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A description of parasites from Mountain Wolf Snakes, *Lycodon ruhstrati ruhstrati* (Serpentes: Colubridae), from two localities in western Taiwan

Gerrut Norval[1*], Stephen R. Goldberg [2], Charles R. Bursey [3], Simon Dieckmann [4], and Jean-Jay Mao[5]

[1]*Applied Behavioural Ecology and Ecosystem Research Unit, Department of Environmental Sciences, University of South Africa, Private Bag X6, Florida, 1710, Republic of South Africa.*

[2] *Department of Biology, Whittier College, Whittier, California 90608, U.S.A.*

[3] *Department of Biology, Pennsylvania State University, Shenango Campus, Sharon, Pennsylvania 16146, U.S.A.*

[4] *430, Huacheng 5th St., Yian Township, Hualien County, 973, Taiwan, R.O.C.*

[5] *Department of Forestry and Natural Resources, National Ilan University, No. 1, Sec. 1, Shen-Lung Rd., Yilan, 260, Taiwan, R.O.C.*

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Based on the results of a recent revision of the species *Lycodon ruhstrati* (Fischer, 1886) by Vogel *et al*. (2009), it was found that *Lycodon ruhstrati ruhstrati* (Fischer, 1886) can be regarded as an endemic subspecies, restricted to Taiwan and that the mainland populations in China and northern Vietnam consisted of the revalidated species *Lycodon futsingensis* (Pope, 1928) and the newly described subspecies *Lycodon ruhstrati abditus* Vogel, David, Pauwels, Sumontha, Norval, Hendrix, Vu & Ziegler, 2009. *Lycodon ruhstrati ruhstrati* is a fairly common subspecies, which tends to inhabit natural forests, secondary forests, plantations, gardens, rice paddies and other agricultural areas in foothills and mountainous areas below 2000 m all over Taiwan (Maki, 1931; Kuntz, 1963; Lazell, 1999; Lue *et al.*, 2002; Lee, 2005). Pope (1929) stated that this species is saurophagous and although Lue *et al*. (2002) reported that they might also be insectivorous, to date, we have recorded no prey types other than saurians (Norval *et al*., 2007; Norval & Mao, 2008a; Norval & Mao, 2008b). There are, to our knowledge, two reports pertaining to parasites from *L. r. ruhstrati* collected in Taiwan (Norval *et al*., 2009a; Norval *et al*., 2009b); which reported *Kiricephalus pattoni* (Stephens, 1908) and *Raillietiella orientalis* (Hett, 1915). The purpose of this paper is thus to add to the parasite list of *L. r. ruhstrati*.

For this study we examined six *L. r. ruhstrati* in the herpetology collection of the Natural History Museum of Los Angeles County (LACM), Los Angeles, California U.S.A. (Table 1), for parasites. The specimens consisted of snakes from western Taiwan, that were collected in 2008 and 2009 from the wild and subsequently died while in captivity (n = 4), and snakes that were found dead on roads (DOR; n = 2). The body cavity of each snake was opened by a longitudinal incision from throat to vent and searched for parasites under a dissecting microscope. The gastrointestinal tract was removed by cutting across the esophagus and rectum, and the esophagus, stomach, small and large intestines were slit longitudinally, and also separately searched for parasites under a dissecting microscope. For study, parasites were placed in a drop of lactophenol on a glass slide, allowed to clear, and identified from these temporary preparations. We used the terminology of Bush *et al.* (1997) to describe the prevalence and mean intensity of the parasites.

The parasites found, and their numbers, are listed in table 2. Parasites were deposited in the United States National Parasite Collection (USNPC), Beltsville, Maryland, U.S.A. as: Ascarididae USNPC 105953, *Kalicephalus posterovulus* USNPC 105954, *Raillietella orientalis* USNPC 105955, Giganthorhynchidea USNPC 105956, *Kiricephalus pattoni* USNPC 105957, and Sparganum (see below) USNPC 105952.

The snakes that were maintained in captivity were fed lizards collected from the same localities in the wild where the snakes were collected, and were thus natural prey, so it is our opinion that the prey did not infect the snakes with parasites that they would not have been exposed to under natural conditions. The fact that many of the same parasites were also found in the DOR snakes support this assumption.

Diesing (1854) proposed the term “sparganum” for unidentifiable cestode larvae, and this designation is currently commonly used when referring to plerocercoid (= infective) larvae of tapeworms in the family Diphyllobothridae. Spargana are known from all vertebrate groups, except fish (Lapage, 1963; Bray *et al*., 1994). The first intermediate host is a freshwater copepod, usually of the genus *Cyclops* (Li, 1929; Lapage, 1963). Infection of snakes can easily occur by ingestion of the copepod or a second intermediate host carrying plerocercoids (Lapage, 1963). No further larval development occurs in the snake, but it may serve as a transport host.

Identification of species of the Nematoda require adult individuals, thus we were unable to specifically identify the ascarid larvae found in this study. However, transmission of ascarids commonly involves terrestrial invertebrates and/or small mammal transport, or intermediate hosts (Anderson, 2000). To our knowledge, only one ascarid species has been reported from

**Corresponding Author's E-mail: gnorval@gmail.com*

Table 1. The collection locality, sex, snout-vent length (SVL in mm), tail length (TL in mm), and body mass (g) of the *Lycodon ruhstrati ruhstrati* used in this study.

Specimen No.	Collection locality	Sex	SVL	TL	Mass
LACM 178149	Chiayi City (N 23º 28' E 120º 29')	M	585	182	19.4
LACM 178150	Taichung City (N 24º 11' E 120º 44')	M	607	202	23.8
LACM 178151	Taichung City (N 24º 11' E 120º 44')	F	505	172	31.9
LACM 178152	Taichung City (N 24º 11' E 120º 44')	F	592	190	23
LACM 178153	Taichung City (N 24º 10' E 120º 46')	M	605	210	33
LACM 178154	Taichung City (N 24º 11' E 120º 44')	M	565	184	35.9

Table 2. The numbers, ranges, prevalence and mean intensity of the parasites recorded in this study.

	n	Range	Prevalence	Mean intensity ± SD
Ascarid larvae	6	6	16.7%	6
Giganthorhynchidea (cystacanths)	120	7 – 75	50%	40 ± 34.0
Kalicephalus posterovulvus	61	2 – 58	33.3%	30.5 ± 38.9
Kiricephalus pattoni (nymph)	2	1	33.3%	1 ± 0.0
Raillietiella orientalis	76	2 – 59	66.7%	19 ± 27.0
Sparganum (cestode larvae)	2	1	33.3%	1 ± 0.0

Table 3. A summery of the reported hosts of *Kalicephalus posterovulvus*.

Host	Locality	Reference
Sauria		
Ceratophora stoddarti	Sri Lanka (Ceylon)	Schad, 1962
Serpentes		
Amphiesma pryeri pryeri (synonym *Natrix pryeri pryeri*)	Okinawa	Hasegawa, 1985
Dendrelaphis caudolineatus (synonym *Ahaetulla caudolineata*; *Dendrophis caudolineatus*)	North Borneo	Schad, 1962; Myers and Kuntz, 1969
Dinodon rufozonatum rufozonatum	Taiwan (Formosa)	Schad, 1962
Lycodon ruhstrati ruhstrati	Taiwan	This study
Lycodon subcinctus	Philippines	Schmidt and Kuntz, 1972
Oligodon formosanus (synonym *Holarchus formosanus*)	Taiwan (Formosa)	Schad, 1962
Psammodynastes pulverulentus	Taiwan (Formosa)	Schad, 1962

Taiwan; *Paraheterotyphlum ophophagos* from the sea snake *Laticauda colubrina* (Schmidt & Kuntz, 1973).

How snakes become infected by kalicephalids is unknown. Schad (1956) experimentally infected snakes by oral inoculation of third-stage larvae but suggested that natural infections might occur if larvae attach to a snake's tongue as it tests its environment. There is no evidence that skin penetration occurs (Anderson, 2000). A host list for *Kalicephalus posterovulvus* Schad, 1962 is given in table 3. *Lycodon r. ruhstrati* represents a new host record for *K. posterovulvus*.

Kiricephalus pattoni adults have only been found in a few snake species, but the nymphs have been recorded in a wide variety of amphibians, lizards, and snakes (Riley & Self, 1980; Bursey & Goldberg, 2004; Norval *et al*., 2009a). The life cycle of this parasite is not clear, but it has been determined that eggs can directly infect amphibians and lizards (first intermediate hosts), snakes are the second intermediate host, and the definite hosts are ophiophagus snakes (Riley & Self, 1980).

The life cycle of *R. orientalis* is also not clear, but both nymphs and adults have been collected from snakes (Lai *et al*., 2004). In Taiwan, *R. orientalis* has been reported from *Elaphe carinata* (Günther, 1864), *Lycodon r. ruhstrati*, *Psammodynastes pulverulentus* (Boie, 1827), and *Daboia russelii* (Shaw & Nodder, 1797) (Self & Kuntz, 1960; Keegan *et al*., 1969; Norval *et al*., 2009a).

Identification of species of the Acanthocephala require adult individuals, thus we cannot identify the Giganthorhynchidea (cystacanths) found in this study to the species level. The life cycles of acanthocephalan species require two hosts (Schmidt, 1985). The life cycle begins with egg ingestion by an arthropod in which development to an infective juvenile (cystacanth) stage occurs. When an infected arthropod is ingested by a definitive host, excystation of the cystacanth occurs and development to maturity begins. Should the infected arthropod be eaten by an inappropriate host, the cystacanth excysts and migrates from the digestive tract into the body cavity and again encysts. We know of no previous reports of cystacanths in Taiwanese snakes.

Because parasites can reach high infection loads in hosts in captivity, parasites can be very problematic and may cause the death of hosts (Klingenberg, 1993), so for conservation efforts involving captive breeding, an understanding of the parasites of a particular species is crucial so that they can be managed. Even for the conservation of ecosystems and biodiversity, an understanding of parasites is important. Under natural conditions, parasites play vital roles in ecosystems because parasite-mediated effects could regulate host abundance (Boots & Sasaki, 2002; Dobson *et al*., 2008), shape host population dynamics (Horwitz & Wilcox, 2005), alter inter-specific competition (Zug, Vitt & Caldwell, 2001; Hatcher, Dick & Dunn, 2008), and influence energy flow (Hudson *et al*., 2006). There is also increasing evidence that parasites are important drivers of biodiversity, and that parasite diversity increases as ecosystem functioning improves (Hudson *et al*., 2006). There is thus a need for descriptions of parasites, and their hosts, as done herein, to ensure an interdisciplinary improvement of an understanding of the ecology of both the parasites and their hosts.

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