 9-11 days at 22-23 C  
*Host*: *Odocoileus virginianus*

*Locality and prevalence*: Franklin and Huntingdon counties, Pennsylvania (4 of 146, 3%); and Bayfield, Forest, Wood and Oneida counties, Wisconsin (5 of 683, <1%).

TABLE 1. *Comparison of Eimeria mccordocki.*

	Landram and Honess, 1955	Present Study
Oocyst		269 sporulated oocysts
shape	ellipsoidal; one end narrower; micropyle present	ellipsoidal with micropyle at slightly narrower end
micropyle	5-6	4.0-8.8 (6.5)
size	33.2-37.3 x 24.9-29 (34.8 x 26.6)	25.0-47.8 x 17.5-28.8 (35.1 x 23.5)
shape index	1.18-1.43 (1.3)	1.29-1.63 (1.43)
residuum	.....	.....
color	dark yellowish brown	yellowish brown
wall	2 layers; outside smooth	2 layers; outside smooth
Sporocyst		
shape	elongate; one end pointed the other blunt and slightly thickened	elongate; one end slightly pointed, the other slightly blunt
size	18-20.7 x 8-12.4	14.0-18.8 x 6.9-9.9 (17.6 x 8.42)
shape index	not reported	1.78-2.43 (2.01)
residuum	+	+
Stieda body	.....	.....
Geographical distribution and prevalence	Albany, Teton and Laramie counties, Wyoming	San Patricio County, Texas (48 of 372; 13%); Franklin and Huntingdon counties, Pa. (18 of 146; 12%); 19 counties in Wisconsin (69 of 683; 10%).
Hosts	<i>Odocoileus h. hemionus</i>	<i>Odocoileus virginianus</i>
Sporulation	5-9 days at room temp.	most oocysts sporulated in 7 days at 20 C

REMARKS: This species does not resemble any previous description from deer, but is similar to some species reported from cattle. The oocyst size, 42.3-55.0 by 26.2-42.0 (49.2 by 32.6), is larger than measurements of *E. auburnensis* Christensen and Porter, 1939; 35-43 by 21-27 (41.3 by 24.7). The smallest dimensions of *E. virginianus* approach the largest measurements of *E. auburnensis*. The sporocyst structure resembles that of *E. brasiliensis* Torres and Ramos, 1939; both have sporozoites which are blunt and overlap, but the number of refractile globules differ: four in *E.*

*virginianus*, and only two in *E. brasiliensis* (Levine and Ivens, 1967).

*Eimeria madisonensis* sp. n.  
(Fig. 4)

*Morphology:* The sporulated oocysts are round with a pale yellow, smooth outer wall of uniform thickness. A micropyle is absent. The wall is approximately 1.5 thick and two layered. Fifty sporulated oocysts measured 14.0 to 19.1 by 12.8 to 16.3 (16.1 by 15.5). The shape index was 1.0 to 1.29 (1.09). An oocyst residuum and polar body are absent.

TABLE 2. Comparison of *Eimeria odocoilei*.

	Levine et al., 1967	Present Study
Oocyst	52 sporulated oocysts	50 sporulated oocysts
shape	subspherical, smooth	subspherical, smooth
micropyle	.....	.....
size	26-28 x 22-26 (26.9 x 23.5)	25.6-32.6 x 22.0-28.0 (28.8 x 25.3)
shape index	1.0-1.2 (1.14)	1.04-1.12 (1.09)
residuum	.....	.....
color	outer 2/3 of wall colorless; inner third brownish yellow	outer layer brownish yellow; inner layer clear to pale yellow
wall	single layer about 1.3 thick	two layers totaling about 1.5 thick
polar granule	+	+
Sporocyst	52 sporulated oocysts	50 sporulated oocysts
shape	ovoid, with Stieda body at small end	elongate with one end rounded; one end narrow with Stieda body
size	13-15 x 8-10 (13.6 x 9.1)	13.0-15.0 x 9.0-12.5 (13.5 x 10.3)
shape index	1.4-1.7 (1.5)	1.2-1.4 (1.3)
residuum	+ coarsely granular	+ granular
Geographical distribution and prevalence	Chelan County, Washington	San Patricio County, Texas (1 of 372; <1%); Huntingdon County, Pa. (1 of 146; <1%); 6 counties in Wisconsin (7 of 683; 1%).
Hosts	<i>Odocoileus h. hemionus</i>	<i>Odocoileus virginianus</i>
Sporulation	allowed to sporulate 1 week	allowed to sporulate 7 days at 20 C

Thin-walled ellipsoidal sporocysts measure 6.5 to 8.5 by 4.0 to 6.0 (7.5 by 4.5). The shape index was 1.41 to 1.72 (1.66). A prominent Stieda body is present. The sporozoites are elongate and lie head to tail in the sporocysts, with a small, clear globule at the large end. There is no sporocyst residuum.

*Sporulation time:* 2-5 days at 22-23 C

*Host:* *Odocoileus virginianus*

*Locality and prevalence:* Columbia, Iowa, and Marinette counties, Wisconsin (3 of 683, <1%).

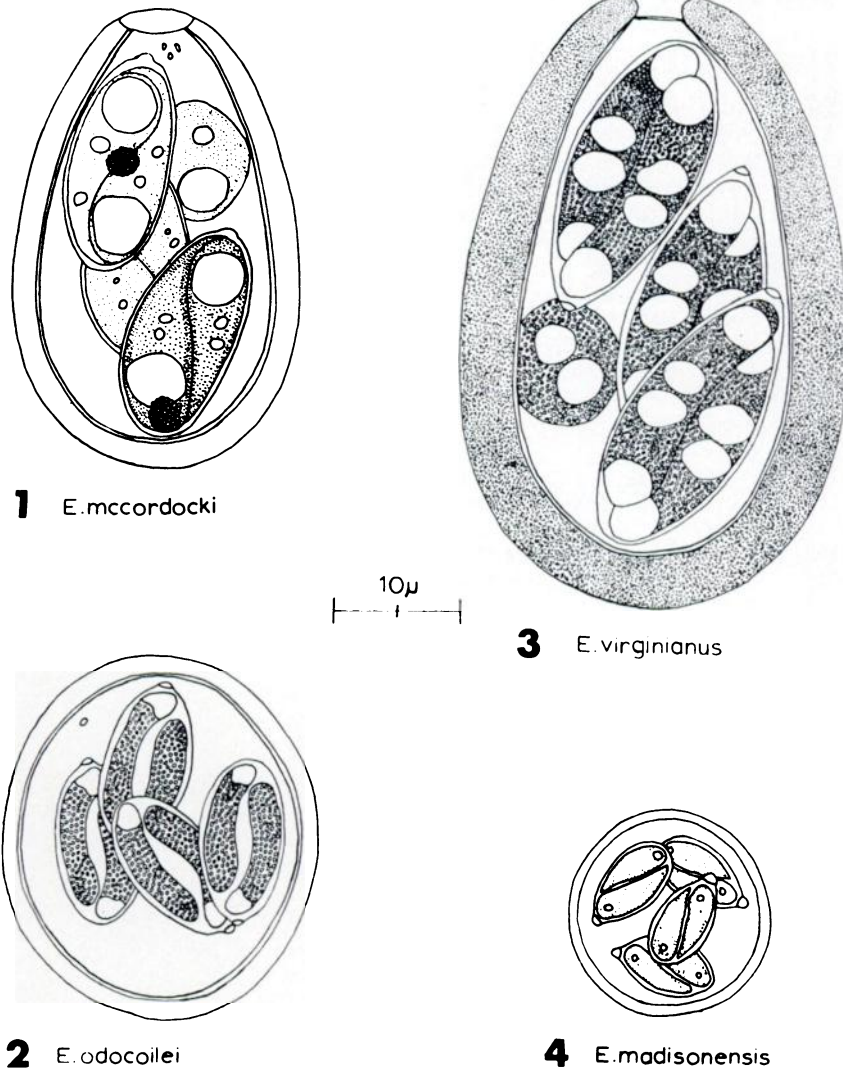
**REMARKS:** *Eimeria madisonensis* most closely resembles *E. zuernii* (Rivolta, 1878) Martin, 1909 reported from

cattle (Levine and Ivens, 1967), but is smaller. The shape of *E. madisonensis* was nearly always spherical and no oocyst polar granules or sporocyst residuum were observed. The mean shape index of the sporocysts was 1.66 compared to 2.12 for *E. zuernii*. The oocysts of *E. madisonensis* were almost never subspherical or bluntly ellipsoidal as in the descriptions of *E. zuernii* by Nyberg and Hammond (1965) and Levine and Ivens (op. cit.). The fact that the Stieda body is very prominent and the above mentioned morphological differences were constant leads us to presume that *E. madisonensis* has not been described previously or reported from cattle.

**Discussion**

The oocysts of the four species of *Eimeria* described in this study have not been reported previously from *Odocoileus virginianus*. Two species (*E. odocoileus* and *E. mccordocki*) have been reported previously from *Odocoileus hemionus* and two (*E. madisonensis* and *E. virginianus*) are new species. None of these species fit descriptions of *Eimeria* re-

ported from cattle, however, Dahlberg and Guettinger (1956) mentioned the occurrence of *E. zuernii* in two deer collected in Bayfield county, Wisconsin in 1941 and 1943. This species was probably *E. madisonensis* or *E. odocoilei*. Further study will be necessary to determine if this *Eimeria* species can infect both deer and other ungulates.



FIGURES 1-4. Sporulated oocysts of *Eimeria* spp. from *Odocoileus virginianus*.

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### Literature Cited

- ANDERSON, D. R., D. W. DUSZYNSKI, and W. C. MARQUARDT. 1968. Three new coccidia (Protozoa: Telosporea) from kingsnakes, *Lampropeltis* spp., in Illinois, with a redescription of *Eimeria zamensis* Phisalix, 1921, J. Parasit. 54: 577-581.
- BENBROOK, E. A. and M. W. SLOSS. 1965. Veterinary Clinical Parasitology. Iowa State University Press, Ames, Iowa, 240 pp.
- DAHLBERG, B. L. and R. C. GUETTINGER. 1956. White-tailed deer in Wisconsin. Wisc. Conserv. Dept. Tech. Wildl. Bull. 14: 119-120.
- HONESS, R. F. 1941. A new coccidium, *Eimeria mccordocki* n. sp. from the black-tailed deer. J. Colorado-Wyoming Acad. Sci. 3: 48.
- LANDRAM, J. F. and R. F. HONESS. 1955. Some internal parasites of the mule deer *Odocoileus hemionus hemionus* in Wyoming. Wyom. Game Fish Commission. 8: 13-22.
- LEVINE, N. D. and V. IVENS. 1967. The sporulated oocysts of *Eimeria illinoisensis* n. sp. and of other species of *Eimeria* of the ox. J. Protozool. 14: 351-360.
- LEVINE, N. D., V. IVENS, and C. M. SENGER. 1967. *Eimeria odocoilei* n. sp. from the mule deer *Odocoileus h. hemionus* in Washington. J. Protozool. 14: 455-456.
- NYBERG, P. A. and D. M. HAMMOND. 1956. Description of the sporulated oocysts and sporozoites of four species of bovine coccidia. J. Parasit. 51: 669-673.
- SAMUEL, W. M. and D. O. TRAINER. 1969. A technique for survey of some helminth and protozoan infections of white-tailed deer. J. Wildl. Mgmt. 33(4): in press.
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