DOI: 10.2478/s11686-014-0304-5

Acta Parasitologica, 2014, 59(4), 686–689; ISSN 1230-2821

VERSITA

A new species of coccidia (Apicomplexa: Eimeriidae) from Cordillera striped shrew-rat, *Chrotomys whiteheadi* (Rodentia: Muridae), from the Philippines

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Abstract

During July 2011, a single Cordillera striped shrew-rat (*Chrotomys whiteheadi*) was collected from the Philippines and its faeces examined for coccidian parasites. It harboured an eimerian that we describe here as new. Oocysts of *Eimeria macarthuri* sp. n. were spheroidal to subspheroidal with a bi-layered wall and measured (length × width, L × W) 18.2 × 17.0 µm, with an L/W ratio of 1.1. A micropyle, oocyst residuum and polar granule were absent. Sporocysts were ovoidal, 9.0 × 6.4 µm, with an L/W ratio of 1.3. A nipple-like Stieda body was present as well as a substieda body. A granular sporocyst residuum was present. To our knowledge, *E. macarthuri* represents the only coccidian ever described from a rodent of the Philippines.

Keywords

Apicomplexa, Coccidia, taxonomy, oocysts, Rodentia, Muridae, *Eimeria macarthuri*, Philippines

Introduction

The Cordillera striped shrew-rat, *Chrotomys whiteheadi* Thomas is one of five members of the genus (Carlton and Musser 2005) that is endemic to the Philippines. This species is restricted to northern Luzon (Benguet, Cagayan, Kalinga and Mountain provinces), where it is common in the northern and central Cordillera occurring from 925–2,700 m (Heaney *et al.* 2008). The species occurs in primary, secondary, and disturbed lower montane forest to mossy forest in the central Cordillera (Sanborn, 1952; Rabor, 1955; Largen, 1985) and agricultural areas adjacent to forest. Although this rat can exist in pristine habitats, it is the most habitat-tolerant native species and can also be found in highly disturbed croplands, vegetable gardens, farms, and rice fields or essentially anywhere where there are earthworms (Ricart *et al*. 2007). However, the species is not found in grasslands or in open agricultural areas.

Nothing is known about the coccidia of *C. whiteheadi* nor, for that matter, any other rodent in the Philippines. Herein, we provide a description of a new species of *Eimeria* from *C. whiteheadi*.

Materials and Methods

During July 2011, a single adult (242 g) male *C. whiteheadi* was collected at 680 m elevation at Mt. Cagua, (Cagayan Province, Luzon Island), Philippines, and examined for coccidia. A fresh faecal sample was placed in an individual vial containing 2.5% (w/v) aqueous potassium dichromate ($K_2Cr_2O_7$). The sample was shipped to the USA and examined for coccidia by light microscopy after flotation in Sheather's sugar solution (specific gravity = 1.30). Measurements were taken on 17 sporulated oocysts using a calibrated ocular micrometer and reported in micrometres (µm) with means followed by the ranges in parentheses; photographs were taken using Nomarski interference-contrast optics. Oocysts were ~515 days old when measured and photographed. 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), 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), substieda body (SSB), parastieda body (PSB), sporocyst

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residuum (SR), sporozoites (SZ) anterior (ARB) and posterior (PRB) refractile bodies, and nucleus (N). A host voucher was accessioned into Kansas Museum of Natural History (KUMNH). Photosyntypes of sporulated oocysts were accessioned into the United States National Parasite Collection (USNPC), Beltsville, Maryland, USA.

Results

The single *R. whiteheadi* was found to be passing oocysts of an eimerian which we describe here as new.

Eimeria macarthuri sp. nov.(Figs 1–4)

Description of sporulated oocyst: Oocyst with 4 sporocysts; shape spheroidal—subspheroidal; bi-layered wall, colourless, ~1.2 thick, textured outer layer ~0.8 thick, smooth inner layer ~0.4 thick; L × W: 18.2 × 17.0 (16–20 × 15–19); L/W: 1.1 (1.0–1.1); M, OR, PG: all absent.

Description of sporocyst and sporozoites: SP ovoidal, with a smooth uni–layered wall, ~ 0.4 thick; L × W: 9.0 × 6.4 (8–10 × 6–7); L/W: 1.3 (1.2–1.6); SB nipple-like, SSB body present, PSB body absent; SR: granular, composed of moderately-sized granules in a compact mass or dispersed between SZ; SZ: (not measured) sausage-shaped with spheroidal ARB and PRB; single N slightly posterior to midpoint.

Taxonomic summary

Type host: Cordillera striped shrew-rat, *Chrotomys whiteheadi* Thomas, 1895 (Rodentia: Muridae). Collected 22 July 2011.

Type specimens: Symbiotype host in the Kansas Museum of Natural History (KUMNH # 168307, Parasite # P-4698). Photosyntype of sporulated oocyst deposited in the USNPC as No. 107957.

Type locality: Mt. Cagua, Cagayan Province, Luzon Island, Philippines (18.236°N, 122.104°E, elev. 680 m).

Prevalence: In one of one (100%) of the type host.

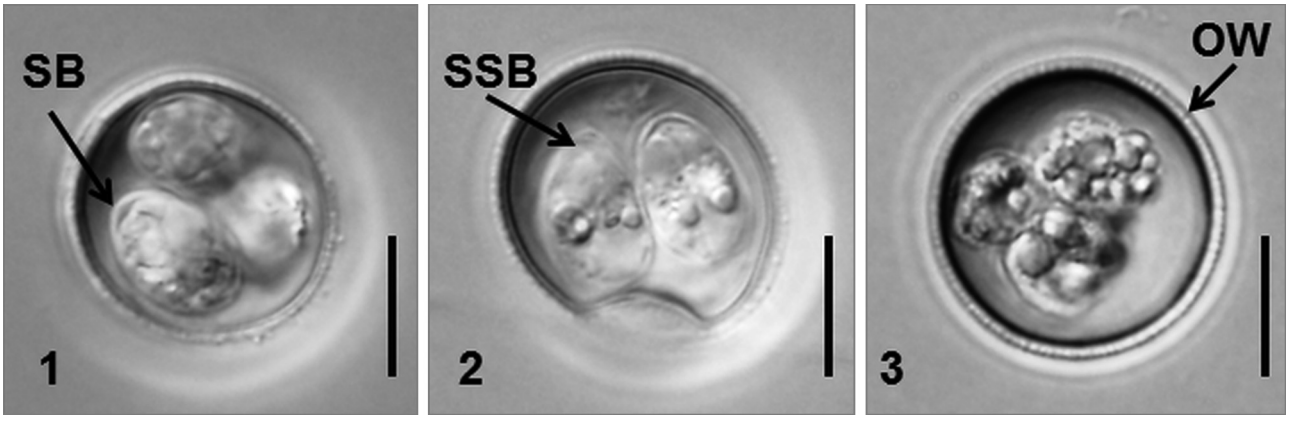
Sporulation: Unknown. Specimens were collected in the field, stored in $K_2Cr_2O_7$ solution, and not examined until 515 days later.

Site of infection: Unknown, oocysts recovered from faeces.

Etymology: The specific epithet is given in honour of General Douglas MacArthur (1880–1964), for his prominent role in the Pacific Theater of WW II, particularly in the Philippines, and the only man ever to become a field marshal in the Philippine Army.

Remarks: As there are no previous coccidians described from any rodent in the Philippines, we restrict our comparisons to eimerians described from rodents found in the general region (i.e., Malaysia) (Colley and Mullin, 1971; Mullin *et al*. 1972). The only species similar in size to the new species is *Eimeria miyairii* Ohira, 1912, originally described from common brown rat, *Rattus norvegicus* from Japan (Ohira 1912), but also reported from "wild rats" in Japan by Matubayasi (1938), Whitehead's spiny rat, *Maxomys* (=*Rattus*) *whiteheadi* from Seangor, West Malaysia, and Malaysian field rat, *Rattus tiomanicus* from Pekan, West Malaysia (Ohira 1912; Mullin *et al*. 1972).

The first reasonable description of any coccidium from *Rattus* was of *E. miyairii* by Ohira (1912), but it was written in Japanese and was not read by Western workers. The result was that for many years the species now known as *Eimeria nieschulzi* Dieben, 1924, was thought to be *E. miyairii* (Pellérdy 1974, p. 584) because their oocysts were somewhat similar. Roudabush (1937) translated Ohira's 1912 paper and, using isolates of oocysts from different colleagues to infect lab rats (presumably *R. norvegicus*), was able to definitively distinguish, in great detail, between the endogenous developmental stages of the three eimerians known from rats at that time, *E. miyairii*, *E. nieschulzi*, and *Eimeria separata* Becker and Hall, 1931. He did not, however, mention the differences between their sporulated oocysts. Matubayasi (1938), unaware of Roudabush's (1937) paper, added further confusion when he studied sporogony and endogenous development and pro-



Figs 1–**3.** Nomarski interference-contrast photomicrographs of oocysts of *E. macarthuri* n. sp. Abbreviations: oocyst wall (OW), Stieda body (SB), substieda body (SSB). Scale bars = 10 μm for all figures

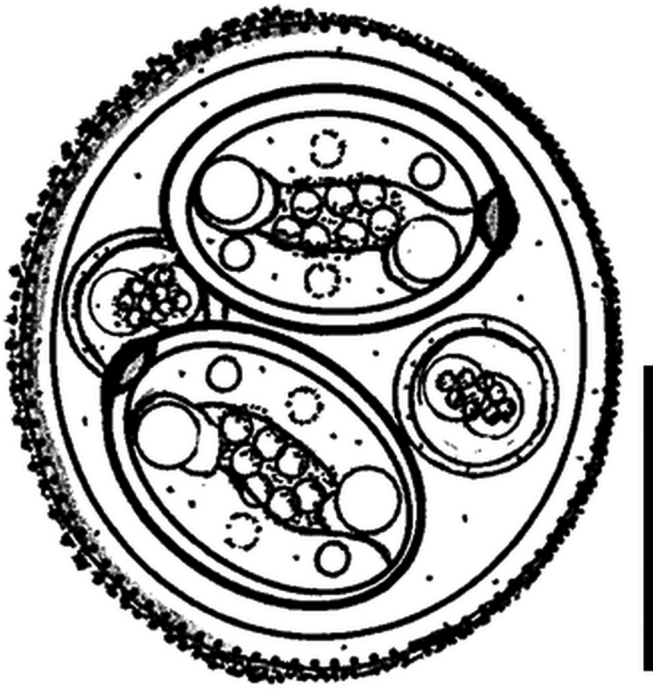


Fig. 4. Composite line drawing of oocyst of *Eimeria macarthuri* n. sp. Scale bar = 10 μm

vided line drawings and photomicrographs of the sporulated oocysts of three eimerians he found in wild rats in Japan: *E. carinii* (which was actually *E. miyairii*), *E. miyairii* (which was actually *E. nieschulzi*) and *E. separata*. Levine and Husar (1979) found *E. miyairii* oocysts in two wild *R. norvegicus* trapped in Illinois, USA; using a translation of Ohira's (1912) paper, they cleared up the nomenclatural confusion between *E. carinii*, *E. miyairii*, and *E. nieschulzi*, and redescribed the sporulated oocyst of *E. miyairii* in detail. Our new species differ from *E. miyairii* by having sporocysts that are smaller (9.0 × 6.4 [8–10 × 6–7] *vs.* 12.0 × 8.0 [11–14 × 7–9]) resulting in a smaller L/W ratio (1.3 vs. 1.6), by lacking a polar granule, and by possessing refractile bodies in the sporozoites. Our sporulated oocysts also differs from those of *E. nieschulzi* in shape (nearly spheroidal *vs.* ovoidal), size (18.2 × 17.0 [16–20 × 15–19] *vs.* 23 × 17 [16–26 × 13–21]), and L/W ratio (1.1 *vs.*1.3), and the latter has a distinct polar granule which our new species lacks. Their sporocysts also are distinctly different in size and our species has a substieda body, which the sporocysts of *E. nieschulzi* lack.

Finally, *Eimeria garumarana* Bandyopadhyay and Dasgupta, 1984, described from the common field rat, *Rattus rattus brunneusculus* (Hodgson) in India, has oocysts that are similar in size and other features to the form we describe here. Its sporulated oocysts are subspheroidal and measure 18 × 17.9 (17–20 × 16.5–19) and lack an oocyst residuum and polar granule. Its ovoidal sporocysts are 9.8 × 7.5 (9–11 × 6–8) and have both a nipple-like Stieda body and a granular sporocyst residuum. There are two differences that distinguish these oocysts from ours, both of which could be questioned: 1) Bandyopadhyay and Dasgupta (1984) stated throughout their paper that there is a distinct micropyle in their oocyst, ~2.0 wide, but their line drawing does not have a micropyle and they did not provide a photomicrograph; and 2) their sporocysts were not reported to have a substieda body (which the authors could have missed), which our form does have. Given these discrepancies, the distance of the Philippines from India (>4,400 km), being separated by part of the Asian continent, and the difference in host genera we are confident that our form is a new species.

Discussion

The mammalian fauna of the Philippine Islands is species-rich and remarkably diverse, and comprises what could be the largest concentration of endemic mammals of any country. In addition, the following murid rodents have been introduced into the Philippines (widespread unless otherwise noted): house mouse, *Mus musculus*, rice-field rat, *Rattus argentiventer* (Mindanao only), Polynesian rat, *Rattus exulans*, Himalayan field rat, *Rattus nitidus* (northern Luzon only), *R. norvegicus*, Tanezumi rat, *Rattus tanezumi* (formerly included in *R. rattus*), and *R. tiomanicus* (Palawan only) (Heaney *et al*. 2010). At least two of these rodents in other locales have been reported to harbor coccidia (see Levine and Ivens 1990). We hope that our initial report of a coccidian from an endemic rodent on this Pacific island will stimulate others to survey additional mammals of the Philippines for these apicomplexan parasites in order to increase our knowledge of their biodiversity.

Acknowledgements. We thank P. A. Pilitt for expert curatorial assistance. We also thank N. Antoque, J. A. Cantil, S. Knutie, and S. Villa for their assistance in the field. This study was supported, in part, by the National Science Foundation BS&I grant DEB 0743491 to R. M. Brown, S. E. Bush, D. H. Clayton, and R. G. Moyle and grants from the National Center for Research Resources (5P20RR016474-12) and the National Institute of General Medical Sciences (8P20GM103432-12) from the National Institutes of Health to R. S. Seville.

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Received: March 14, 2014
Revised: July 16, 2014
Accepted for publication: July 27, 2014