Coccidia from Kangaroo Rats (*Dipodomys* spp.) in the Western United States, Baja California, and Northern Mexico with Descriptions of *Eimeria merriami* sp. n. and *Isospora* sp.

Carla A. Stout  
*University of New Mexico*

Donald W. Duszynski  
*University of New Mexico*, eimeria@unm.edu

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COCCIDIA FROM KANGAROO RATS (DIPodomys spp.)
IN THE WESTERN UNITED STATES, BAJA CALIFORNIA,
AND NORTHERN MEXICO WITH DESCRIPTIONS OF
EIMERIA MERRIAMI SP. N. AND ISOSPORA SP.

Carla A. Stout and Donald W. Duszynski
Department of Biology, The University of New Mexico, Albuquerque, New Mexico 87131

ABSTRACT: Since January 1975, 104 of 361 (29%) kangaroo rats (Dipodomys spp.) examined for Coccidia had oocysts in their feces. These included 32 of 71 (45%) D. agilis from California (3 of 8, 38%) and Baja California Norte (29 of 63, 46%); none of 18 D. deserti from Sonora, Mexico; one of one D. gravipes from Baja Norte; 43 of 124 (35%) D. merriami from California (1 of 4, 25%), New Mexico (16 of 49, 33%), Baja Norte (12 of 23, 52%), Baja Sur (6 of 20, 30%), and Sonora, Mexico (8 of 28, 29%); 17 of 103 (17%) D. ordii from Oregon (0 of 9), Texas (3 of 9, 33%), and New Mexico (14 of 85, 17%); three of 14 (21%) D. panamintinus from California; and eight of 30 (27%) D. spectabilis from New Mexico. The following coccidians were identified from infected rats: Eimeria balphae, E. chobotari, E. scholtysecki, Eimeria sp., E. utahensis, and Isospora sp. from D. agilis; E. scholtysecki from D. gravipes, E. balphae, E. chobotari, E. chihuahuaensis, E. dipodomysis, Eimeria merriami sp. n., Eimeria sp., and E. utahensis from D. merriami; E. balphae, E. chobotari, and E. dipodomysis from D. ordii; E. scholtysecki and Eimeria sp. from D. panamintinus; and E. balphae and E. scholtysecki from D. spectabilis. Sporulated oocysts of Eimeria merriami sp. n. from D. merriami were subspherical, 24.3 × 22.7 (21-27 × 20-26) μm with ovoid sporocysts 10.6 × 7.6 (9-12 × 7-9) μm. No micropyle or polar body were present, but oocyst and sporocyst residua, Stieda and substieda bodies were present. The oocyst wall has two layers. Sporulated oocysts of Isospora sp. from D. agilis were nearly spherical, 25.5 × 25 (21-28 × 20-28) μm with broadly ovoid sporocysts 14.5 × 10.0 (12-19 × 9-13) μm. No micropyle, oocyst residuum and substieda body were present, but a polar granule, sporocyst residuum and Stieda body were present. The oocyst wall had two layers. There are no other isosporans described from heteromyid rodents. Greater than 91% (195 of 213) of all Dipodomys found to be naturally infected with Coccidia in this study, and in all other published surveys, harbored only a single parasite species at any one time.

We examined eight species of Dipodomys from California, New Mexico, Oregon, Baja California (Norte and Sur), and Sonora, Mexico, and found them to be infected with seven eimerians and one isosporan. One of the eimerians, found in two specimens of D. merriami, is described here as new. Oocysts of an isosporan were also found in one specimen of D. agilis, but because only a few oocysts were available for study we decline to name it at this time.

MATERIALS AND METHODS

All hosts were killed in the field a few hr after being live trapped. The abdominal cavity was opened, the intestinal tract removed, and the cecum and colon were slit lengthwise and preserved, with their contents, in vials containing 2.5% aqueous (w/v) K₂Cr₂O₇.

Upon return to the laboratory, vials were refrigerated (4 C) until they could be processed and examined. Processing for oocysts consisted of separating fecal contents from cecal/colon tissue, filtering, incubating and examining by coverslip flotation as described elsewhere (Duszynski et al., 1982). Oocysts were measured with an ocular micrometer and photographed with either Panatomic-X or Ilford Pan F 35 mm film within a Zeiss Universal Photomicroscope equipped with both brightfield (Neofluar) and Nomarski-interference 100× objectives. All measurements are in μm with the ranges in parentheses following the means.

RESULTS

The hosts, the coccidians with which they were infected, and collection localities are presented in Table I.

Coccidians

Eimeria balphae Ernst, Chobotar, and Anderson, 1967. This species was found in 10 of 32 (31%) infected D. agilis, three of 43 (7%) infected D. merriami, 11 of 17 (65%) infected D. ordii, and seven of eight (88%) infected D. spectabilis.

Eimeria chobotari Ernst, Oaks, and Sampson, 1970. This species was found in two of 32 (6%) infected D. agilis, 25 of 43 (58%) infected D. merriami, and in five of 17 (29%) infected D. ordii.

Eimeria chihuahuaensis Short, Mayberry, and Bristol, 1980. This species was found in 10 of 43 (23%) infected D. merriami.

Eimeria dipodomysis Levine, Ivens, and Kruidenier, 1957. This species was found in one of
TABLE I. Eimeria spp. recovered from seven Dipodomys spp. collected from the western United States, Baja California, and northern Mexico including new host (*) and/or locality (state or country) records (†).

<table>
<thead>
<tr>
<th>Dipodomys spp.</th>
<th>Country: County and/or state</th>
<th>No. hosts infected/ examined (%)</th>
<th>Eimeria spp. identified from hosts</th>
<th>All previous studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>agilis</td>
<td>Mexico Baja Norte</td>
<td>29/63 (46)</td>
<td>balpha†, chobotar†, scholtysecki†, utahensis†, sp.‡</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td>USA San Bernardino Co., CA</td>
<td>1/3 (33)</td>
<td>balpha†, sp.‡</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Riverside Co., CA</td>
<td>2/5 (40)</td>
<td>chobotar†, sp.‡</td>
<td></td>
</tr>
<tr>
<td>deserti</td>
<td>Mexico Sonora</td>
<td>0/18</td>
<td>-</td>
<td>none</td>
</tr>
<tr>
<td>gravipes</td>
<td>Mexico Baja Norte</td>
<td>1/1</td>
<td>scholtysecki‡</td>
<td></td>
</tr>
<tr>
<td>merriami</td>
<td>Mexico Baja Norte</td>
<td>12/23 (52)</td>
<td>chobotar†, merriami†, utahensis†, chihuahuaensis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Baja Sur</td>
<td>6/20 (30)</td>
<td>chobotar†, chihuahuaensis†, sp.‡</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sonora</td>
<td>8/28 (29)</td>
<td>balpha†, chobotar†, chihuahuaensis†</td>
<td></td>
</tr>
<tr>
<td>ordii</td>
<td>USA Kern Co., CA</td>
<td>1/4 (25)</td>
<td>chobotar</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chavez Co., NM</td>
<td>10/30 (30)</td>
<td>dipodomysis†</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hidalgo Co., NM</td>
<td>1/3 (33)</td>
<td>chobotar</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Socorro Co., NM</td>
<td>4/12 (33)</td>
<td>balpha†, chobotar, chihuahuaensis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Valencia Co., NM</td>
<td>1/4 (25)</td>
<td>balpha</td>
<td></td>
</tr>
<tr>
<td>panamintinus</td>
<td>USA Kern Co., CA</td>
<td>3/14 (21)</td>
<td>chobotar, dipodomysis</td>
<td></td>
</tr>
<tr>
<td>spectabilis</td>
<td>USA Chavez Co., NM</td>
<td>6/9 (67)</td>
<td>chobotar, balpha</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hidalgo Co., NM</td>
<td>1/4 (25)</td>
<td>balpha</td>
<td>dipodomysis</td>
</tr>
<tr>
<td></td>
<td>Torrence Co., NM</td>
<td>3/14 (21)</td>
<td>balpha</td>
<td>scholtysecki</td>
</tr>
<tr>
<td></td>
<td>Valencia Co., NM</td>
<td>4/58 (7)</td>
<td>balpha</td>
<td>utahensis</td>
</tr>
<tr>
<td></td>
<td>Harney Co., OR</td>
<td>0/9</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Motley Co., TX</td>
<td>3/9 (33)</td>
<td>balpha</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Totals</td>
<td>104/361 (29)</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>

† Unsporulated oocysts, unable to identify.

17 (6%) infected D. ordii and in 10 of 43 (23%) infected D. merriami.

Eimeria scholtysecki Ernst, Frydendall, and Hammond, 1967. This species (Figs. 1, 2) was found in eight of 32 (25%) infected D. agilis, one of one infected D. gravipes, two of three (67%) infected D. panamintinus, and one of eight (13%) infected D. spectabilis. Photomicrographs of this species have not been previously published thus are included here (Figs. 1, 2).

Eimeria sp. Some hosts had oocysts which either never sporulated or were too deteriorated to identify at the time they were examined. These included 18 of 32 (56%) infected D. agilis, one of 43 (2%) infected D. merriami and one of three (33%) infected D. panamintinus.

Eimeria utahensis Ernst, Hammond, and Chobotar, 1968. This species was found in four of 32 (13%) infected D. agilis and one of 43 (2%) infected D. merriami.

Eimeria merriami sp. n. (Figs. 3–5, 8)

Description

Oocyst ellipsoid (Figs. 3, 4); wall = 1.6 consisting of two layers: outer layer smooth, light yellow, ≈ ½ of

Figures 1–7. Sporulated oocysts of coccidians recovered from feces of Dipodomys spp. ×1,866. 1, 2. Eimeria scholtysecki from D. agilis. 3–5. Eimeria merriami sp. n. from D. merriami; note oocyst residuum (*) and substieda body (arrow). 6, 7. Isospora sp. from D. agilis.
**Taxonomic summary**

**Diagnosis:** This species most closely resembles *E. chihuahuaensis* but differs from it in being consistently smaller (22 x 24 vs. 26 x 33), in having an oocyst residuum composed of two, three, or more globules, and in having sporocysts with substieda bodies.

**Host:** *Dipodomys merriami* Mearns, Merriam's kangaroo rat, Museum of Southwestern Biology, Division of Mammalogy, MSB 40168 (male), T. L. Yates #523, 24 May 1979 and MSB 40175 (male), D. J. Hafner #1422, 24 May 1979.

**Locality:** Near San Felipe, Baja California Norte, Mexico.

**Prevalence:** Found in two of 23 (9%) *D. merriami* collected in Baja California Norte, Mexico.

**Site of infection:** Unknown. Oocysts recovered from feces.

**Etymology:** The specific name is derived from the trivial name of the host.

*Isospora sp.*

(Figs. 6, 7, 9)

**Description**

Oocyst spherical or nearly so; wall ≈ 1.6 consisting of two layers: outer layer smooth, pale yellow, ≈ 2/3 of total wall thickness, inner layer colorless, ≈ 1/3 of total thickness; micropyle and oocyst residuum absent; single polar granule present; sporulated oocysts (n = 15) 25.5 x 25 (21–28 x 20–28) with L:W ratio 1.02 (1.00–1.09); sporocysts broadly ovoid, 14.5 x 10.0 (12–19 x 9–13) with L:W ratio 1.33 (1.20–1.61); Stieda body present; substieda body absent; sporocyst residuum extensive, composed of dispersed granules of various sizes (Fig. 9). Oocysts were 300 days old when measured.

**Taxonomic summary**

**Diagnosis:** No isosporans have been named from *Dipodomys* spp. or any other heteromyid rodents. This species closely resembles *I. lacazei* structurally (a common parasite of birds and often seen in transit through the gut of other hosts), except that sporocysts of *I. lacazei* have a substieda body that is absent in the isosporan reported here. We decline to name this form because: (1) only 15 sporulated oocysts were available for study; (2) oocysts were only found in one host animal; and (3) the oocysts were not transmissible (as measured by oocyst discharge) by oral inoculation to *D. ordii* or *D. merriami* under laboratory conditions.

**Host:** *Dipodomys agilis* Mearns, kangaroo rat, Museum of Southwestern Biology, Division of Mammalogy, MSB 42876 (female), T. L. Best #8545, 27 June 1980.

**Locality:** Misión de San Borja, Baja California Norte, Mexico.

**Prevalence:** Found in one of 54 (1.8%) *D. agilis* collected in Baja California Norte, Mexico.

**Site of infection:** Unknown. Oocysts recovered from feces.

**Hosts**

*Dipodomys agilis* Gambel, 1848. Twenty-four of the 32 (75%) infected rats were singly-infected with either *E. balphae* (4), *E. chobotari* (2), *E.
scholtysecki (5), Eimeria sp. (12), or Isospora sp. (1). Five rats had double infections with E. utahensis and Eimeria sp. (1), E. scholtysecki and Eimeria sp. (1), E. balphae and Eimeria sp. (2), or E. balphae and E. utahensis (1). Three rats had triple infections with E. balphae, E. scholtysecki, and E. utahensis (1); E. balphae, E. scholtysecki, and Eimeria sp. (1); or E. balphae, E. utahensis, and Eimeria sp. (1).

Dipodomys deserti Stephens, 1887. None of 18 rats collected in Sonora, Mexico had coccidian oocysts in their feces at the time they were examined.

Dipodomys gravipes Huey, 1925. The only rat of this species had oocysts of E. scholtysecki at the time we examined it.

Dipodomys merriami Mearns, 1890. Thirty-five of the 43 (81%) infected rats were singly-infected with either E. balphae (2), E. chobotari (17), E. chihuahuaensis (3), E. dipodomysis (10), E. merriami (2), or Eimeria sp. (1). Seven rats had double infections with E. chobotari and E. utahensis (1) or E. chobotari and E. chihuahuaensis (6). Only one rat had a triple infection with E. balphae, E. chobotari, and E. chihuahuaensis.

Dipodomys ordii Woodhouse, 1853. All 17 infected rats were singly-infected with either E. balphae (11), E. chobotari (5), or E. dipodomysis (1).

Dipodomys panamintinus (Merriam, 1894). All three infected rats were singly-infected with either E. scholtysecki (2) or Eimeria sp. (1).

Dipodomys spectabilis Merriam, 1890. All eight infected rats were singly-infected with either E. balphae (7) or E. scholtysecki (1).

**DISCUSSION**

The literature on eimerians from kangaroo rats is mostly descriptive with incidental remarks on laboratory infections and patent periods (e.g., Ernst et al., 1967b) and sympatric species with greatly different infection rates (e.g., Ernst et al., 1968). Only Doran (1953) surveyed more than three Dipodomys spp. and tried to use cross-infection experiments, host behavior and climatic and ecological factors to help explain the infection patterns he observed in nature. The results in our study combined with the published literature on coccidians of Dipodomys spp. show that only 213 of 1,590 specimens (13.4%) of 11 species of Dipodomys from Baja California (present study), California (Doran and Jahn, 1952; Doran, 1953; Ernst et al., 1970), Mexico (Levine et al., 1957; present study), New Mexico (present study), Oregon (present study), Texas (Short et al., 1980; present study), and Utah (Ernst et al., 1967a, b, 1968) had oocysts in their feces at the time they were examined. In any host population sampled the prevalence of infection ranged from 0 to 45% although it rarely exceeded 25%. Possible reasons for this low natural incidence of infection include such factors as solitary behavior of the rats and environmental extremes of the deserts they inhabit (Doran, 1953). Even with such factors considered, there is other evidence that infections are long-lived (Ernst et al., 1968) with weak host immunity evident except during massive infections (Doran, 1953). With little host immunity and long patent periods (extended merogony?) we expected a higher prevalence than we actually found in our rats or in our literature survey of rats sampled by others.

We also noted that more than 91% of infected rats harbor only single species infections. Of the 213 infected rats noted above only 18 (< 9%) were infected with more than one coccidian species at the time they were examined. Experimental work by Doran (1953) and the accumulating evidence from this and previous studies (Ernst et al., 1968, 1970; Short et al., 1980) strongly indicate that eimerians originally described from certain Dipodomys spp. show little specificity among congeneric hosts. Nonetheless, of the Dipodomys spp. sampled for coccidia in this study and all published reports, > 91% harbored only a single species at the time they were examined. This may suggest there is genetic control of, or some selective advantage for, Dipodomys spp. harboring only one eimerian species. For example Doran (1953) collected 327 D. panamintinus (4 subspecies) and 197 D. merriami from various localities in California, but found only 22 of 251 (9%) D. p. mohavensis infected with E. mohavensis. None of the other three subspecies of D. panamintinus were infected, nor were any of the D. merriami (found sympatrically with D. p. mohavensis) found to be naturally infected, although all other host species could be infected experimentally. In fact, D. merriami was found to be more susceptible to infection under laboratory conditions (as judged by number of oocysts discharged) than was the natural host D. p. mohavensis. Perhaps some mechanism operates that allows two sympatric species to divide up the microhabitat such that the more...
resistant species maintains a natural low-level infection while the more susceptible species never comes in contact with the parasite in its natural environment.

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LITERATURE CITED


