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EIMERIA FROM BATS OF THE WORLD: A NEW SPECIES IN TOMOPEAS RAVUS FROM PERU

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ABSTRACT: Two of 17 (12%) crevice bats, *Tomopeas ravus* (Chiroptera: Vespertilionidae), from Peru had coccidian oocysts in their feces when examined. Sporulated oocysts of *Eimeria tomopea* n. sp. are ellipsoid to subspheroid, 30.6×24.6 ($26\text{--}34 \times 20\text{--}28$) μm with ovoid sporocysts 13.9×9.0 ($12\text{--}15 \times 8\text{--}10$) μm . A micropyle and substieda body are absent, but polar bodies, oocyst and sporocyst residua, and small, indistinct Stieda bodies are present. The oocyst wall is thick, $\approx 1.5 \mu\text{m}$ and consists of 2 layers, the outermost being rough and mammillated. This is only the 13th eimerian to be described from bats worldwide. The currently recognized species of *Eimeria* are listed, and a possible New World–Old World phyletic split within the genus is described.

Tomopeas ravus is a very small (3 g), insectivorous bat known only from the arid and semiarid coastal region of Peru. In June and July 1981, one of us (LJB) collected 17 specimens as part of a study to determine the systematic relationships and natural history of this rare Peruvian mammal. Two of the bats were infected with an eimerian (Protozoa, Eimeriidae) which we describe here.

MATERIALS AND METHODS

Hosts were killed in the field a few hours after being removed from rock crevices by hand. All procedures for removing intestines, preserving fecal material, and processing, measuring and photographing oocysts were described earlier (Duszynski et al., 1982; Stout and Duszynski, 1983). All measurements are in μm with means given in parentheses following the ranges.

RESULTS

Two of 17 (12%) specimens of *Tomopeas ravus* from Peru had large numbers of oocysts in their feces, and there is no doubt these represent a new species of coccidia which we describe below.

DESCRIPTION

Eimeria tomopea n. sp.

(Figs. 1–12)

Oocyst wall of uniform thickness ≈ 1.5 wide, consisting of 2 layers: outer layer yellowish, mammillated (Fig. 4), $\approx \frac{2}{3}$ of total thickness; inner layer colorless, smooth; micropyle absent; polar body present (Fig. 2); oocyst residuum variable from a spheroid, homogeneous, lipid-like body ≈ 5 (Figs. 1, 5), to multiple bodies (Fig. 6), to a coarse, granular sphere (Figs. 3, 7); sometimes there is a membrane-like structure associated with the lipid-like sphere (Figs. 1, 5); sporulated oocysts ($n = 100$) ellipsoid (Figs. 1, 2) to subspheroid (Fig. 3), $26\text{--}34 \times 20\text{--}28$ (30.6×24.6) with L:W ratio 1.16–1.35 (1.24); sporocysts ovoid (Figs. 8–11), $12\text{--}15 \times 8\text{--}10$ (13.9×9.0) with L:W ratio 1.38–1.80 (1.54); substieda body absent; Stieda body small, not easily seen by brightfield microscopy unless sporocysts are freed from oocyst (cf. Figs. 1–3, 8, 10); even then, Stieda body is seen to better advantage with Nomarski interference contrast (NIC) microscopy (Figs. 9, 11); sporocyst residuum present as large scattered granules obscuring sporozoites (Figs. 1, 12); sporozoites with 1, large, posterior refractile body (Figs. 1, 8–12).

TAXONOMIC SUMMARY

Diagnosis: Of the 12 valid eimerians previously described from bats (Table I), only *E. eumopos* described from *Eumops trumbulli* from Colombia (South America) resembles *Eimeria tomopea*. The sporulated oocysts of *E. tomopea* differ from those of *E. eumopos*, however, by being smaller (31×25 vs. 35×28), by having a distinct oocyst residuum that *E. eumopos* lacks, by having larger sporocysts (14×9 vs. 12×5) with a large, granular residuum, and by having a Stieda body that is indistinct.

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FIGURES 1–11. Photomicrographs of sporulated oocysts (1–7) and sporocysts (8–11) of *Eimeria tomopea* sp. n. $\times 1,815$. 1. Oocyst in optical cross-section; note oocyst residuum (*) and associated membrane-like structure (arrow); 2. A second sporulated oocyst showing polar body (arrow); 3. Subspheroid morph with granular oocyst residuum (*); 4. Mammillated surface of oocyst wall (NIC); 5–7. Sporulated oocysts showing variation in oocyst residuum (arrows); 8–11. Sporocysts seen with brightfield (8, 10) and NIC (9, 11); note the small Stieda body seen best with NIC optics (arrows).

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FIGURE 12. Schematic line drawing of sporulated oocyst of *Eimeria tomopea*. Bar = 5 μ m.

Host: *Tomopeas ravidus* Miller, 1900, Peruvian crevice bat, Louisiana State University Museum of Zoology, LSUMZ 25067 (male), L. J. Barkley #1667, 7 July 1981 and LSUMZ 25085 (male), J. C. Smith #707, 15 July 1981.

Locality: Peru: Dpto. Lambayeque; Cerro la Vieja, 7 km S Motupe; ca. 150 m.

Site of infection: Unknown. Oocysts recovered from feces.

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

DISCUSSION

To our knowledge, *E. tomopea* is the first new coccidian to be described from bats in the last 9 yr. This is surprising because bats are the second most diverse order of mammals in the world, yet only 13 valid eimerians have been described from them. Levine and Ivens (1981) listed 3 additional "species" (*E. myotis*, *E. plecoti* and *E. viridis*), but we are inclined to agree with Wheat (1975) and consider these *nomina nuda* because their initial descriptions were based on unsporulated oocysts. Since coccidians cannot be assigned to genus without knowledge of their sporulated oocysts it is pure speculation these 3 are eime-

TABLE I. *Valid Eimeria spp. described from bats of the world.*

Host	Locality	<i>Eimeria</i> spp.	Citation
Emballonuridae			
<i>Rhynchonycteris naso</i> (Brazilian long-nosed bat)	British Honduras, Central America	<i>rhynchonycteridis</i>	Lainson (1968)
<i>Taphozous melanopogon</i> (Tomb bat)	Andaman Island, India	<i>andamanensis</i>	Mandal and Nair (1973)
<i>T. nudiventris</i> (Tomb bat)	Egypt, North Africa	<i>dukei</i>	Černá and Ryšavý (1976)
Molossidae			
<i>Eumops trumbulli</i> (Mastiff bat)	Colombia, South America	<i>eumopos</i>	Marinkelle (1968)
<i>Tadarida bennettii</i> (Free-tailed bat)	Liberia, West Africa	<i>levinei</i>	Bray (1958)
<i>T. limbatas</i> and <i>T. pumilus</i> (Free-tailed bats)	Uganda, Central Africa	<i>dukei</i>	Lavier (1927)
Rhinolophidae			
<i>Rhinolophus hipposideros</i> (Lesser horseshoe bat)	France, Western Europe	<i>hessei</i>	Lavier (1924)
<i>R. mehelyi</i> (Horseshoe bat)	Azerbaijdzhan, Soviet Union	<i>mehelyi</i>	Mussaiev and Gauzer (1971)
Vespertilionidae			
<i>Nyctalus noctula</i> (Noctule bat)	Germany, Eastern Europe	<i>nyctali</i>	Gottschalk (1974)
<i>N. noctule</i> (Noctule bat)	Czechoslovakia, Eastern Europe	<i>vejsovi</i>	Černá (1976)
<i>Pipistrellus subflavus</i> (Eastern pipistrelle)	Alabama, North America	<i>macyi</i>	Wheat (1975)
<i>Tomopeas ravidus</i> (Crevice bat)	Peru, South America	<i>tomopea</i>	Present study
<i>Vespertilio murinus</i> (Frosted bat)	Azerbaijdzhan, Soviet Union	<i>vespertilii</i>	Mussaiev and Weisssov (1961)
<i>V. murinus</i> (= <i>V. kuhlii</i>) (Frosted bat)	Azerbaijdzhan, Soviet Union	<i>zakirica</i>	Mussaiev (1967)

rians. Thus, even though the term *nomen nudum* indicates that no description was given, we hold this to be the proper placement for *myotis*, *plecoti* and *viridis* because their sporulated oocysts were never seen. This must represent only a small fraction of the number which actually parasitize these mammals, as *Eimeria* spp. have been described from only 4 of the 18 (22%) Recent families of bats, 9 of the 168 (5%) Recent bat genera, and 13 of the 853 (1.5%) living species of bats recognized by Vaughan (1978). Although some bat eimerians may occur in more than 1 host (e.g., *E. dukei*), we also know that most vertebrate host species harbor 1 or more coccidian species that can be unique to them. If we assume conservatively that there is at least 1 eimerian per bat species, as was done for rodents (Levine and Ivens, 1965), we estimate there may be about 850 species of *Eimeria* in bats, alone. The number described to date is only 1.5% of this number.

Tomopeas ravidus, the only species in the genus, is known only from the arid and semiarid coastal region of Peru where it can be found from sea level to an elevation of 1,000 m (Nowak and Paradiso, 1983). This insectivorous species roosts in crevices under the exfoliation of granite boulders and outcroppings. The genus has been placed traditionally in a separate subfamily of the Vespertilionidae because *T. ravidus* has physical characteristics that suggest phyletic relationships to both the Vespertilionidae and the Molossidae. Many mammalogists believe it to be an ancient, ancestral type that bridges the gap between these 2 families. However, a recent analysis based largely on biochemical evidence (Barkley, 1984) suggests that *T. ravidus* is more closely related to bats of the family Molossidae and should be recognized as a distinct molossid subfamily.

Unfortunately, only 4 species in 4 genera (of the 275 species in 38 genera) of vespertilionids and only 4 species in 2 genera (of the ≈ 80 species in 12 genera) of molossids have been examined for coccidians. Most bats in these 2, cosmopolitan families are insectivorous. It is interesting to note that the 3 eimerians described from New World vespertilionids and molossids (*E. macyi*, *E. tomopea*, *E. eumopos*) have thick, rough, mammillated oocyst walls, whereas the 6 described from African and Old World vespertilionids and molossids (*E. dukei*, *E. levinei*, *E. nyctali*, *E. vejsovi*, *E. vespertili*, *E. zakerica*) have smooth-walled oocysts. This pattern, if real, may indicate 2, independent eimerian lineages, 1 Old World, 1 New World. Comparative studies of

the lineages (e.g., biochemical) may provide important information on host biogeography and phylogeny and host-parasite coevolution.

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