
Second Report of *Isoospora boulengeri* from Satanic Leaf-Tailed Geckos, *Uroplatus phantasticus* (Sauria: Gekkonidae), with a New Host Record for *Choleoeimeria* (Apicomplexa: Eimeriidae) and a Summary of the Choleoeimerians from the Gekkonidae

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Abstract: Five adult captive specimens of satanic leaf-tailed geckos, *Uroplatus phantasticus*, housed at the Dallas Zoo, Dallas County, Texas, were examined for coccidian parasites. One was found to harbor *Isoospora boulengeri* in its feces while another was infected with an unknown species of *Choleoeimeria*. Spheroidal to subspheroidal oocysts of *I. boulengeri* averaged (L × W) 16.9 × 16.1 μm; one (typically) or two polar granule(s) were present but an oocyst residuum and micropyle were absent. Ovoidal sporocysts of *I. boulengeri* averaged 9.6 × 6.9 μm and possessed a sporocyst residuum and Stieda and sub-Stieda bodies. Cylindroidal to elongate oocysts of a *Choleoeimeria* sp. averaged 28.0 × 14.8 μm. Here, we provide the second report of *I. boulengeri* from *U. phantasticus* as well as the first report of a *Choleoeimeria* sp. from this host. In addition, we provide a summation of the choleoeimerians from the family Gekkonidae.

Introduction

Geckos are excellent hosts of coccidian parasites (El-Toukhy et al. 2013; McAllister et al. 2016, 2020) and the satanic leaf-tailed gecko, *Uroplatus phantasticus* Boulenger is no exception. McAllister et al. (2016) described *Isoospora boulengeri* and *Eimeria schneideri* from *U. phantasticus* originally collected in Madagascar and housed at the Dallas Zoo, Dallas County, Texas. Here, we report *I. boulengeri* for

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the second time from *U. phantasticus* housed at the Dallas Zoo as well as documenting, for the first time, a *Choleoeimeria* from this host. We also provide a summary of the choleoeimerians from geckos of the world.

Methods

Between July 2018 and June 2019, feces from five adult *U. phantasticus* housed at the Dallas Zoo were collected and placed in individual vials containing 2.5% (w/v) aqueous potassium

dichromate ($K_2Cr_2O_7$). They were not shipped to the senior author until July 2023 for initial coccidial examination. Those samples found positive were sent to JAH for further examination via flotation in a 15-ml conical centrifuge tube (with centrifugation) containing Sheather's sugar solution (Ricca Chemical Company, Arlington, Texas; specific gravity: 1.25) using an Olympus BX43 light microscope (Olympus Corporation, Center Valley, Pennsylvania). All morphological measurements are reported in micrometers (μm) with the means followed by the ranges in parentheses. Oocysts were ~1,825 days old once they were deposited, measured, and photographed using Nomarski interference-contrast optics at $\times 1,000$ magnification. Oocyst and sporocyst descriptions follow the standard guidelines of Wilber et al. (1998) including oocyst length (L) and width (W), their ranges and ratios (L/W), micropyle (M), oocyst residuum (OR), polar granule(s) (PG), sporocyst length (L) and width (W), their ranges and ratio (L/W), sporocyst (SP), Stieda body (SB), sub-Stieda body (SSB), para-Stieda body (PSB), sporocyst residuum (SR), sporozoites (SZ) anterior (ARB) and posterior (PRB) refractile bodies, and nucleus (N).

A photovoucher of a *U. phantasticus* was accessioned into the Eastern Oklahoma State Collection, Idabel, Oklahoma. Photovouchers of sporulated oocysts of the coccidians were accessioned into the Harold W. Manter Laboratory of Parasitology (HWML), Lincoln, Nebraska.

Results and Discussion

Two coccidians were recovered from the fecal samples and identified as: *Isospora boulegeri* and *Choleoecimeria* sp. Data are provided on each in an annotated format below.

Isospora boulegeri McAllister, Seville, and Hartdegen, 2016 (Figs. 1–3)

Description of sporulated oocyst: Oocyst shape (n = 15): spheroidal to subspheroidal; bilayered wall, ~1.2 (1.0–1.5) tan outer layer

smooth to lightly pitted, ~2/3 total thickness; darker inner layer. L \times W (n = 15): 16.9 \times 16.1 (15–20 \times 14–19); L/W ratio: 1.1 (1.0–1.1); M and OR absent; 1 (typically) or 2 PG(s) present.

Description of sporocyst and sporozoites: Sporocyst shape (n = 15): ovoidal; L \times W (n = 15): 9.6 \times 6.9 (9–11 \times 6–8); L/W ratio: 1.4 (1.3–1.7); knob-like SB and rounded SSB present, PSB: absent; SR: present; SR characteristics: compact rounded or irregular mass of various-sized granules. Sporozoite (not measured) shape: sausage-shaped, small subspheroidal ARB, large subspheroidal PRB, N posterior to midpoint.

Taxonomic Summary

Host: Satanic leaf-tailed gecko, *Uroplatus phantasticus* (Boulenger, 1888); photovoucher host deposited in the EOSC collection.

Geographic distribution: USA: Texas, Dallas, Dallas Zoo Herpetarium (32°44'26.28"N, -96°49'00.12"W).

Type host and locality: *U. phantasticus*, Madagascar (exact locale unknown) (McAllister et al. 2016).

Other localities: Dallas Zoo (McAllister et al. 2016).

Prevalence: 1/5 (20%).

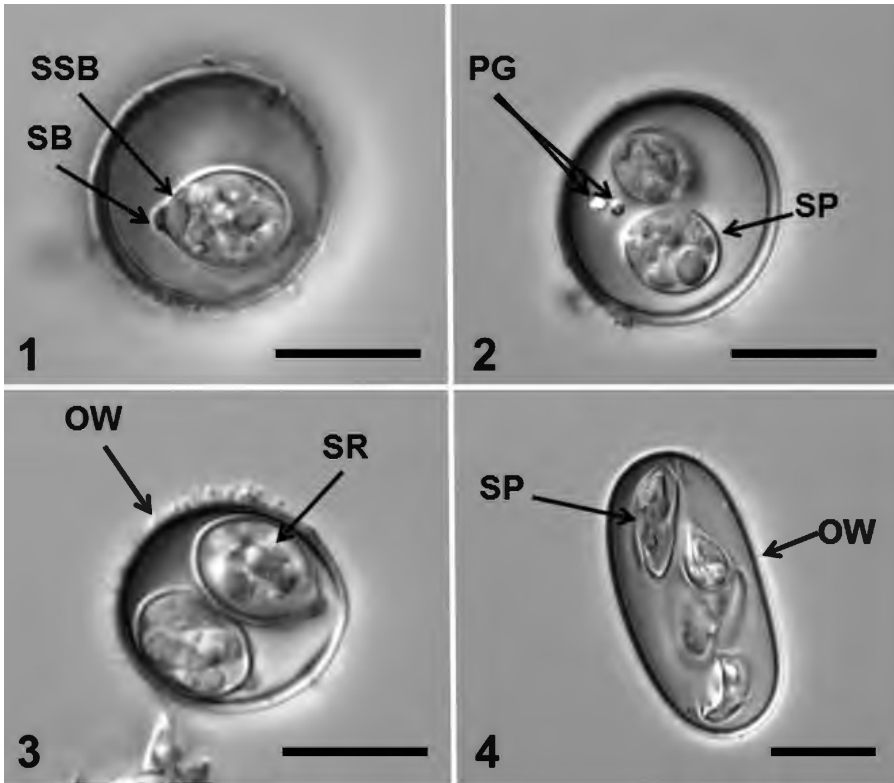
Sporulation: Oocysts were completely sporulated when samples were received in July 2023.

Site of infection: Unknown; oocysts passed in feces.

Materials deposited: Photovoucher of sporulated oocysts are deposited as HWML 217049.

Remarks

All morphological and mensural characteristics of the present oocysts and sporocysts were quite similar to those from *I. boulegeri* previously reported for *U. phantasticus* (McAllister et al. 2016). This



Figures 1–4. Sporulated oocysts of coccidians from *Uroplatus phantasticus*. (1–3) *Isospora boulengeri*. (4) *Choleoeimeria* sp. Scale bars = 10 μ m. Abbreviations: OW (oocyst wall); PG (polar granule); SB (Stieda body); SSB (sub-Stieda body); SP (sporocyst); SR (sporocyst residuum).

is the second report of *I. boulengeri* from *U. phantasticus* since the original report more than seven years ago.

***Choleoeimeria* sp.**
(Fig. 4)

Taxonomic Summary

Host: Satanic leaf-tailed gecko, *Uroplatus phantasticus* (Boulenger, 1888); photovoucher host deposited in the EOSC collection.

Description of sporulated oocyst, sporocysts and sporozoites: Regrettably, all cylindrical oocysts possessed collapsed sporocysts likely due to aging (~5 yr); five oocysts measured (L \times W) 28.0 \times 14.8 (27–29 \times 14–15), with a L/W ratio of 1.9.

Geographic distribution: USA: Texas, Dallas,

Dallas Zoo Herpetarium (32°44'26.28"N, -96°49'00.12"W).

Prevalence: 1/5 (20%).

Site of infection: Unknown; oocysts passed in feces. However, choleoeimerians develop in the gallbladder and biliary epithelium.

Materials deposited: Photovoucher of sporulated oocysts are deposited as HWML 217050.

Remarks

There are 17 choleoeimerians (Table 1) that have been previously reported from the gallbladder of gekkonid lizards of the world. Of these, only two taxa possess oocysts that are (1) similar in size, (2) elongate-ellipsoidal or cylindrical in shape, and (3) with L/W ratios

Table 1. Comparison of the sporulated oocysts of elongate-ellipsoidal/cylindroidal *Choleoeimeria* (syn. *Eimeria*) spp. from the gallbladder of gekkonids.

<i>Choleoeimeria</i> spp.	Type host or host and type locality or locality	Oocyst shape, size, features*†	Sporocyst shape, size, features*†	References
<i>Choleoeimeria</i> sp.	<i>Uroplatus phantasticus</i> Dallas Zoo, USA	Cylindroidal 28.0 × 14.8; L/W 1.9 27–29 × 14–15	Unknown‡	This study
<i>Choleoeimeria</i> sp. (III)	<i>Hemidactylus frenatus</i> Taiwan	Elongate-ellipsoidal 26.0–27.6 × 14.4–15.6; L/W 1.8 Not given	Not given	Yamamoto (1933)
<i>C. bunopusi</i>	<i>Bunopus tuberculatus</i> Saudi Arabia	Ellipsoidal 31.0 × 21.0; L/W 1.5 30–33 × 20–22 PG: –	Ellipsoidal 12.0 × 7.0; L/W 1.4 11–13 × 6–8 SR: +	Al-Quraishy et al. (2013)
<i>C. delalandii</i>	<i>Tarentola delalandii</i> Canary Islands	Cylindroidal 45.1 × 21.7; L/W 2.1 42–48 × 20–26 PG: –	Subspheroidal-ovoidal 13.8 × 10.3; L/W 1.3 12–15 × 10–11 SR: +	Matushka and Bannert (1986)
<i>C. duszynskii</i>	<i>Stenodactylus doriae</i> Saudi Arabia	Ellipsoidal 24.0 × 17.0; L/W 1.4 23–25 × 16–18 PG: –	Ellipsoidal 9.0 × 5.0; L/W 1.7 8–10 × 4–6 SR: +	Abdel-Baki (2014)
<i>C. flaviviridis</i>	<i>Hemidactylus flaviviridis</i> India	Ellipsoidal 25–34 × 11–14; L/W 2.4 Not given PG: –	Ovoidal 8.0 × 6.0; L/W 1.3 Not given SR: +	Setna and Bana (1935)
<i>C. gehyrae</i> n. comb.	<i>Gehyra variegata</i> Australia	Elongate-ellipsoidal 32.8 × 20.5; L/W 1.6 30–35 × 20–22 PG: –	Elongate-ellipsoidal 13.6 × 7.7; L/W 1.8 13–14 × 7–8 SR: +	Cannon (1967)
<i>C. hailensis</i> n. comb.	<i>Ptyodactylus hasselquistii</i> Saudi Arabia	Cylindroidal 36.7 × 17.2; L/W 2.1 36–38 × 16–20 PG: +	Subspheroidal to ovoidal 10.1 × 8.1; L/W 1.2 8–12 × 8–9 SR: +	Abdel-Aziz (2001)
<i>C. heteronotis</i>	<i>Heteronotia binoei</i> Australia	Oblong 32.8 × 16.9; L/W 1.9 33–34 × 16–18 PG: –	Ellipsoidal 9.9 × 7.6; L/W 1.3 8–10 × 6–8 SR: +	Paperna (2007)
<i>C. japonicus</i> n. comb.	<i>Gekko japonicus</i> Japan	Cylindroidal 31.0 × 15.0; L/W 2.1 28–35 × 14–19 PG: –	Ellipsoidal 12.0 × 7.0; L/W 1.8 11–14 × 7–10 SR: +	Bovee (1971)
<i>C. koidzumii</i> n. comb.	<i>G. japonicus</i> Japan	Elongate-ellipsoidal 30.0 × 14.0; L/W 2.1 Not given PG: –	Ovoidal 13.0 × 9.0; L/W 1.4 Not given SR: +	Matubayasi (1941)
<i>C. pachydactyli</i>	<i>Pachydactylus capensis</i> South Africa	Cylindroidal 28.3 × 13.9; L/W 2.1 25–31 × 11–17 PG: –	Ellipsoidal 11.4 × 6.9; L/W 1.7 10–13 × 6.5–7.2 SR: +	Paperna and Landsberg (1989)

similar to this unidentified taxon. They include: *frenatus* Duméril and Bibron from Taiwan an unnamed choleoeimerian from *Hemidactylus* (Yamamoto 1933) and *Choleoeimeria scabrum*

Table 1 Continued.

<i>C. phelsumae</i> n. comb.	<i>Phelsuma grandis</i> Madagascar	Cylindroidal 31.8 × 15.0; L/W 2.1 30–33 × 14–17 PG: –	Ellipsoidal 9.8 × 7.0; L/W 1.4 8–12 × 7–9 SR: +	Daszak and Ball (1991)
<i>C. rochalimai</i>	<i>Hemidactylus mabouia</i> Brazil	Ellipsoidal 30.6 × 16.8; L/W 1.8 Not given PG: –	Spheroidal- subspheroidal 9.0 × 8.0; L/W 1.1 Not given SR: +	Carini and Pinto (1926)
<i>C. scabrum</i>	<i>Cyrtopodion scabrum</i> Egypt	Ellipsoidal 26.0 × 13.0; L/W 1.8 25–27 × 12–14 PG: –	Ellipsoidal 8.0 × 5.0; L/W 1.5 7–9 × 4–6 SR: +	Abdel-Haleem (2015)
<i>C. turcicus</i>	<i>Hemidactylus turcicus</i> USA: Texas	Cylindroidal 38.2 × 17.9; L/W 2.1 35–41 × 17–20 PG: +	Ovoidal 11.0 × 8.8; L/W 1.3 10–12 × 8–9 SR: +	Upton et al. (1988)
<i>C. vittati</i> n. comb.	<i>Gekko vittatus</i> Solomon Islands	Elongate-ellipsoidal 34.3 × 16.9; L/W 2.0 33–37 × 17–18 PG: –	Ovoidal 11.0 × 6.5; L/W 1.7 10–13 × 5–8 SR: +	Ball and Daszak (1995)
<i>C. xiangmati</i>	<i>Hemidactylus frenatus</i> Thailand	Oblong 29.7 × 15.1; L/W 2.0 29–33 × 13–16 PG: –	Subspheroidal to ellipsoidal 9.3 × 5.7; L/W 1.7 8–10 × 5–8 SR: +	Paperna (2007)

*Measurements in μm .

†Descriptions of oocysts and sporocysts follow guidelines of Wilber et al. (1998) as follows: oocyst length (L) and width (W), their ranges and ratios (L/W), polar granule(s) (PG), sporocyst (SP) length (L) and width (W), their ratio (L/W), and sporocyst residuum (SR). A micropyle (M), oocyst residuum (OR), Stieda body (SB), sub-Stieda (SSB), and para-Stieda (PSB) do not occur in oocysts of *Choleoimeria* spp.

‡Sporocysts were collapsed due to aging.

Abdel-Haleem, 2015 from rough-tailed geckos, *Cyrtopodion scabrum* (Heyden) from Egypt. Unfortunately, the only information reported on Yamamoto's (1933) sample was some measurements on oocysts; no other morphological data is available. Comparison of our oocysts to *C. scabrum* is similar in size and shape but Abdel-Haleem (2015) did not report a polar granule for *C. scabrum*. Unfortunately, without fresh samples containing viable oocysts and sporocysts, it is impossible to distinguish our form and provide a complete description.

like coccidians infecting the lumen of the gallbladder and biliary epithelium of reptiles and their view has been supported (Megia-Palma et al. 2015; and others). This genus is further characterized by elongate-ellipsoidal oocysts that usually have an L/W ratio ≥ 1.4 and sporocysts without a SB/SSB complex, but with two plates with meridional sutures in their walls (Kruth et al. 2020). Therefore, as our oocysts conform to this description, we document the first report of a *Choleoimeria* sp. from *U. phantasticus*.

Paperna and Landsberg (1989) erected the genus *Choleoimeria* to accommodate eimeriid-

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