

Description of the Oocysts of Three New Species of *Eimeria* (Apicomplexa: Eimeriidae) from Iguanid Lizards (Sauria: Iguanidae) of Central and South America

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Three new species of *Eimeria* are described from iguanid lizards of Central and South America. The oocysts of each species have no micropyles or residua and the sporocysts lack Stieda bodies, but all have a sporocyst residuum. *Eimeria sanctaluciae* n.sp. was found in the St. Lucia tree lizard, *Anolis luciae*, collected from the Maria Islands, Lesser Antilles. The oocysts are spherical to subspherical, averaging 17.3 x 16.5 μm , with a single layered colourless wall; about 60% contain polar granules. The sporocysts are ellipsoidal and average 7.7 x 5.5 μm . *Eimeria liolaemi* n.sp. was recovered from the blue-gold swift, *Liolaemus taeniis*, from Chile. The oocysts are spherical to subspherical, measuring 21 x 20.1 μm with a single-layered colourless wall. The sporocysts are subspherical and average 7.4 x 6.8 μm . *Eimeria caesicia* n.sp. is described from the Brazilian collared iguanid, *Tropidurus torquatus*. The oocysts measure 27.4 x 23.7 μm , are spherical to subspherical, with a bilayered wall, the outer surface of which appears pale blue in colour; the thin, inner wall appearing brown, when viewed by direct light under the optical microscope. The sporocysts are subspherical and average 9.4 x 7.2 μm . Unnamed polysporocystid oocysts with dizoic sporocysts are reported from the faeces of the lesser St. Vincent tree lizard, *Anolis trinitatis* and the possibility of spurious parasitism briefly discussed. In addition, oocysts of an unnamed *Isospora* sp. with a smooth oocyst wall which closely resembles *I. reui* were recovered from *A. trinitatis*.

Key words: Coccidia - Apicomplexa - Eimeriidae - Reptilia - Sauria - Iguanidae

At least 16 species of *Eimeria* have been named from members of the family Iguanidae (Bastardo de San José 1974, Matuschka & Bannert 1987, Aquino-Shuster et al. 1990, Daszak & Ball 1991, Cisper et al. 1995). During the past five years we have had the opportunity to examine newly imported lizards, as well as lizards collected during two expeditions to the Maria Islands, Lesser Antilles. This work has yielded three new species of *Eimeria* from iguanids.

MATERIALS AND METHODS

Animals were housed individually or only with members of the same species immediately after capture and up to the point of collection of faeces for the present study. Containers were sterilised prior to use with 10% aqueous sodium hypochlorite (Clorox®) for 10 min. Faecal samples were placed in 2.5% potassium dichromate and examined by direct, wet mounts. Oocysts were photographed on a Zeiss photomicroscope III using

Nomarski differential interference contrast optics. The oocysts and sporocysts were measured and compared with those already reported from the family Iguanidae. Mean oocyst lengths and widths are given with standard deviations, ranges in parentheses and all measurements in micrometres.

RESULTS AND DISCUSSION

Paperna and Landsberg (1989) proposed a new generic name, *Acroeimeria*, for coccidia of lizards whose endogenous stages develop immediately beneath the brush border of the intestinal epithelial cells, which are displaced into the lumen of the gut and aggregated on the epithelium surface. Mature oocysts contain four sporocysts which are devoid of a Stieda body. We prefer to assign the coccidial oocysts described in the current paper to the genus *Eimeria* pending study of their endogenous development and a general acceptance of the criteria defining the genus *Acroeimeria*.

Eimeria sanctaluciae n. sp. (Figs 1, 8)

Description: oocysts spherical to subspherical, 17.3 \pm 0.6 x 16.5 \pm 0.7 (16.0 - 17.6 x 16.0 - 17.6), n = 10; shape index (SI, = mean length/mean width) 1.05. Wall single layered, smooth and colourless, about 1.0 thick, no micropyle or oocyst residuum

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(Fig. 1). Approximately 60% of oocysts with a polar granule. Sporocysts spherical to subspherical, 7.7×5.5 ($6.4 - 8.0 \times 4.8 - 6.4$), $n = 10$; SI 1.4. Sporocyst residuum present, consisting of 3-4 granules in a homogenous matrix (Figs 1, 8). Stieda body absent.

Type host: *Anolis luciae*, "St. Lucia tree lizard".

Prevalence: oocysts were found in the faeces of 1/3 adult male *A. luciae*, caught during August 1993 in scrubland on the largest of the two Maria Islands.

Type locality: Maria Islands of St. Lucia, Lesser Antilles.

Type material: due to the constraints of expedition field work, it was impossible to produce type material for this species. However, the drawing (Fig. 8) is a composite based on observations of many oocysts and therefore gives a representation of variation within the species.

Etymology: the specific name reflects the main area of inhabitation by the host species.

Remarks: four other eimerians have been reported from members of the genus *Anolis*. *Eimeria intermedia* from *A. intermedius* from Costa Rica (Ruiz 1959) has ellipsoidal oocysts, 20.3×14.9 with wide ranges of both length and width measurements, and larger sporocysts than those of *E. sanctaluciae* n.sp. The oocysts of *E. anolidis* from *A. carolinensis* (Daszak & Ball 1991) are cylindrical and about twice the length of the new species. Oocysts of *E. schwartzi* from *A. armouri* of The Dominican Republic (Cisper et al. 1995) are ellipsoidal and the ranges of length do not overlap with *E. sanctaluciae* n.sp. Another eimerian, *E. avilae* from *A. olssoni* was described by Cisper et al. (1995) from The Dominican Republic. The oocysts of this species are cylindrical and even larger than *E. schwartzi*. Of the other oocysts reported from iguanids, those of *E. leioccephali* from Haiti (Daszak & Ball 1991) are the nearest in appearance to *E. sanctaluciae* n.sp. but the former are larger, 21×19 , have a bilayered wall and larger sporocysts.

Eimeria liolaemi n.sp. (Figs 2, 4, 9)

Description: oocysts subspherical, $21 \pm 1.1 \times 20.1 \pm 1.0$ ($19.4 - 23.8 \times 17.7 - 22.9$), $n = 20$. SI 1.08, with a single layered, smooth colourless wall about 1.0 thick, polar granules lacking, no micropyle or oocyst residuum. Sporocysts subspherical/ellipsoidal, 7.4×6.8 ($7.1 - 8.8 \times 6.2 - 7.9$), $n = 20$, SI 1.1. (Figs 4, 9). Globular sporocyst residuum present (Fig. 2). Stieda body absent.

Type-host: *Liolaemus pictus*, "Orange-flanked Swift".

Prevalence: 1/1 imported adult lizards (faeces collected approximately eight weeks after impor-

tation).

Type locality: Chile.

Type material: phototypes submitted to the Natural History Museum, London, UK. Accession numbers: holotype, 1997: 10: 13: 1; paratype, 1997: 10: 13: 2. The phototypes will be digitised and kept in perpetuity in the form of computer files as well as printed micrographs and negatives.

Etymology: the specific name reflects the generic name of the host.

Remarks: of the spherical/subspherical oocysts described from iguanids, those of both *E. molochis* from *Moloch horridus* in Queensland (Bovee & Telford 1965) and *E. hispidi* from the Venezuelan lizard *Tropidurus hispidus* (Bastardo de San José 1974) are larger. The oocysts of *E. intermedia* from *A. intermedius* in Costa Rica have a single-layered wall and a smaller width to give an SI of 1.36 (Ruiz 1959). *E. leioccephali* from *Leioccephalus carinatus* of Haiti (Daszak & Ball 1991) has oocysts that are larger than *E. liolaemi* n.sp., although there is some overlapping of width and length ranges in the formers lower measurements. However, *E. leioccephali* oocysts have a few scattered polar granules and spherical sporocysts with compact, finely granular residuum.

Note: further collections of this species from 4/4 individuals of *L. taenioides* from a different imported group revealed a population of oocysts (Figs 2, 9) which were somewhat smaller ($19.6 \pm 1.6 \times 18.6 \pm 1.5$ ($16.8 - 21.2 \times 15.9 - 20.3$), $n = 16$, SI 1.06) than the type, with a slight overlap of ranges. The oocyst wall appeared to be bi-layered. The sporocysts also showed differences, 7.2×5.6 ($6.2 - 7.9 \times 5.3 - 7.1$), $n = 20$, SI 1.3. It was felt that this population could not be considered a different species, since differences in number of layers of oocyst walls may be an artifact of diffraction within the microscope.

Eimeria caesicia n.sp. (Figs 3, 10)

Description: oocysts spherical to subspherical, $27.4 \pm 1.7 \times 23.7 \pm 2.3$ ($24.7 - 30.0 \times 21.2 - 28.2$), $n = 16$, SI 1.16. The smooth bilayered wall appears pale blue in colour, with a thin, brown inner wall, when viewed under the optical microscope using a standard light source by which the oocyst walls of other *Eimeria* species of reptiles, birds and mammals appeared either colourless or pale brown. Polar granules, micropyle and oocyst residuum not present. Sporocysts subspherical, 9.4×7.2 ($8.8 - 9.7 \times 7.1 - 7.9$), $n = 20$, SI 1.3. Sporocyst residuum present as small granules (Fig. 3). Stieda body absent.

Type-host: *Tropidurus torquatus*, "Brazilian collared iguanid".

Prevalence: 1/2 imported adults. Samples taken

approximately one month after importation. Infected animal passed oocysts for nine weeks after purchase.

Type locality: Brazil.

Type material: phototypes submitted to the Natural History Museum, London, UK. Accession numbers: holotype, 1997: 10: 13: 3; paratype, 1997: 10: 13: 4. A colour photomicrograph is deposited as a paratype to demonstrate the peculiar oocyst wall. The phototypes will be digitised and kept in perpetuity in the form of computer files as well as printed micrographs and negatives.

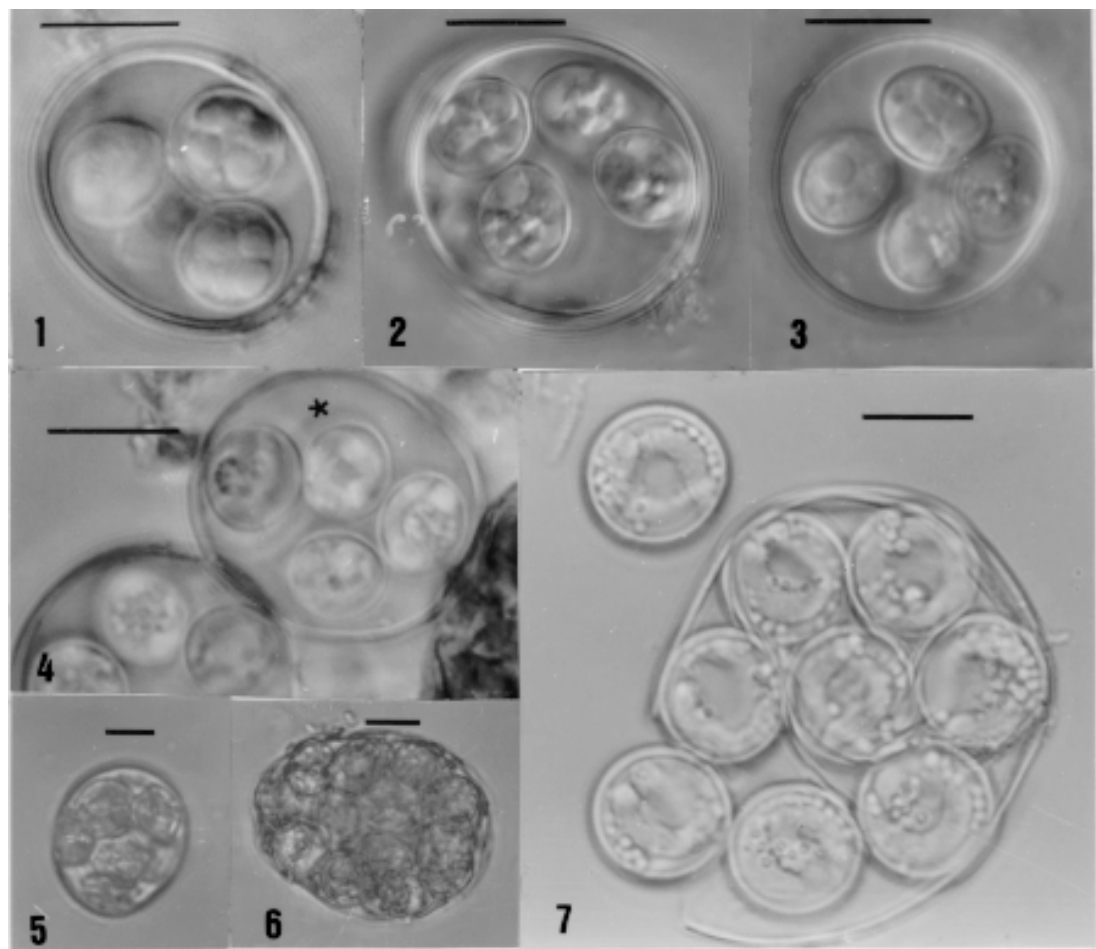
Etymology: the specific name relates to the pale blue colour of the oocyst wall.

Remarks: three species of *Eimeria* have been reported from lizards of the genus *Tropidurus*. Apart from the distinctive appearance of the oocyst wall

of *E. caesicia* n.sp., the following characteristics distinguish these species. *E. hispidi* Bastardo de San José, 1974 from *T. hispidus* has a greater width than *E. caesicia* n.sp. and has larger sporocysts. *E. tropidura* and *E. galapagoensis*, both from *T. delanonis* of the Galapagos Islands, are ellipsoidal and cylindrical respectively and have SI values of 1.4 and 2.4 respectively (Aquino-Shuster et al. 1990). Oocysts of *E. caesicia* n.sp. are larger than those of *E. leiocephali*, and smaller than those of *E. molochis* (SI 1.3). Oocysts of *E. stenocerci* from a lizard of the genus *Stenocercus*, have a similar length but smaller width to give SI 1.26 - 1.35 (Carini 1940).

Unnamed polysporocystid oocysts (Figs 5-7)

Description: a few oocysts with spherical dizoic



Bright field and Nomarski Differential Interference Contrast photomicrographs of oocysts isolated from iguanid reptiles. Fig. 1: the holotype for *Eimeria sanctaluciae* n.sp. Fig. 2: an oocyst of *E. liolaemi* n.sp. from *Liolaemus taenioides* which appears to show a bi-layered oocyst wall. Fig. 3: an oocyst of *E. caesicia* n.sp. from *Tropidurus torquatus*. Fig. 4: two oocysts of *E. liolaemi* n.sp. from *L. taenioides*. The holotype for the species is asterisked. Figs 5-7: polysporocystid oocysts with dizoic sporocysts from the faeces of *Anolis trinitatis*. Fig. 5: oocyst with 8 sporocysts. Fig. 6: oocyst with 16 sporocysts. Fig. 7: broken oocyst which contained 11 sporocysts (2 out of field). Bars= 10 μ m.

sporocysts were found. The number of sporocysts per oocyst varied and oocysts with 7, 8 (Fig. 5), 11 (Fig. 6, two of the sporocysts are out of this field of view), 12, 14 and 16 (Fig. 6) sporocysts were observed. The average size of the oocysts appeared to increase with higher numbers of sporocysts contained, eg. with 8 sporocysts, 30.5 x 26.5 (n = 5), SI 1.15; with 14 sporocysts, 37.5 x 30.8 (n = 3), SI 1.22; with 16 sporocysts, 39.2 x 31.7 (n = 3), SI 1.24. Oocysts are subspherical to ovoidal with a smooth, double layered wall, about 1.0 thick, no micropyle, polar granule or oocyst residuum. Sporocysts spherical to subspherical, sporocyst residuum present consisting of 10-20 scattered granules, 1-1.5 µm in diameter. Stieda body absent.

Type host: *Anolis trinitatis* Reinhardt & Lütking, 1863, "lesser St. Vincent tree lizard".

Prevalence: oocysts recovered from faecal samples collected from one of two adult male lizards.

Type locality: St. Vincent, Lesser Antilles.

Remarks: McQuiston (1990), when reporting polysporocystid oocysts with dizoic sporocysts found in the faeces of *Nesomimus parvulus*, the Galapagos mockingbird, suggested caution in naming the host(s) of such parasites due to the possibility of spurious parasitism derived through the diet. The oocysts found by McQuiston (1990) contained 9-15 (usually 11-14) sporocysts and so differed from the genus *Octosporella* which contains 8 sporocysts and *Hoarella* with 16 sporocysts. The oocysts described from *A. trinitatis* were scarce and passed sporulated, therefore could possibly be placed within the two genera mentioned above or *Polysporella* McQuiston, 1990. However, they equally fit the description of the genus *Adelina* (see Levine 1977, 1988) which infects annelids, chilopods and insects.

Polysporocystic oocysts have been previously

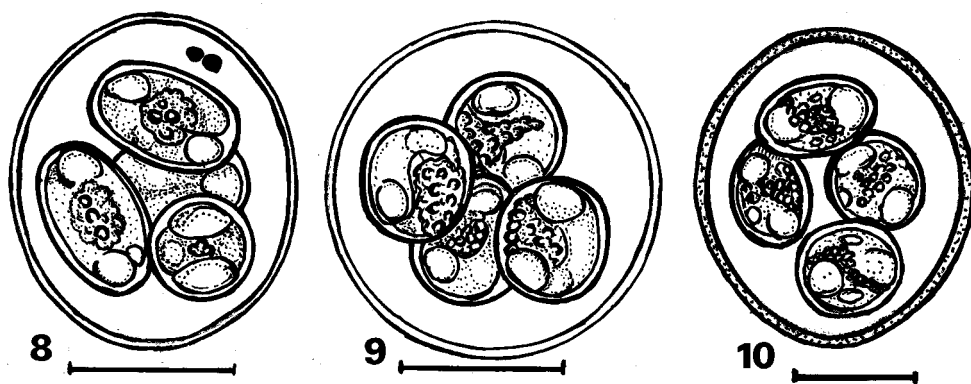
reported from other vertebrates. Anpilogova (1971) and Barnard et al. (1974) reported *Adelina* oocysts from faeces of *Vulpes vulpes* and *Hystrix leucura* in Tadjhikistan and *Sigmodon hispidus* in Alabama, USA respectively. Levine et al. (1955), Dorney (1965) and Seville et al. (1992) reported *Klossia*-like oocysts from North American mammals, and suggested that they were of ingested invertebrate origin. Courtney et al. (1975) reported *Adelina* oocysts in Sandhill cranes (*Grus canadensis*), and Parker and Duszinski (1986) reported *Adelina* oocysts in 1 of 212 New Mexican sandhill crane viscera examined for coccidia.

As far as we are aware, there are only two previous reports of *Adelina* oocysts from reptiles: Wacha (1972) and Daszak (1995) concerning *Thamnophis sirtalis parietalis* and *Nactus serpensinsula durrelli* respectively. The morphology of the *Adelina* oocysts recovered in low numbers in the faeces of *Nactus serpensinsula*, a gecko from Round Island, Mauritius have since been identified as an *Adelina* sp. isolated in large numbers from the centipede *Scolopendra abnormis*, upon which the lizard preys.

Polysporocystic oocysts were recovered by Arcay de Perez (1963) from *Cnemidophorus l. lemniscatus* of Venezuela and described *Hoarella garnhami* n. gen. n. sp. However, in light of the above discussion, the low prevalence (2/200) reported for *H. garnhami* and the description of oocyst development, it appears that this genus is in need of re-examination and the oocysts considered spurious parasitism by an invertebrate adeleid coccidian.

Unnamed isosporan oocysts

Oocysts of an isosporan were also recovered from one of the two *A. trinitatis* faecal samples collected from St. Vincent, however only two oocysts



Line drawings of oocysts isolated from iguanid reptiles. Fig 8: *Eimeria sanctalucia* n.sp. Fig 9: *E. liolaemi* n.sp. from *Liolaemus pictus*. Fig 10: *E. caesicia* n.sp. Bars = 10 µm.

were measured before the sample was lost. These were 16.3 x 15 and 18.8 x 17.5 with ellipsoidal sporocysts of 7.5 width (length not taken). The wall was double-layered and smooth, polar granule not noted in the two oocysts observed. This species appears similar to the only other smooth-walled isosporan reported from *Anolis - I. reui* from *A. baharucuensis* in the Dominican Republic (Cisper et al. 1995). However, further measurements may reveal differences between these coccidians from geographically widely separated hosts.

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REFERENCES

- Anpilogova NV 1971. Discovery of coccidial oocysts of the genus *Adelina* in vertebrates. *Izvestia Akademii Nauk Tadzhikskoi SSR. Otdelyeniye Biologicheskikh Nauk* 4: 110-111.
- Aquino-Shuster AL, Duszinski DW, Snell HL 1990. Three new coccidia from the Hood Island lizard, *Tropidurus delaloni*, from the Galápagos Archipelago. *J Parasitol* 76: 313-318.
- Arcay de Perez L 1963. Studies on two new coccidia from the Venezuelan lizard *Cnemidophorus lemniscatus lemniscatus*: *Hoarella garnhami* gen. nov., sp. nov. and *Eimeria flaviviridis americana* subsp. nov. *Parasitology* 53: 95-107.
- Barnard WP, Ernst JV, Dixon CF 1974. Coccidia of the cotton rat, *Sigmodon hispidus*, from Alabama, USA. *J Parasitol* 60: 406-414.
- Bastardo de San José T 1974. Descripción y ciclo evolutivo de dos nuevos coccidia de *Tropidurus hispidus* de Venezuela: *Wenyonella arcayae* sp. n. y *Eimeria hispidi* sp.n. con discusión de la clasificación de los Eimeriidae y nueva diagnosis para el genero *Wenyonella* Hoare, 1933. *Acta Biol Venezuel* 8: 567-578.
- Bovee EC, Telford SR 1965. *Eimeria sceloporis* and *Eimeria molochis* spp. n. from lizards. *J Parasitol* 51: 85-94.
- Carini A 1940. Sobre uma *Eimeria* de um lagarto de Goiás. *Arq Biol* 24: 282.
- Cisper GL, Huntington C, Smith DD, Powell R, Parmerlee JS, Lathrop A 1995. Four new coccidia (Apicomplexa: Eimeriidae) from anoles (Lacertilia: Polychrotidae) in the Dominican Republic. *J Parasitol* 81: 252-255.
- Courtney CH, Forrester DJ, Ernst JV, Nesbitt SA 1975. Coccidia of sandhill cranes *Grus canadensis*. *J Parasitol* 61: 695-699.
- Daszak P 1995. Prevalence of endoparasites in Round Island reptiles. *Herpetol J* 5: 195-199.
- Daszak P, Ball SJ 1991. Five new species of *Eimeria* (Apicomplexa: Eimeriidae) from lizards. *Syst Parasitol* 20: 141-147.
- Dorney RS 1965. *Eimeria tuscarorensis* n.sp. (Protozoa: Eimeriidae) and redescription of other coccidia of the woodchuck, *Marmota monax*. *J Protozool* 12: 423-426.
- Levine ND 1977. The Adeleid coccidia. *Protozoology* 3: 173-182.
- Levine ND 1988. *The Protozoan Phylum Apicomplexa*, (Vol. 1), CRC Press Inc., Boca Raton, FL, 203 pp.
- Levine ND, Ivens V, Kruidenier FJ 1955. Two species of *Klossia* (Sporozoa: Adeleidae) from a deer mouse and a bat. *J Parasitol* 41: 623-629.
- Matuschka F-R, Bannert B 1987. New Eimeriid coccidia from the Canarian lizard, *Gallotia galloti* Oudart, 1839. *J Protozool* 34: 231-235.
- McQuiston TE 1990. *Polysporella genovesae* n. gen., n. sp. (Apicomplexa: Eimeriidae) from the faecal contents of the Galapagos Mockingbird, *Nesomimus parvulus* (Passeriformes: Mimidae). *Trans Am Microsc Soc* 109: 412-416.
- Paperna I, Landsberg JH 1989. Description and taxonomic discussion of *Eimeria coccidia* from African and Levantine geckoes. *S Afr J Zool* 24: 345-355.
- Parker BB, Duszinski DW 1986. Coccidiosis of sandhill cranes *Grus canadensis* wintering in New Mexico, USA. *J Wild Dis* 22: 25-35.
- Ruiz A 1959. *Eimeria intermedia* n.sp., parásita de la lagartija *Anolis intermedius* Peters. *Rev Biol Trop* 7: 109-112.
- Seville RS, Thomas DM, Pickering R, Stanton NL 1992. Species of *Eimeria* from the thirteen-lined ground squirrel, *Spermophilus tridecemlineatus*, from Wyoming. *Great Basin Naturalist* 52: 309-312.
- Wacha RS 1972. Coccidia from the red-sided garter snake, *Thamnophis sirtalis parietalis*, in Iowa. *J Protozool* 19 (Suppl.): 13-14.

