

SHORT COMMUNICATION

Helminths of five species of lizards of the genus *Draco* (Squamata: Agamidae) from peninsular Malaysia and one species from Cambodia

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The genus *Draco* Linnaeus, 1758 contains some 40 species of lizards that collectively range from southern India and Indochina, east to the Philippines, and south through the Malay Peninsula and throughout the Indo-Australian Archipelago and East to the Key Islands of Indonesia (Grismer 2011, Uetz and Hosek 2015). There are few reports of helminths from *Draco*. Bain *et al.* (1982) described the filariid, *Conispiculum ramachandranii* Bain, Kouyate and Baker, 1982, from *Draco maximus* Boulenger, 1893 collected in Malaysia. Tkach *et al.* (2011) described *Rhabdias mcquirei* Tkach, Kuzmin and Brown, 2011, and Kuzmin *et al.* (2012) described *R. odilebaini* Kuzmin, Tkach and Bush, 2012; both nematode species are from *Draco spilopterus* (Wiegmann, 1834) collected on Luzon Island, Philippines.

Herein, we provide preliminary lists of helminths from five species of *Draco* from Peninsular Malaysia and one species from Cambodia (Table 1). *Draco abbreviatus* ranges from Thailand, southward through peninsular Malaysia to Singapore, Sumatra, and Borneo (Grismer 2011); *D. blanfordii* occurs in parts of Myanmar, Thailand, northern peninsular Malaysia, and Indonesia (Grismer 2011); *D. formosus* ranges from southern Thailand, southward throughout the Malay Peninsula (Grismer 2011); *D. sumatrana* occurs in Thailand, peninsular Malaysia, Singapore, Sumatra, and Borneo (Das 2010); *D. taeniopterus* ranges from Myanmar, central Thailand, and central Cambodia, south to northern peninsular Malaysia (Grismer 2011); and *D. maculatus* (from Cambodia) ranges from southern China, southward to northern peninsula Malaysia (Grismer 2011).

Sixteen individuals of six species of *Draco* were borrowed from the herpetology collection of La Sierra University (LSUHC), Riverside

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Table 1. Number of helminths (N), prevalence (P as %). Mean (X) and range (r) in 11 *Draco* lizards from peninsular Malaysia: *D. abbreviatus* (N = 1), *D. blanfordii* (N = 2), *D. formosus* (N = 2), *D. maculatus* (N = 5), *D. sumatranaus* (N = 3), *D. taeniopterus* (N = 3), and 5 from Cambodia: *D. maculatus* (N = 5). All helminth findings are new host records.

Helminth	<i>D. abbreviatus</i>			<i>D. blanfordii</i>			<i>D. formosus</i>			<i>D. maculatus</i>			<i>D. sumatranaus</i>			<i>D. taeniopterus</i>							
	N	%	X	r	N	%	X	r	N	%	X	r	N	%	X	r	N	%	X	r			
<i>Abbreviata achari</i>	1	100	1.0	(1)	14	100	7.0	1-13	-	-	-	9	20	4.5	(2-7)	5	100	1.7	(1-3)	2	33	2.0	(2)
<i>Gonofilaria rudnicki</i>	4	100	4.0	(4)	-	-	-	-	2	50	2.0	(2)	-	-	-	-	-	-	-	-	-	-	
<i>Ornatoascaris sandoshami</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	33	1.0	(1)	-	-	-	
<i>Strongyluris calotis</i>	6	100	6.0	(6)	1	(100)	1.0	(1)	1	50	1.0	(1)	-	-	-	-	-	-	-	3	33	3.0	(3)
<i>Physocephalus</i> cysts	-	-	-	-	-	-	-	-	-	-	-	-	4	20	4.0	(4)	-	-	-	-	-	-	

California (Appendix I) and examined for helminths: *D. abbreviatus* (N = 1); *D. blanfordii* (N = 2); *D. formosus* (N = 2); *D. maculatus* (N = 5); *D. sumatranaus* (N = 3); *D. taeniopterus* (N = 3).

Specimens had been fixed in 10% formalin and later stored in 70% ethanol. The body cavity was opened by a longitudinal incision and the gastrointestinal tract was removed by cutting across the esophagus and rectum. The esophagus, stomach, small intestine, large intestine, and body cavity were examined separately with a dissecting microscope for helminths. Nematodes were cleared in lactophenol. All were examined under a compound microscope and identified. Nematodes were identified to genus using Anderson *et al.* (2009) and Gibbons (2010) and to species by comparison with the original descriptions. Helminths were deposited in the Harold W. Manter Laboratory (HWML), University of Nebraska, Lincoln, USA (Appendix II). Parasite terminology follows that of Bush *et al.* (1997). Number of helminths, prevalence (%), mean, and range are in Table 1. All 13 reported occurrences of Nematoda are new host records.

The following five species of Nematoda were identified: *Abbreviata achari* (Mirza, 1935) (infection sites: stomach, small intestine); *Gonofilaria rudnicki* Mullin, 1973 (body cavity); *Ornatoascaris sandoshami* (Yuen, 1963) (small intestine); *Strongyluris calotis* Baylis and Daubney, 1923 (small and large intestines); *Physocephalus* sp. (larvae in cysts in stomach wall).

Abbreviata achari was described from *Calotes versicolor* (Daudin, 1802) collected in Hyderabad, Deccan, India (Mirza 1935). Soota and Chaturvedi (1969) redescribed the species from *C. versicolor* from Odisha, (formerly Orissa) India. Goldberg *et al.* (2003) recorded it from *C. versicolor* from Pakistan. *Abbreviata achari* has the widest distribution in the current study and was found in five species of *Draco* (Table 1). Peninsular Malaysia is a new locality record.

Gonofilaria rudnicki was described from two species of agamid lizards, *Gonocephalus bornensis* (Schlegel, 1851) and *Acanthosaura armata* (Gray, 1827) from Selangor State, West Malaysia, by Mullin (1973). An immature female *G. rudnicki* also was found in *Limnonectes macrodon* (Duméril and Bibron, 1841) (as *Rana macrodon*) (Mullin 1973).

Orneoascaris sandoshami (Yuen, 1963) originally was described as *Amplicaeum sandoshami* by Yuen (1963) from the Malayan Horned Frog, *Megophrys nasuta* (Schlegel, 1858) (Megophryidae), collected in Singapore, but was reassigned to its current position by Sprent (1985). *Orneoascaris sandoshami* was reported in *Gonocephalus abbotti* Cochran, 1922 by Goldberg *et al.* (2005), *Aphaniotis fusca* (Peters, 1864) (Goldberg *et al.* 2015a), *Larutia trifasciata* (Tweedie, 1940) (Goldberg *et al.* 2015b), *Bronchocela cristatella* (Kuhl, 1820) (Goldberg *et al.* 2015d), *Gonocephalus bellii*, (Duméril and Bibron, 1837), *G. grandis* (Gray, 1845) (Goldberg *et al.* 2016) from peninsular Malaysia and *Acanthosaura cardamomensis* Wood, Grismer, Grismer, Neang, Chav and Holden, 2010, from Cambodia (Bursey *et al.* 2015).

Strongyluris calotis is widely distributed in Asian agamid lizards (Baker 1987) and also has been reported in agamids of Palestine (Rayyan *et al.* 2013) and Pakistan (Goldberg *et al.* 2003). *Strongyluris calotis* was present in four species of *Draco* lizards (Table 1). The species also was found in the agamid lizards, *B. cristatella* (Goldberg *et al.* 2015d), *Gonocephalus bellii* (Duméril and Bibron, 1837), and *G. grandis* from peninsular Malaysia (Goldberg *et al.* 2016).

Infective larvae of *Phyocephalus sexalatus* (Molin, 1860) have been found encapsulated in tissues of numerous species of dung beetles; encapsulated infective larvae are common in tissues of amphibians, reptiles, birds, and mammals that serve as paratenic (= transport) hosts (Anderson 2000). Development to the adult form occurs when they are ingested by mammals (Anderson 2000). Goldberg *et al.*

(1994) reported larvae of *Phyocephalus* sp. in stomach granulomas of *Sceloporus cyanogenys* Cope, 1885 (as *Sceloporus serrifer*). Fourth-stage larvae or mature nematodes were not found; thus, identification to species of *Phyocephalus* is not possible.

*Draco abbreviatu*s was infected with three nematode species, whereas each of the other five species was infected by two nematode species. *Draco blanfordii* was infected with the most individuals of nematodes (15), and *D. formosus* had the fewest (3). Mean number of helminths infecting each species of *Draco* is 8.8 ± 4.8 SD, range = 3–15.

Four of five nematodes reported to infect *Draco* lizards—*Abbreviata achari*, *Gonofilaria rudnicki*, *Orneoascaris sandoshami*, and *Phyocephalus* sp.—are heteroxenous utilize intermediate hosts to complete their life cycles (Anderson 2000). *Gonofilaria rudnicki*, is transmitted by haematophagous vectors (Anderson 2000). The remaining species, *Strongyluris calotis* is monoxenous (direct life cycle, no intermediate host), infection by egg ingestion (Anderson 2000).

Examination of our limited samples of *Draco* suggests that this lizard genus is infected by generalist helminths, capable of infecting a variety of lizard hosts. This is also the case for species of *Cnemaspis* (Goldberg *et al.* 2015c) and *Gonocephalus* (Goldberg *et al.* 2016) from Southeast Asia. With some 40 known species of *Draco* (Uetz and Hosek 2015), additional species should be examined to document the diversity of helminths infecting this genus.

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Appendix I. *Draco* specimens examined from the herpetology collection of
La Sierra University (LSUHC), Riverside, California, USA.

Draco abbreviatus ($N = 1$)—(LSUHC 7613) West Malaysia, Johor State, Endau Rompin, Peta (02°32'74" N, 03°24'79" E), August 2005.

Draco blandfordii ($N = 2$)—(LSUHC 7090) West Malaysia, Kedah State, Pulau Langkawi (04°47'58.419" N, 101°03'30.3012" E), March 2005; (LSUHC 8982) West Malaysia, Perlis State, Wangkelian (06°40'43.9464" N, 100°11'12.4224" E), June 2008.

Draco formosus ($N = 2$)—(LSUHC 4712) West Malaysia, Johor State, Pulau Tinggi (02°18'19.7994" N, 104°07'5.1594" E), July 2002; (LSUHC 4952) West Malaysia, Pahang State, Sungai Lembring Logging Camp (03°45' N, 102°19' E), August 2002.

Draco maculatus ($N = 5$)—(LSUHC 7343, 7389, 7390, 7411) Cambodia, Kampong Speu Province, Phnom (12°01'0.12" N, 104°09' E), August 2005; (LSUHC 8411) Cambodia, Pursat Province, Che Teal Chrum (12°11'53.8794" N, 103°06'53.9994" E), June 2007.

Draco sumatranaus ($N = 3$)—(LSUHC 9393, 9406) West Malaysia, Terengganu State, Pulau Redang (05°46'30" N, 103°0'54" E), September 2009; (LSUHC 9426) West Malaysia, Kedah State, Pulau Langkawi, Temurun (06°20'44.412" N, 99°51'48.5634" E), September 2009.

Draco taeniopterus ($N = 3$)—(LSUHC 8797) West Malaysia, Perlis State, Perlis State Park (06°37'41.3" N, 100°11'13.6" E), March 2008; (LSUHC 10306) West Malaysia, Kedah State, Ulu Muda (96°0' N, 100°58'0.12" E), September 2011; (LSUHC 10908) West Malaysia, Terengganu State, Gunung Tebu (05°33'3.31" N, 102°35'58.8" E), September 2012.

Appendix II. Harold W. Manter Laboratory (HWML) accession numbers for helminths from *Draco* spp.
taken from the herpetology collection of La Sierra University (LSUHC), Riverside, California, USA.

Draco abbreviatus: *Abbreviata achari* (HWML 94144), *Gonofilaria rudnicki* (HWML 94145), *Strongyluris calotis* (HWML 94146); *Draco blanfordii*: *Abbreviata achari* (HWML 94147), *Strongyluris calotis* (HWML 94148); *Draco formosus*: *Gonofilaria rudnicki* (HWML 94150), *Strongyluris calotis* (HWML 94151); *Draco maculatus*: *Abbreviata achari* (HWML 94152), *Phyocephalus* sp. (HWML 94153); *Draco sumatranaus*: *Abbreviata achari* (HWML 94154), *Orneoascaris sandoshami* (HWML 94155); *Draco taeniopterus*: *Abbreviata achari* (HWML 96271), *Strongyluris calotis* (HWML 96272).