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INTERNAL PARASITES OF LIZARDS FROM TAIWAN

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***Abstract*.—We examined specimens of *Anolis sagrei*, *Eutropis longicaudata*, *Eutropis multifasciata*, *Japalura polygonata xanthostoma*, *Japalura swinhonis*, *Plestiodon elegans*, and *Sphenomorphus indicus* that we collected opportunistically from Taiwan for endoparasites. We recorded parasites in 52 of the 91 lizards examined, and the infected individuals harbored one to three species of parasites. We identified the parasites as *Cyrtosomum penneri*, *Kiricephalus pattoni*, *Mesocoelium sociale*, *Meteterakis govindi*, *Oochoristica chinensis*, *Oswaldocruzia japalurae*, *Parapharyngodon maplestonei*, *Pseudabbreviata yambarensis*, *Pseudoacanthocephalus bufonis*, or *Strongyluris calotis*. We also recorded an unidentifiable acanthocephalan infective juvenile (cystacanth) and an unidentifiable larva of a cestode (sparganum).**

Key Words.—*Anolis sagrei*; *Eutropis longicaudata*; *Eutropis multifasciata*; *Japalura polygonata xanthostoma*; *Japalura swinhonis*; *Plestiodon elegans*; *Sphenomorphus indicus*

INTRODUCTION

From an anthropogenic perspective, parasites are viewed with disdain, disgust, and/or condemnation (Lapage 1963). These views ignore the ecological roles parasites play, such as regulating host abundances (Boots and Sasaki 2002; Dobson et al. 2008), shaping host population dynamics (Horwitz and Wilcox 2005), altering interspecific competition (Zug et al. 2001; Hatcher et al. 2008), and influencing 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).

Further, parasites potentially play a role in the establishment and success of exotic invasive species. When a host species is introduced outside of its native range, it tends to be liberated from many parasites ("enemy release hypothesis") from its native range (Torchin et al. 2003; Prenter et al. 2004; Miura et al. 2006). This is due to a reduced probability of the introduction of parasites with exotic species (or early extinction after the establishment of the host), the absence of other required hosts in the new location, and the host-specific limitations of native parasites adapting to new hosts (Torchin et al. 2003). In some instances this may allow the host to grow to larger sizes than in its native range (e.g., Torchin et al. 2001). If a larger size makes the invader more competitive, it may contribute to its success in establishing new populations and/or competing with native species.

Parasites also may be introduced into new localities along with invasive species. When naïve host populations are infected by a new parasite transported by an introduced host, the invasive host species may acquire an advantage over the local species, which would contribute to the success of the invading species (Prenter et al. 2004; Horwitz and Wilcox 2005; Dunn et al. 2012). Even though under some conditions exotic invasive species can acquire non host-specific parasites from the new locality into which they have been introduced (e.g., Rolbiecki 2006), there may also be an absence of transmission routes that could be specific to native hosts, in which case the invaders are protected from native parasites (Prenter et al. 2004; Horwitz and Wilcox 2005). Under such conditions the protected invaders may thus have an advantage over the native species that can be infected by the parasites. It is, thus, important to report on parasites, their hosts, and other related information collected from the field as accurately and in as much detail as possible to improve the understanding of the ecology of both the parasites and their hosts. Herein we report on parasites removed from lizards collected on an ad hoc basis from Taiwan.

MATERIALS AND METHODS

As part of ongoing research on the Brown Anole (*Anolis sagrei*), an exotic invasive species, we collected

FIGURE 1. Lizards from which we removed endoparasites. A) The Brown Anole (*Anolis sagrei*) is an exotic invasive species in Taiwan. B) The Swinhoe's Tree Lizard (*Japalura swinhonis*) is an endemic species in Taiwan, and occurs throughout the island at elevations below 1500 m. C) The Elegant Skink (*Plestiodon elegans*) is a common indigenous species at elevations below 2500 m island-wide. D) The Indian Forest Skink (*Sphenomorphus indicus*) is an indigenous species in forested areas in Taiwan, and occurs throughout the island at elevations below 1500 m. E) The Long-tailed Sun Skink (*Eutropis longicaudata*) is Taiwan's largest indigenous lizard species, and their distribution is limited to low elevation (< 500 m) areas of western, southern and eastern parts of Taiwan. F) The Yellow-mouthed Tree Lizard (*Japalura polygonata xanthostoma*) is an endemic sub-species, and its occurrence is limited to the northern parts of Taiwan. G.) The Common Sun Skink (*Eutropis multifasciata*) is a large exotic invasive lizard species in Taiwan. (Photographed by Gerrut Norval [A-E, G] and Jean-Jay Mao [F]).

30 male and female lizards (Fig. 1) in March and July 2009 in Chisintang, Hualien County, Taiwan (24°01'00"N, 121°37'50"E). We also collected 31 *A. sagrei*, eight *Japalura swinhonis* (Fig. 1), nine *Plestiodon elegans* (Fig. 1), and four *Sphenomorphus indicus* (Fig. 1) in July and August 2009 in Santzepu, Sheishan District, Chiayi County, Taiwan (23°25'51"N, 120°28'30"E). We measured the snout-vent length (SVL) and tail length (TL) of the lizards to the nearest mm with a transparent plastic ruler while the animal was still alive, after which we killed lizards with ether and weighed them to the nearest 0.1g with a digital scale. We fixed specimens by injecting 10% formalin into the body cavity via the muscle posterior to the cloacal opening and left them on paper towels dampened with 10% formalin in a plastic container for two days. After the two-day fixation period, we placed each specimen, along with its field number label, individually in a sealed plastic bag, which we filled with 75% ethanol. We also examined one *Eutropis longicaudata* (Fig. 1) and two *J. swinhonis* specimens that were found dead on roads (DOR), three *Japalura polygonata xanthostoma* (Fig. 1) that were accidentally collected and died in other studies, and two *E. longicaudata* and one *Eutropis multifasciata* (Fig. 1) that were donated to us. We measured, weighed, and preserved all these lizards as described above. We packed and shipped all specimens to Whittier College, Whittier, California, USA, for examination.

During examination, we opened the body cavity of each lizard by making a longitudinal incision from the throat to the vent and removed the gastrointestinal tract by cutting across the esophagus and rectum. We slit longitudinally and separately searched under a dissecting microscope the esophagus, stomach, and small and large intestines for helminths. The lungs were not examined. Some of the donated lizards were already dissected, and sometimes incomplete, in which case we examined them as far as possible.

We cleared the helminths in a drop of undiluted glycerol on a glass slide to study. We identified nematodes from these temporary preparations, while digeneans and cestodes were regressively stained in haematoxylin, cleared in xylene, and mounted in Canada balsam. We examined them as whole mounts under a compound microscope. We followed the methods of Bush et al. (1997) to describe the prevalence of each parasite species in every host species as the number of infected hosts/number of examined specimens × 100, and the mean intensity of the infection as the mean number of a particular parasite species infecting the infected individuals of a specific host species (± SD). There were only sufficient numbers of *A. sagrei* to permit intersexual and interlocality comparisons. For the other lizards, due to the small sample sizes, we did not note the sexes and the data from various localities for every species was pooled. We deposited selected lizard specimens in the herpetology collection of the Natural History Museum of Los Angeles County (LACM), Los Angeles, California, USA (Appendix 1), and selected helminths in the United States Parasite Collection (USNPC), Beltsville, Maryland, USA (Appendix 2).

FIGURE 2. A *Kiricephalus pattoni* nymph (Top) visible through the skin of a female Brown Anole (*Anolis sagrei*) specimen collected (not part of this study), in Santzepu, southwestern Taiwan, and the same specimen after dissection (Bottom), with the parasite visible under the skin. (Photographed by Gerrut Norval).

RESULTS

We examined 91 lizards from seven species belonging to three families for this study (Table 1). We recorded parasites in 52 (57.1%) of the examined lizards and they harbored one to three species (mean ± SD = 1.3 ± 0.6) of parasites. The SVLs of the infected *A. sagrei* males from Chiayi County ranged from 48 to 51 mm (n = 3; mean ± SD = 49.7 ± 1.5) and that of the females from Chiayi County ranged from 38 to 46 mm (n = 8; 43.1 ± 2.7). The SVLs of the infected *A. sagrei* males from Hualien County ranged from 29 to 59 mm (n = 6; 40.7 ± 10.2) and that of the females from Hualien County ranged from 23 to 42 mm (n = 10; 33.6 ± 6.1). We recorded parasites from the phyla Acanthocephala, Arthropoda, Nematoda and Platyhelminthes (Table 2).

TABLE 1. The collection localities (CYC – Chiayi County; HLC – Hualien County; NTPC – New Taipei City; and TNC – Xinying, Tainan City), sex, numbers (n), and the ranges of snout-vent lengths (SVL) with means and standard deviations in parenthesis of lizards examined in this study.

Species	Locality	Sex	n	SVL (mm)
Agamidae				
Japalura polygonata xanthostoma	NTPC	–	3	39–58 (51.7 ± 11.0)
Japalura swinhonis	CYC	–	10	58–78 (70.4 ± 6.9)
Dactyloidae				
Anolis sagrei	CYC	Male	12	33–56 (45.8 ± 7.6)
	CYC	Female	19	27–48 (39.8 ± 6.5)
	HLC	Male	8	29–59 (42.8 ± 10.2)
	HLC	Female	22	23–43 (34.6 ± 5.1)
Scincidae				
Eutropis longicaudata	CYC	–	1	105
	TNC	–	2	104–113 (108.5 ± 6.4)
Eutropis multifasciata	TNC	–	1	115
Plestiodon elegans	CYC	–	9	43–80 (64.7 ± 13.6)
Sphenomorphus indicus	CYC	–	4	42–77 (64.5 ± 15.4)

We identified the acanthocephalan specimens as either being *Pseudoacanthocephalus bufonis* or as an unidentifiable infective juvenile (cystacanth). The pentastome *Kiricephalus pattoni* was the only parasitic arthropod we recorded in this study. Nematodes were the most numerous parasites we recorded, and were identified as *Cyrtosomum penneri*, *Meteterakis govindi*, *Oswaldocruzia japalurae*, *Parapharyngodon maplestonei*, *Pseudabbreviata yambarensis*, or *Strongyluris calotis* (Table 2). The only platyhelminths we found were the trematode *Mesocoelium sociale*, the eucestode *Oochoristica chinensis*, and an unidentifiable larva of a cestode. Some parasites infected only one host species, while we recorded others from multiple host species (Table 2).

DISCUSSION

The identification of Acanthocephala species requires adult individuals, so we cannot identify the cystacanths found in this study to the species level. The life cycles of acanthocephalan species require two hosts (Kennedy 2006), and begins with the ingestion of an egg (voided by a definitive host) by an arthropod (intermediate host) in which development to an infective juvenile (cystacanth) stage occurs (Roberts and Janovy 2005). When the infected arthropod is ingested by a definitive host, excystation of the cystacanth occurs and the development to maturity begins. If the infected arthropod is eaten by an inappropriate host (paratenic host), then the cystacanth excysts and migrates from the digestive tract into the body cavity, encysts, and survives without further development (Roberts and Janovy 2005; Kennedy 2006). Should a paratenic host be eaten by a proper definitive host, the parasite excysts and matures after attaching to the intestinal mucosa (Roberts and Janovy 2005). We are unaware of any other reports of cystacanths from *J. swinhonis*.

Bush et al. (2009) recently redescribed *P. bufonis* from the Chinese anurans *Odorrana versabilis* and *Polypedates mutus*, and since then, this parasite has also been found in *Fejervarya limnocharis* and *Polypedates megacephalus* from Taiwan (Norval et al. 2013; Yang et al. 2014). *Sphenomorphus indicus* represents a new host record for *P. bufonis*. *Sphenomorphus indicus* is an active, cruising predator also known as widely foraging (Norval et al. 2012a), and tends to feed more on prey types that are sedentary, unpredictably distributed, clumped, and/or are large and hidden (Huey and Pianka 1981). This means that they would be able to find prey that are nocturnal and thus usually only accessible to frogs. If such a prey item is the intermediate host of *P. bufonis*, it would explain the absence of this parasite in the diurnal *A. sagrei* and *J. swinhonis*, which tend to prey on more active prey, that are mobile, on the surface,

TABLE 2. The host lizard, numbers (n) of parasite specimens found, and the prevalence and mean intensity of each parasite species collected in this study. The parasite intensity ranges are given in parenthesis.

Parasite	Host	n	Prevalence	Intensity
Acanthocephala				
Cystacanth	*Japalura swinhonis*	1	10%	1
Pseudoacanthocephalus bufonis	*Sphenomorphus indicus*	2	50%	1 ± 0.0
Arthropoda				
Kiricephalus pattoni	*J. swinhonis*	4	10%	4
Nematoda				
Cyrtosomum penneri	*Anolis sagrei* (male; CYC)	123	25%	41 ± 34.1 (17–80)
	A. sagrei (female; CYC)	318	42.1%	39.8 ± 35.8 (3–107)
	A. sagrei (male; HLC)	108	75%	18 ± 13.4 (1–35)
	A. sagrei (female; HLC)	283	45.5%	28.3 ± 42.5 (3–142)
Meteterakis govindi	*Eutropis longicaudata*	2	33.3%	2
	Eutropis multifasciata	54	100%	54
Oswaldocruzia japalurae	*Japalura polygonata xanthostoma*	2	33.3%	2
	J. swinhonis	6	20%	3 ± 0.0
	Plestiodon elegans	5	33.3%	1.7 ± 0.6 (1–2)
	S. indicus	12	50%	6 ± 0.0
Parapharyngodon maplestonei	*P. elegans*	2	11.1%	2
Pseudabbreviata yambarensis	*J. swinhonis*	3	30%	1 ± 0.0
Strongyluris calotis	*J. polygonata xanthostoma*	13	66.7%	6.5 ± 6.4 (2–11)
	J. swinhonis	106	80%	13.3 ± 5.5 (6–22)
Platyhelminthes				
Mesocoelium sociale	*A. sagrei* (male; CYC)	1	1.6%	1
	E. longicaudata	43	66.7%	21.5 ± 27.6 (2–41)
	J. swinhonis	1	10%	1
	P. elegans	3	11.1%	3
	S. indicus	6	50%	3 ± 1.4 (2–4)
Oochoristica chinensis	*E. longicaudata*	1	33.3%	1
	J. swinhonis	3	30%	1 ± 0.0
Spargana	*J. swinhonis*	2	10%	2

and visually conspicuous (Huey and Pianka 1981; Norval et al. 2012b).

Kiricephalus pattoni is a fairly common parasite in parts of Australia, India, and Southeast Asia (Riley and Self 1980). The eggs of *K. pattoni* can directly infect amphibians and lizards (first intermediate hosts), as well as some snakes (second intermediate hosts), and as a result, nymphs have been recorded in a wide variety of amphibians, lizards, and snakes (Riley and Self 1980; Bursey and Goldberg 2004; Norval et al. 2009a). The definite hosts are primarily large ophiophagus snakes (Riley and Self 1980). *Japalura swinhonis* is a known host for the nymphs of *K. pattoni* (Riley and Self 1980). It is worth noting that of the lizard species we examined in this study, *K. pattoni* nymphs have previously also been recorded in *A. sagrei* (Norval et al. 2009b; Fig. 2) and *P. elegans* (Norval et al. 2014).

A large variety of nematodes infect reptiles (Frye 1991; Klingenberg 1993; Lane and Mader 1999), and as can be seen in this study, they can be very common. Some nematodes have a direct life cycle, while others have an indirect life cycle that may involve one or more intermediate hosts (Lane and Mader 1999). Although some parasitic nematodes appear to cause little harm to their reptilian hosts, other species (usually species that inhabit the digestive system) can potentially be harmful to the host (Lane and Mader 1999). The life cycles of many of the species discussed herein have not been studied, so little is known about their infection routes and affects on their hosts.

Cyrtosomum penneri is known to infect a variety of lizard species (including *A. sagrei*) from several genera in North and Central America (Bursey at al. 2012). This nematode was introduced into Taiwan along with *A. sagrei* that originated in Florida (Kolbe et al. 2004; Norval et al. 2011). *Cyrtosomum penneri* is transmitted from one host to another during copulation, and as a result, are usually only recorded from sexually mature individuals (Norval et al. 2011; Langford et al. 2013). The SVLs of the infected *A. sagrei* from Chiayi County were within the size ranges reported by Norval et al. (2011) and Langford et al. (2013). However, the minimum SVLs of the infected *A. sagrei* from Hualien County were smaller than those described in other studies (ca. SVL = 30 mm; Norval et al. 2011; Langford et al. (2013), which indicates that immature individuals may also copulate with infected adults. Although *C. penneri* seems to exhibit a degree of host specificity

(Langford et al. 2013), it should be noted that it has been recorded from several unrelated taxa, warranting empirical studies involving species sympatric with *A. sagrei* in Taiwan. *Meteterakis govindi* has been recorded from the bufonids, *Duttaphrynus himalayanus* and *Duttaphrynus melanostictus*, and an unspecified tree frog (Inglis 1958 and the references therein). Apart from a reference to a record of *M. govindi* from a *Varanus bengalensis* at a zoological garden (Inglis 1958; Sou and Nandi 2011), we are unaware of any other lizards as hosts of this parasite, so the *E. longicaudata* and *E. multifasciata* we discussed herein represents new host records for this parasite.

Jiang and Lin (1980) described *O. japalurae* from specimens taken from *Japalura swinhonis formosensis*. The former two subspecies, *Japalura swinhonis formosensis* and *Japalura swinhonis mitsukurii*, are currently regarded as synonyms of *J. swinhonis* (Ota 1991a, b, 2000), while specimens of the subspecies *Japalura swinhonis swinhonis* have been allocated to either *Japalura brevipes* (Ota 1989) or *Japalura polygonata xanthostoma* (Ota 1991b). Based on the location (central western Taiwan), habitat, and sizes of the lizards used in the study by Jiang and Lin (1980), the lizards were most likely of the species that is currently regarded as *J. swinhonis*. The results of our investigation therefore confirm that *O. japalurae* is also a parasite of *J. swinhonis* in southwestern Taiwan. *Japalura polygonata xanthostoma*, *P. elegans*, and *S. indicus*, however, represent new host records for *O. japalurae* from Taiwan. Studies are needed to verify whether *O. japalurae* infect lizards orally or percutaneously.

Apart from an unidentified *Parapharyngodon* specimen recorded from an *A. sagrei* collected in Santzepu, southwestern Taiwan (Norval et al. 2011), we are unaware of any other reports pertaining to these parasites in reptiles from Taiwan. To our knowledge, *P. elegans* represents a new host record for *P. maplestonei*, and Taiwan is also a new locality record for this parasite.

Pseudabbreviata yambarensis was first described from the agamid *Japalura polygonata polygonata* collected on Okinawa Island, Japan (Hasegawa and Otsuru 1984). We found no other host records for this parasite. As far as can be determined, *J. swinhonis* and *J. polygonata xanthostoma* represent new host records for *P. yambarensis* and Taiwan is also a new locality record for this parasite.

Strongyluris calotis appears to have a wide distribution in Asia, and has been recorded from a variety of lizard species, including *J. swinhonis* and *J. polygonata xanthostoma* (Balasingam 1964; Goldberg et al. 2003; Yildirimhan et al. 2006 and the references therein). *Strongyluris calotis* and *P. yambarensis* appear to be fairly common in adult *J. swinhonis* specimens. For example, in another study (Norval et al. 2012b), we used stomach-flushing as a non-lethal means to examine the diet of *J. swinhonis* and numerous of these nematodes were flushed from the stomach of the collected lizards.

Mesocoelium sociale is a parasite of the intestines of Asian amphibians and reptiles (Killick and Beverley-Burton 1982; Kennedy et al. 1987b). This parasite exhibits limited host specificity, so it is not surprising that in our study it was the parasite that was recorded in the largest variety of hosts (five species). Infection by *M. sociale* occurs through the ingestion of infected molluscan intermediate hosts or vegetation contaminated with cercarial cysts (Kennedy et al. 1987a). *Mesocoelium monas* was formerly considered a synonym of *M. sociale* (Dronen et al. 2012). Because *M. monas* has been reported from *A. sagrei* (Norval et al. 2011) and *E. longicaudata* (Goldberg et al. 2014) in Taiwan, the records in these species in our study are thus confirmations of these lizards as hosts of *M. sociale* rather than new host records. *Mesocoelium sociale* has previously been reported as a parasite of *J. swinhonis* (Fischthal and Kuntz 1975), but *P. elegans* and *S. indicus* represent new host records for *M. sociale* from Taiwan.

Oochoristica chinensis is a parasite of the small intestines and *J. swinhonis* is the type host (Jensen et al. 1983). Although the life cycle of this worm has not been fully studied, based on the life cycles of other species of *Oochoristica* (Widmer and Olsen 1967; Conn 1985; Criscione and Font 2001), it can be deduced that the intermediate host is very likely a coleopteran and/or lepidopteran. As far as can be determined, *E. longicaudata* represents a new host record for *O. chinensis*.

The term “sparganum” was proposed for any unidentifiable cestode larvae, but this designation is currently commonly used when referring to plerocercoid (= infective) larvae of tapeworms in the family Diphyllobothridae (Roberts and Janovy 2005). 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 lizards can easily occur by ingestion of the copepod or a second intermediate host carrying plerocercoids (Lapage 1963). We are unaware of reports of spargana from *J. swinhonis*, but Jensen et al. (1983) reported spargana from various other reptiles collected in Taiwan.

As outlined in the introduction, parasites can be important components of ecosystems. They can also contribute to our understanding of the distribution and spread of native and exotic species (e.g. Norval et al. 2011). Considering the large number of newly described squamate species in the last decade (Pincheira-Donoso et al. 2013), there is evidently a need for the description of the parasites of these species. Because the taxonomy of many parasites and/or their hosts has changed, the known host lists of parasites require revision. There is, thus, a need for descriptions of parasites and their hosts, as done herein, to ensure an understanding of the ecology of both the parasites and their hosts. For example, in recent years, some widespread parasite species have been found to be comprised of morphologically similar cryptic species (Leung et al. 2009; Walker et al. 2012.). Considering the large geographic distribution of species such as *K. pattoni*, *M. monas*, and *S. calotis*, which includes oceanic islands, the possibility of cryptic speciation seems highly probable. Thus, future studies on widespread parasites are warranted and should incorporate morphological, allometric, and molecular approaches (e.g. Kelehear et al. 2011; Brock et al. 2012.). We encourage researchers to include parasitological studies in their herpetological works to expand our understanding of host-parasite ecology.

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Gerrut Norval (pictured here with a Swinhoe's Tree Lizard, *Japalura swinhonis*, in Chong-san Park, Chiayi City, Taiwan) received a National Certificate (N.Cert.) in Production Management from Technikon Witwatersrand (1997). He also received a N.Cert: Nature Conservation (2003) and a National Diploma: Nature Conservation (2010) from the University of South Africa (UNISA). Since 2000, Gerrut has been actively involved in field research on squamates in Taiwan, and has been an Associate Researcher of the Applied Behavioural Ecology and Ecosystem Research Unit (ABEERU), Department of Environmental Sciences, UNISA, since 2004. He has broad research interests in the natural history of lizards and snakes, reptiles as invasive species, and reptile parasitology. Currently, Gerrut is in the process of completing his M.Sc. in Nature Conservation through UNISA. His main research focus is on the exotic invasive population of the Brown Anole (*Anolis sagrei*) in Taiwan. (Photographed by Liudmila V. Ivanova).

Stephen Robert Goldberg is a Biology Professor at Whittier College, Whittier, California. He received a B.A. degree from Boston University in 1962 and studied at the University of Arizona, Tucson under the well-known herpetologist, Charles H. Lowe, where he received a M.S. in 1965 and Ph.D. in 1970. He has been teaching Biology at Whittier College, Whittier, California since 1970. He has had a very productive career in research and authored or co-authored over 600 publications in scientific journals. His areas of expertise are reproductive histology and parasitology. He was a Research Associate in the Herpetology Section of the Natural History Museum of Los Angeles County starting in 1976 and donated thousands of amphibians and reptiles to their collection. He had an extremely productive collaboration in parasitology with Charles R. Bursey (Pennsylvania State University, Shenango), which led to over 400 publications on parasitology of amphibians and reptiles. (Photographed by Edward W. Goldberg).

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Kerry Slater is a senior lecturer at the University of South Africa. She received her B.Sc. (Hons.) in Zoology and M.Sc. in African Mammalogy from the University of Pretoria, South Africa and her Ph.D. in Zoology as a collaboration between the University of Pretoria, Oxford University, and Wisconsin University. She currently teaches 10 modules within the Diploma and B.Tech. qualifications in Nature Conservation. Her main research interests are within the field of Behavioral Ecology and she has supervised a number of Master and Doctorate students within this field. She also has several publications in journals and has presented at various conferences. (Photographed by Shooheima Champion).

Appendix 1. We deposited the following lizard specimens in the Natural History Museum of Los Angeles County (LACM), Los Angeles, California, USA.

Species	LACM accession numbers
Anolis sagrei	177948–177978, 178156–178184
Eutropis longicaudata	177901, 177902, 182830, 188389
Japalura polygonata xanthostoma	182822, 182832
Japalura swinhonis	177907–177910, 180356, 180358, 182829, 183317
Mabuya multifasciata	175800
Plestiodon elegans	177893–177896, 177898–177900
Sphenomorphus indicus	177904, 177906, 177979

Appendix 2. The helminths we deposited in the United States Parasite Collection (USNPC), Beltsville, Maryland, USA.

Host	Parasite	USNPC accession number
Eutropis longicaudata	*Mesocoelium sociale*	107331
	Meteterakis govindi	107332
Eutropis multifasciata	*M. govindi*	107528
Japalura polygonata xanthostoma	*Oswaldocruzia japalurae*	107333
Japalura swinhonis	*Oochoristica chinensis*	107334
	O. japalurae	107335
	Pseudabbreviata yambarensis	107336
	Strongylus calotes	107337
	Kiricephalus pattoni	107338
Plestiodon elegans	*M. sociale*	107339
	O. japalurae	107340
	Parapharyngodon maplestoni	107341
Sphenomorphus indicus	*Pseudoacanthocephalus bufonis*	107342
	O. japalurae	107343