BioOne RESEARCH EVOLVED

New Host and Distributional Records for *Cryptosporidium* sp. (Apicomplexa: Cryptosporidiidae) from Lizards (Sauria: Gekkonidae, Scincidae) from the Cook Islands and Vanuatu, South Pacific

Author(s): Chris T. McAllister , Donald W. Duszynski and Robert N. Fisher
Source: Comparative Parasitology, 80(2):297-300. 2013.
Published By: The Helminthological Society of Washington
DOI: http://dx.doi.org/10.1654/4646.1
URL: http://www.bioone.org/doi/full/10.1654/4646.1

BioOne (www.bioone.org) is a nonprofit, online aggregation of core research in the biological, ecological, and environmental sciences. BioOne provides a sustainable online platform for over 170 journals and books published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Web site, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/page/terms_of_use.

Usage of BioOne content is strictly limited to personal, educational, and non-commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Comp. Parasitol.
80(2), 2013, pp. 297–300

Research Note

New Host and Distributional Records for *Cryptosporidium* sp. (Apicomplexa: Cryptosporidiidae) from Lizards (Sauria: Gekkonidae, Scincidae) from the Cook Islands and Vanuatu, South Pacific

Chris T. McAllister,[1,4] Donald W. Duszynski,[2] and Robert N. Fisher[3]

[1] Science and Mathematics Division, Eastern Oklahoma State College, Idabel, Oklahoma 74745, U.S.A. (e-mail: cmcallister@se.edu),

[2] Department of Biology, University of New Mexico, Albuquerque, New Mexico 87131, U.S.A. (e-mail: eimeria@unm.edu), and

[3] U.S. Geological Survey, Western Ecological Research Center, San Diego Field Station, 4165 Spruance Road, Suite 200, San Diego, California 92101–0812, U.S.A. (e-mail: rfisher@usgs.gov)

ABSTRACT: Between 1991 and 1993, 295 lizards, comprising 21 species in 2 families (Gekkonidae, Scincidae) from the Cook Islands, Fiji, Palau, Takapoto, and Vanuatu in the South Pacific, were examined for *Cryptosporidium* oocysts. Only 6 lizards (2%) were found to be passing *Cryptosporidium* oocysts in their feces, including 2 of 30 (7%) Oceania geckos, *Gehyra oceanica*, from Rarotonga, Cook Islands, and 4 of 26 (15%) Pacific blue-tailed skinks, *Emoia caeruleocauda*, from Efate Island, Vanuatu. This represents the largest survey for *Cryptosporidium* in Pacific island lizards, and we document 2 new host and 2 new locality records for this parasite genus.

KEY WORDS: Apicomplexa, Cryptosporidiidae, *Cryptosporidium* sp., Gekkonidae, Scincidae, South Pacific, Cook Islands, Vanuatu, lizards, *Gehyra oceanica*, *Emoia caeruleocauda*.

Cryptosporidium species, like the traditional coccidian groups (Eimeriidae, Sarcocystidae, etc.) to which they are distantly related, use direct life cycles and produce very small (~4–8 μm) oocysts containing 4 naked sporocysts. These parasites infect the microvillus area of epithelial cells in the stomach, intestine, cloaca, bile ducts (rarely), and lungs of various vertebrates, depending on which species and which host is infected; at least 28 species are currently recognized (Šlapeta, 2009). The taxonomic affinity of this genus has been increasingly debated in the past decade (Xiao, Fayer et al., 2004; Xiao, Ryan et al., 2004), and there is good evidence that *Cryptosporidium* species may have close affinity to the gregarines (Carreno et al., 1999). In reptiles, only 2 species have been described, *Cryptosporidium serpentis* Levine, 1980, and *Cryptosporidium varanii* (syn. *C. saurophilum*) Pavlásek, Lávickova, Horák, Král, and Král, 1995 (Levine, 1980; Pavlásek et al., 1995; Koudela and Modrý, 1998). The former infects lizards and snakes and can cause morbidity and mortality in captive specimens (Brownstein et al., 1977; Cranfield and Graczyk, 1994; McAllister et al., 1995; Koudela and Modrý, 1998), whereas the latter species was described from captive emerald monitors, *Varanus prasinus*, from the Prague Zoo (originally collected in New Guinea) but is also known from other lizards and even snakes (Pavlásek et al., 1995; Fayer et al., 1997; Koudela and Modrý, 1998; Xiao, Fayer et al., 2004; Xiao, Ryan et al., 2004; Fayer, 2010; Richter et al., 2011). For a historical review of this literature, see Duszynski and Upton (2009).

Hanley et al. (1995) examined a large sample of South Pacific lizards for coccidia, including 207 mourning geckos, *Lepidodactylus lugubris*, and 63 common house geckos, *Hemidactylus frenatus*, from several islands. Although species of *Eimeria* and *Isospora* were reported (Hanley et al., 1995), they did not find any lizards to be passing *Cryptosporidium* oocysts. Herein, we report new host and distributional records for *Cryptosporidium* species in a gekkonid and scincid lizard species.

Between 1991 and 1993, 295 lizards, comprising 21 species within the families Gekkonidae ($n = 157$) and Scincidae ($n = 138$), from several South Pacific Islands, including Cook Islands, Fiji, Palau, Takapoto, and Vanuatu, were collected by hand, and their feces were collected, so they could be examined later for *Cryptosporidium* oocysts. Host species examined included 30 Oceania geckos (*Gehyra oceanica*), 2 Palau geckos (*Gehyra brevipalmata*), 1 Pacific stump-tailed gecko (*Gehyra insulensis*), 2 Palau ghost geckos (*Gekko remotus*), 31 mourning geckos (*Lepidodactylus lugubris*), 6 Micronesian flat-tailed geckos (*Lepidodactylus moestus*), 6 Vanuatu forest geckos (*Lepidodactylus vanuatuensis*), 7 *H. frenatus*

[4] Corresponding author.

geckos, 2 Pacific slender-toed geckos (*Nactus pelagicus*), 25 Melanesia slender-toed geckos (*Nactus multicarinatus*), 22 Fiji snake-eyed skinks (*Cryptoblepharus eximius*), 23 Vanuatu snake-eyed skinks (*Cryptoblepharus novohebridicus*), 26 Pacific blue-tailed skinks (*Emoia caeruleocauda*), 12 Fiji slender treeskinks (*Emoia concolor*), 1 green-bellied vineskink (*Emoia cyanogaster*), 23 white-bellied copper-striped skinks (*Emoia cyanura*), 16 dark-bellied copper-striped skinks (*Emoia impar*), 27 Vanuatu coppery vineskinks (*Emoia nigromarginata*), 9 toupeed treeskinks (*Emoia sanfordi*), 5 Rarotonga treeskinks (*Emoia tuitarere*), and 19 moth skinks (*Lipinia noctua*). Fresh fecal samples were placed in individual vials containing 2.5% (w/v) aqueous potassium dichromate ($K_2Cr_2O_7$) and examined for *Cryptosporidium* oocysts by light microscopy after flotation in Sheather's sugar solution (specific gravity = 1.30). Measurements were taken on 20 oocysts with a calibrated ocular micrometer and reported in micrometers with means ± 1 SD by the ranges in parentheses; photographs were taken using Nomarski interference-contrast optics. Oocysts were ~300 d old when measured and photographed. Unfortunately, tissue samples were not retained for histological preparations nor were oocysts saved for molecular analyses; thus, we were unable to determine whether we were dealing with 1 or more species of *Cryptosporidium*. Host vouchers were accessioned into the California Academy of Sciences (CAS), San Francisco, California, U.S.A., or the Smithsonian Institution National Museum of Natural History (NMNH), Washington, DC, U.S.A. Photo vouchers of sporulated oocysts were accessioned into the United States National Parasite Collection (USNPC), Beltsville, Maryland, U.S.A. Lizard taxonomy follows the field guide to Pacific reptiles (Zug, 2013).

Of the 295 lizards examined, only 6 (2%) were found to be passing oocysts of *Cryptosporidium* sp. in their feces, with the following descriptions.

Apicomplexa: Cryptosporidiidae *Cryptosporidium* Tyzzer, 1907 (Fig. 1)

Hosts and localities: 2 *Gehyra oceanica* (Lesson, 1830) (CAS 183320–183321), collected on 15 September 1991, from Tupapa Stream, Rarotonga, Cook Islands (21°13′8.52″S; 159°44′59.148″E); 4 *Emoia caeruleocauda* (DeVis, 1892) (NMNH 333954–333957), collected 16–17 February 1993, from 4.5 km SE of Mangaliu, Klem's Hill, Efate Island, Vanuatu (17°39′50.28″S; 168°15′35.83″E).

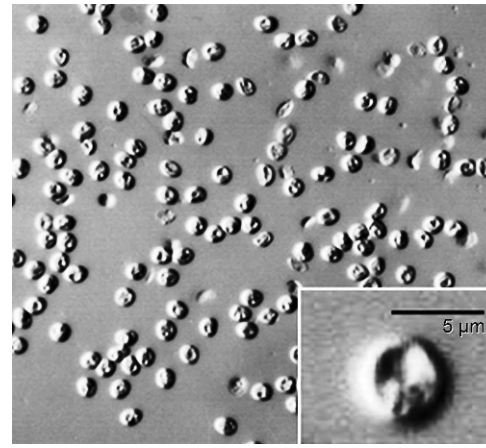

Figure 1. Nomarski interference-contrast photomicrograph of oocysts of *Cryptosporidium* sp. from *Gehyra oceanica* from the Cook Islands. Inset: single oocyst.

Prevalence: 2/30 (7%) *G. oceanica*; 4/26 (15%) *E. caeruleocauda*.

Intensity: Oocysts too numerous to count.

Site of infection: Unknown; oocysts passed in feces (tissues not examined).

Additional Cook Island and Vanuatu records: None.

Other reported reptilian hosts: There are numerous reptilian hosts of *Cryptosporidium* spp., including both captive and wild specimens and those in the lizard families Agamidae, Chamaeleonidae, Gekkonidae, Helodermatidae, Iguanidae, Lacertidae, and Varanidae, and snake families Boidae, Colubridae, Elapidae, and Viperidae (see Funk, 1987; Upton et al., 1989; Fayer et al., 1997; Koudela and Modrý, 1998; Xiao, Fayer et al., 2004; Xiao, Ryan et al., 2004; Duszynski and Upton, 2009).

Geographic range: The genus is cosmopolitan in distribution.

Specimens deposited: USNPC 106476 (photo voucher).

Remarks

Oocysts from *G. oceanica* measured (L × W) 5.2 ± 1.2 (4.4–5.8) × 4.6 ± 0.5 (4.2–5.4) with a shape index (L/W) of 1.13 (1.1–1.2). These measurements compare favorably with *C. varanii* (=*saurophilum*) (Koudela and Modrý, 1998; Xiao, Fayer et al., 2004; Xiao, Ryan et al., 2004); however, identification to species using microscopy alone is problematic (see

Table 1. Summary of gekkonid and scincid hosts of *Cryptosporidium* spp.*

Family/species	Locality	Reference
Gekkonidae		
Chondrodactylus anguilifer	Namibia	Upton et al. (1989)
Eublepharis macularius	Czech Republic†	Koudela and Modrý (1998); Xiao et al. (2004b); Richter et al. (2011)
Gehyra oceanica	Cook Islands	This report
Hemidactylus turcicus	Texas, U.S.A.	Upton et al. (1989)
Naultinus grayi	New Zealand	Funk (1987)
Phelsuma madagascariensis	Madagascar	Upton and Barnard (1987)
Rhacodactylus auriculatus	Unknown‡	Xiao et al. (2004b)
Unknown gecko	Switzerland	Xiao et al. (2004b)
Scincidae		
Emoia caeruleocauda	Vanuatu	This report
Plestiodon schneideri	Egypt	Koudela and Modrý (1998)
Trachylepis perrotetii	Ghana	Koudela and Modrý (1998); Xiao et al. (2004b)

* Includes *Cryptosporidium* sp., *C. serpentis*, and *C. varanii*.
† Originated from a commercial breeding population.
‡ Endemic to New Caledonia.

Fayer, 2010). We report 2 new host and 2 new distributional records for *Cryptosporidium* sp. in gekkonid and scincid hosts from the Cook Islands and Vanuatu, respectively.

Before 1977, earlier reports of *Cryptosporidium* in lizards and snakes (*Cryptosporidium ameivae*, *Cryptosporidium crotali*, *Cryptosporidium ctenosauris*, and *Cryptosporidium lampropeltis*) were considered either *nomen nuda* or sporocysts of *Sarcocystis* spp. (Upton et al., 1989). The first genuine report of the genus *Cryptosporidium* in reptiles appears to be that of Brownstein et al. (1977), who reported the parasite caused severe, chronic, hypertrophic gastritis in 14 captive snakes, and Levine (1980) assigned the name *C. serpentis* to this species (Duszynski and Upton, 2009). Approximately 80 species of lizards, snakes, and tortoises have been reported previously to be hosts of *Cryptosporidium* (Graczyk, 2008), and based on SSU rRNA data from oocysts from several species of reptiles, 9 distinct types of the parasite were found (Xiao, Fayer et al., 2004).

Previous reports of *Cryptosporidium* spp. in gekkonid and scincid hosts included 8 and 3 species, respectively (Table 1). With additional surveys, we suggest additional lizard hosts will be reported to be infected with various *Cryptosporidium* species.

We thank the late Steve J. Upton for technical assistance, and Scott L. Gardner (Manter Parasite Collection, Lincoln, Nebraska, U.S.A.) for parasitological training of R.N.F. The Ministry of Natural Resources, Vanuatu, and the National Research Council, Prime Ministers Department, Cook Islands, supplied export permits for the lizard and parasite collections. The field work of R.N.F. in Vanuatu and Fiji was supported in part by the Smithsonian Scholarly Studies Program funding to George R. Zug (NMNH). Further appreciation is extended to Patricia A. Pilitt (USNPC) for expert curatorial assistance. The use of trade, product, or firm names in this publication does not imply endorsement by the U.S. Government.

LITERATURE CITED

Brownstein, D. G., J. D. Stranberg, R. J. Montali, M. Bush, and J. Fortner. 1977. *Cryptosporidium* in snakes with hypertrophic gastritis. Veterinary Pathology 14:606–617.

Carreno, R. A., D. S. Martin, and J. R. Barta. 1999. *Cryptosporidium* is more closely related to the gregarines than to coccidia as shown by phylogenetic analysis of apicomplexan parasites inferred using small subunit ribosomal RNA gene sequences. Parasitology Research 85:899–904.

Cranfield, M. R., and T. K. Graczyk. 1994. Experimental infection of elaphid snakes with *Cryptosporidium serpentis* (Apicomplexa: Cryptosporidiidae). Journal of Parasitology 80:823–826.

Duszynski, D. W., and S. J. Upton. 2009. The Biology of the Coccidia (Apicomplexa) of Snakes of the World: A Scholarly Handbook for Identification and Treatment. 422 pp. http://www.CreateSpace.com/3388533. ISBN 1448617995. Accessed February 19, 2013.

Fayer, R. 2010. Taxonomy and species delimitation in *Cryptosporidium*. Experimental Parasitology 124:90–97.

Fayer, R., C. A. Speer, and J. P. Dubey. 1997. General biology of *Cryptosporidium*. Pages 1–49 *in* R. Fayer, ed. *Cryptosporidium* and Cryptosporidiosis. CRC Press, Boca Raton, Florida. 576 pp.

Funk, R. S. 1987. Implications of cryptosporidiosis in emerald tree boas, *Corallus caninus*. Pages 139–144 *in*

M. J. Rosenberg, ed. Proceedings of the 11th International Herpetological Symposium Captive Propagation and Husbandry, Chicago, Illinois, 17–20 June 1987, Zoological Consortium Inc., Thurmont, Maryland.

Graczyk, T. K. 2008. Fish, amphibians, and reptiles. Pages 387–394 *in* R. Fayer and L. Xiao, eds. *Cryptosporidium* and Cryptosporidiosis. 2nd ed. CRC Press, Boca Raton, Florida. 576 pp.

Hanley, K. A., D. M. Vollmer, and T. J. Case. 1995. The distribution and prevalence of helminths, coccidia, and blood parasites in two competing species of gecko: implications for apparent competition. Oecologia 102: 220–229.

Koudela, B., and D. Modrý. 1998. New species of *Cryptosporidium* (Apicomplexa: Cryptosporidiidae) from lizards. Folia Parasitologica 45:93–100.

Levine, N. D. 1980. Some corrections of coccidian (Apicomplexa: Protozoa) nomenclature. Journal of Parasitology 66:830–834.

McAllister, C. T., R. Lenington, and S. Tucker. 1995. Notes on the general ecology of *Cryptosporidium* spp. Vivarium 7:10–12.

Pavlásek, I., and U. Ryan. 2008. *Cryptosporidium varanii* takes precedence over *C. saurophilum*. Experimental Parasitology 118:434–437.

Pavlásek, I., M. Lávickova, P. Horák, J. Král, and B. Král. 1995. *Cryptosporidium varani* n. sp. (Apicomplexa: Cryptosporidiidae) in emerald monitor (*Varanus prasinus* Schlegel, 1893) in captivity at Prague Zoo. Gazella 22: 99–108.

Richter, B., N. Nedorost, A. Maderner, and H. Weissenböck. 2011. Detection of *Cryptosporidium* species in feces or gastric contents from snakes and lizards as determined by polymerase chain reaction analysis and partial sequencing of the 18S ribosomal RNA gene. Journal of Veterinary Diagnosis and Investigation 23: 430–435.

Šlapeta, J. 2009. Centenary of the genus *Cryptosporidium*: From morphological to molecular species identification. Pages 31–50 *in* M. G. Ortega-Pierres, S. Caccio, R. Fayer, T. Mank, H. Smith and R. C. A. Thompson, eds. *Giardia* and *Cryptosporidium*. CABI Publishing, Morelia, Mexico. 520 pp.

Upton, S. J., and S. M. Barnard. 1987. Two new species of coccidia (Apicomplexa: Eimeriidae) from Madagascar gekkonids. Journal of Protozoology 34:452–454.

Upton, S. J., C. T. McAllister, P. S. Freed, and S. M. Barnard. 1989. *Cryptosporidium* in wild and captive reptiles. Journal of Wildlife Diseases 25:20–30.

Xiao, L., R. Fayer, and S. J. Upton. 2004. *Cryptosporidium* taxonomy: Recent advances and implications for public health. Clinical Microbiology Reviews 17:72–97.

Xiao, L., U. M. Ryan, T. K. Graczyk, J. Limor, L. Li, M. Kombert, R. Junge, B. Koudela, D. Modrý, and A. A. Lai. 2004. Genetic diversity of *Cryptosporidium* spp. in captive reptiles. Applied Environmental Microbiology 70:891–899.

Zug, G. R. 2013. Reptiles and amphibians of the Pacific Islands: a comprehensive guide. University of California Press, Berkeley, California. 400 pp.