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Gastrointestinal Helminths in Two Species of Geckos, *Gekko vittatus*, *Gehyra oceanica*, and Five Species of Skinks, *Caledoniscincus atropunctatus*, *Emoia cyanogaster*, *Emoia erronan*, *Emoia nigra*, *Emoia sanfordi* (Squamata) from the Republic of Vanuatu, Oceania

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Gastrointestinal Helminths in Two Species of Geckos, *Gekko vittatus*, *Gehyra oceanica*, and Five Species of Skinks, *Caledoniscincus atropunctatus*, *Emoia cyanogaster*, *Emoia erronan*, *Emoia nigra*, *Emoia sanfordi* (Squamata) from the Republic of Vanuatu, Oceania

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ABSTRACT: Two species of geckos, *Gekko vittatus*, *Gehyra oceanica* and 5 species of skinks, *Caledoniscincus atropunctatus*, *Emoia cyanogaster*, *Emoia erronan*, *Emoia nigra*, and *Emoia sanfordi* from the Republic of Vanuatu were examined for helminths. One species of Digenea (*Mesocoelium microom*), 3 species of Cestoda (*Gekkotaenia novaeguineensis*, *Cylindrotaenia hickmani*, *Ophiotaenia greeri*), and 7 species of Nematoda, gravid individuals of *Hedrwis hanleyae*, *Maxvachonia chabaudi*, *Parapharyngodon maplestoni*, *Spauligodon gehyrae*, *Spauligodon zweifeli*, juveniles assigned to the Filarioidea, and larvae of *Physocephalus* sp. in cysts were found. Eighteen new host records and 7 new locality records are reported. The lizards of Vanuatu are infected by generalist helminths that occur in a variety of lizards throughout Oceania.

KEY WORDS: Cestoda, Digenea, Nematoda, Gekkonidae, Scincidae, Oceania.

The Republic of Vanuatu is located in the South Pacific Ocean (17°45'S; 168°18'E), situated some 1,750 km east of northern Australia and 500 km northeast of New Caledonia (Fig. 1). This oceanic archipelago is comprised of 83 islands with a total land mass of approximately 18,000 km² (Hamilton et al., 2009; Goldberg et al., 2011). The majority of the islands of Vanuatu are small: only 2 islands in this archipelago are greater than 1,000 km² and only a single island has an elevation greater than 1,000 m (Hamilton et al., 2009).

Prior research has examined the helminth fauna of 2 species of gecko (*Nactus multicarinatus* and *N. pelagicus*) and 5 species of skink (*Emoia caeruleocauda*, *Emoia cyanogaster*, *Emoia impar*, *Emoia nigromarginata*, and *Emoia sanfordi*) from Vanuatu (Goldberg et al., 2005, 2011; Burse et al., 2010). These studies have generated a faunal list for Vanuatu consisting of 7 species of helminths (Table 1). Here we present data on the endoparasites from an additional 2 species of geckos (*Gekko vittatus* and *Gehyra oceanica*) and 3 species of skinks (*Caledoniscincus atropunctatus*, *Emoia erronan*, and *Emoia*

nigra). We also add to the previously reported endoparasite records from 2 other species of skink from Vanuatu: *E. cyanogaster* and *E. sanfordi*.

Both gecko species (family Gekkonidae) have relatively broad distributions in the Pacific region. *Gekko vittatus* occurs in Indonesia, Palau, New Guinea, the Solomon Islands, and Vanuatu (McCoy, 2006). Within Vanuatu, *G. vittatus* has a relatively limited distribution, occurring only in the Banks and Torres island groups on northern Vanuatu (Hamilton, personal observations). *Gehyra oceanica* is widespread in the islands of the Pacific basin and occurs from the Caroline Islands, the Mariana Islands, Papua New Guinea, the Solomon Islands, and Vanuatu eastward to the Marquesas Islands, the Society Islands, and the Tuamotu Archipelago (Fisher, 1997). Two of the skink species examined in this study also have broad distributions. *Emoia cyanogaster* occurs throughout the Vanuatu archipelago (Hamilton, personal observations) as well as the Solomon Islands and the islands of the Bismarck Archipelago of Papua New Guinea (McCoy, 2006). *Emoia nigra* ranges from the Bismarck Archipelago through the Solomon Islands and Vanuatu eastward to Samoa and Tonga (Brown, 1991). Like *Gekko vittatus*, *E. nigra* has a limited distribution within

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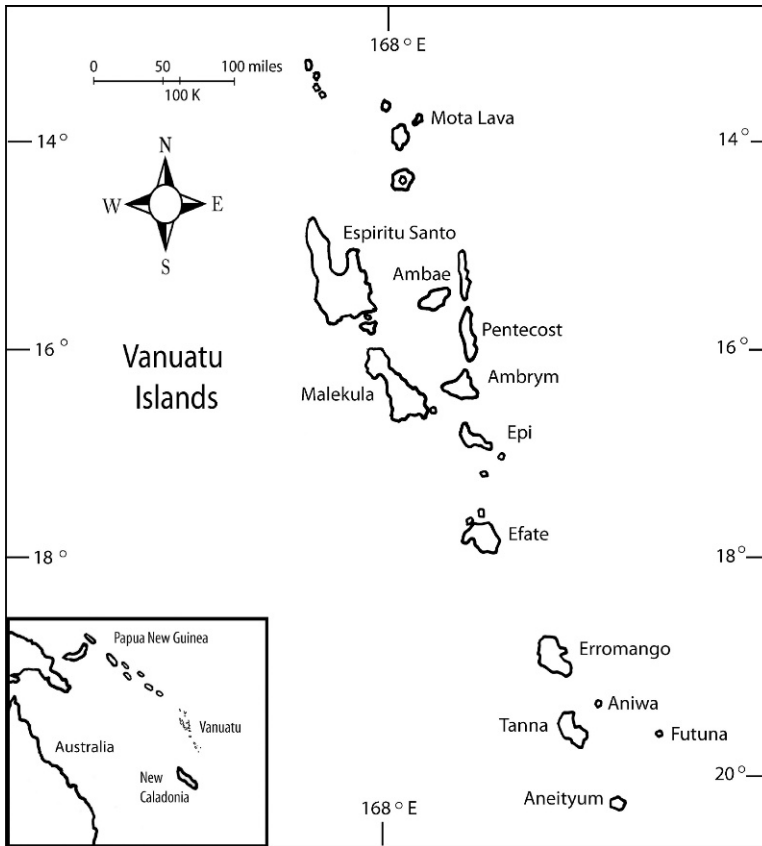


Figure 1. Map of Vanuatu Archipelago. Islands from which specific lizards were collected are indicated in the text.

Table 1. Previous reports of helminths from lizards of Vanuatu (Goldberg et al., 2005; Goldberg, Bursley, Hamilton et al., 2011; Bursley et al., 2010). Number of helminths, prevalence (%), mean intensity \pm 1 SD, and range for 7 helminth species in 2 gekkonid species (*Nactus multicarinatus* and *Nactus pelagicus*) and 5 scincid species (*Emoia caeruleocauda*, *Emoia cyanogaster*, *Emoia impar*, *Emoia nigromarginata*, and *Emoia sanfordi*). Values calculated from the original data sets.

Digenea	Gekkonidae					
	<i>Nactus multicarinatus</i>		<i>Nactus pelagicus</i>		<i>Emoia caeruleocauda</i>	
	No. and prevalence (%)	Mean intensity \pm SD (range)	No. and prevalence (%)	Mean intensity \pm SD (range)	No. and prevalence (%)	Mean intensity \pm SD (range)
<i>Mesocoelium microon</i>	2; 2/265 (1)	1 \pm 0 (0)	—	—	—	—
Cestoda						
<i>Ochroristica javaensis</i>	67; 32/165 (19)	2.1 \pm 1.7 (1–7)	4; 3/172 (2)	1.3 \pm 0.6 (1–2)	—	—
Nematoda						
<i>Falcaustra tannaensis</i>	—	—	19; 7/172 (4)	3.0 \pm 2.8 (1–8)	—	—
<i>Hedruris hanleyae</i>	137; 63/165 (38)	2.2 \pm 2.0 (1–11)	91; 18/172 (10)	5.0 \pm 3.2 (1–14)	18; 8/8 (100)	2.3 \pm 1.5 (1–5)
<i>Parapharyngodon maplestoni</i>	460; 120/125 (73)	3.8 \pm 2.9 (1–17)	448; 127/172 (74)	3.5 \pm 2.4 (1–11)	—	—
<i>Physocephalus</i> sp. (larvae)	82; 20/165 (12)	4.1 \pm 5.3 (1–24)	223; 7/172 (4)	31.8 \pm 79.4 (1–212)	—	—
Filarioidae gen. sp.	3; 2/165 (1)	1.5 \pm 0.7 (1–2)	—	—	—	—

Vanuatu, occurring in the northern islands of the archipelago, as well as Ambae, Maewo, and northern Espiritu Santo (Hamilton, personal observation). The other 3 skinks examined in this study have more restricted distributions. *Caledoniscincus atropunctatus* occurs on New Caledonia and southern Vanuatu (Bauer and Sadler, 2000; Hamilton et al., 2010). The remaining 2 species are endemic to the Vanuatu archipelago. *Emoia sanfordi* is distributed in northern and central Vanuatu but absent from the islands south of Cheesman's line, a name proposed by Hamilton et al. (2010) to designate faunal and floral discontinuity between northern and southern islands of Vanuatu. *Emoia erronan* is known only from the small islands of Futuna and Aniwa in southern Vanuatu (Brown, 1991; Hamilton, personal observations). In this study we establish an initial helminth list for *C. atropunctatus* and *E. erronan* and add to the previously reported helminth faunas of *E. cyanogaster*, *E. nigra*, *E. sanfordi*, *Gehyra oceanica*, and *Gekko vittatus*.

METHODS

We examined a total of 30 lizards comprising 7 species collected from 7 islands in the Republic of Vanuatu, Oceania during 2005 and deposited them in the herpetology collection of Louisiana State University, Baton Rouge, Louisiana, U.S.A. (Table 2). Lizards were collected by hand, preserved in 10% neutral buffered formalin, and stored in 70% ethanol. Visceral organs were removed and sent to Whittier College for helminthological examination. The esophagus, stomach, and large and small intestines were examined under a dissecting microscope. Digeneans and

cestodes were regressively stained in hematoxylin, mounted in Canada balsam, and examined with a compound microscope. Nematodes were cleared in glycerol for examination. Parasite terminology is in accordance with Bush et al. (1997). Voucher helminths were deposited in the United States National Parasite Collection, Beltsville, Maryland, U.S.A. (Table 3).

RESULTS

A total of 369 individual endoparasites was collected from the 18 skinks and 12 geckos. A total of 11 species of endoparasites was detected in this sample. Found were 1 species of Digenea (*Mesocotyle microon* [Nicoll, 1914]); 3 species of Cestoda (*Cylindrotaenia hickmani* Jones, 1985; *Gekkotaenia novaeguineensis* Bursey, Goldberg, and Kraus 2005; *Ophiotaenia greeri* [Bursey et al., 2006]); and 6 species of Nematoda (*Hedruris hanleyae* Bursey and Goldberg, 2000; *Maxvachonia chabaudi* Mawson, 1972; *Parapharyngodon maplestoni* Chatterji, 1933; *Spauligodon gehyrae* Bursey and Goldberg, 1996; *Spauligodon zweifeli* Bursey, Goldberg, and Kraus, 2005; Filarioidea gen. sp. [juveniles]; *Physocephalus* sp. [larvae in cysts]). The 2 lizard species for which we examined the largest number of specimens contained the most diverse parasite communities. *Emoia sanfordi* ($N = 12$) harbored 8 species of helminths; the greatest diversity of endoparasites in our study, including digeneans, cestodes, and nematodes, were found in specimens of this species (Table 4). *Gehyra oceanica* ($N = 9$) also had a relatively diverse assemblage of 6 species

Table 1. Extended.

Gekkonidae		Scincidae					
<i>Emoia cyanogaster</i>		<i>Emoia impar</i>		<i>Emoia nigromarginata</i>		<i>Emoia sanfordi</i>	
No. and prevalence (%)	Mean intensity \pm SD (range)	No. and prevalence (%)	Mean intensity \pm SD (range)	No. and prevalence (%)	Mean intensity \pm SD (range)	No. and prevalence (%)	Mean intensity \pm SD (range)
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
2; 2/2 (100)	1 \pm 0 (0)	6; 4/4 (100)	1.5 \pm 1.0 (1–3)	27; 10/10 (100)	2.7 \pm 0.9 (1–4)	1; 1/1 (100)	0 (0)
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—

Table 2. Host specimens examined for parasites in this study. Specimens are deposited in the herpetology collection of the Louisiana State University Museum of Natural Science (LSUMZ), Baton Rouge, Louisiana.

Host taxon	N	Locality and voucher number
Gekkonidae		
<i>Gehyra oceanica</i>	9	Aniwa: LSUMZ 91309; Espiritu Santo: LSUMZ 91311, 91315; Malekula: LSUMZ 91298; Mota Lava: LSUMZ 91317, 91318, 91322, 91325; Tanna: LSUMZ 91304
<i>Gekko vittatus</i>	3	Mota Lava: LSUMZ 91222, 91223, 91230
Scincidae		
<i>Caledoniscincus atropunctatus</i>	1	Tanna: LSUMZ 90073
<i>Emoia cyanogaster</i>	1	Malekula: LSUMZ 91529
<i>Emoia erronan</i>	1	Aniwa: LSUMZ 91772
<i>Emoia nigra</i>	1	Mota Lava: LSUMZ 90107, 90109, 90110
<i>Emoia sanfordi</i>	12	Ambrym: LSUMZ 90171; Epi: LSUMZ 89895; Espiritu Santo: LSUMZ 90909; Malekula: LSUMZ 90135, 90136, 90145, 90146; Mota Lava: LSUMZ 89904, 89906, 89913, 89915, 89916

representing digeneans, cestodes, and nematodes (Table 4). Number of helminths, prevalence (%), mean intensity \pm 1 SD, and range for these 11 species of helminths by host species are given in Table 4.

DISCUSSION

Dronen et al. (2012) revised the Mesocoelidae Dollfus, 1929 and recognized 43 valid species. In prior revisions, Freitas (1963) established 19 species, which Nasir and Diaz (1971) reduced to 4. Previous Vanuatu helminthological studies have followed the keys of Nasir and Diaz (1971). Following the key provided by Dronen et al. (2012), we have assigned our specimens to *M. microon* (vitelline fields and ceca moderately long and of similar length, genital pore prebifurcal and median, gonads overlapping

acetabulum), a species originally described from the hylid frog species *Litoria caerulea* and *Litoria gracilentata* (reported as *Hyla caerulea*, *Hyla gracilentata*) and *Tiliqua scincoides* (Scincidae) collected in Queensland, Australia by Nicoll (1914). Given the recent revision of the Mesocoelidae, specimens from the gecko *N. multicaarinatus* collected in Vanuatu (Goldberg et al., 2011) and assigned to *Mesocoelium monas* should be re-evaluated. *Gehyra oceanica*, *E. nigra*, and *E. sanfordi* represent new host records for *M. microon*; Vanuatu is a new locality record.

Gekkotaenia novaeguineensis was described from *Cyrtodactylus louisidensis* (Gekkonidae) collected in Papua New Guinea (Burse et al., 2005b). *Gehyra oceanica* represents a new host record and is only the second host record for *G. novaeguineensis*. Vanuatu is a new locality record.

Table 3. Voucher helminths from lizards from Vanuatu deposited in the U.S. National Parasite Collection, (USNPC), Beltsville, Maryland, U.S.A.

Host taxon	N	Helminth and voucher number
Gekkonidae		
<i>Gehyra oceanica</i>	9	<i>Mesocoelium microon</i> (USNPC 106897); <i>Gekkotaenia novaeguineensis</i> (USNPC 106818); <i>Hedruris hanleyae</i> (USNPC 106819); <i>Parapharyngodon maplestoni</i> (USNPC 106820); <i>Spauligodon gehyrai</i> (USNPC 106821); <i>Spauligodon zweifeli</i> (USNPC 106822)
<i>Gekko vittatus</i>	3	<i>Hedruris hanleyae</i> (USNPC 106823); <i>Maxvachonia chabaudi</i> (USNPC 106824)
Scincidae		
<i>Caledoniscincus atropunctatus</i>	1	<i>Parapharyngodon maplestoni</i> (USNPC 106825)
<i>Emoia cyanogaster</i>	1	<i>Hedruris hanleyae</i> (USNPC 106826)
<i>Emoia erronan</i>	1	<i>Cylindrotaenia hickmani</i> (USNPC 106827); <i>Hedruris hanleyae</i> (USNPC 106828); <i>Parapharyngodon maplestoni</i> (USNPC 106829)
<i>Emoia nigra</i>	1	<i>Mesocoelium microon</i> (USNPC 106898); <i>Ophiotaenia greeri</i> (USNPC 106830, 106831); <i>Hedruris hanleyae</i> (USNPC 106832)
<i>Emoia sanfordi</i>	12	<i>Mesocoelium microon</i> (USNPC 106899); <i>Cylindrotaenia hickmani</i> (USNPC 106833, 106834, 106835); <i>Hedruris hanleyae</i> (USNPC 106836); <i>Maxvachonia chabaudi</i> (USNPC 106837); <i>Parapharyngodon maplestoni</i> (USNPC 106838); <i>Spauligodon zweifeli</i> (USNPC 106839); <i>Physocephalus</i> sp. (USNPC 106840); Filarioidea gen. sp. (USNPC 106841)

Cylindrotaenia hickmani was originally described as *Baerietta hickmani* from Australian populations of 5 species of scincid lizards, *Lampropholis challengeri*, *Lampropholis delicata*, *Lampropholis guichenoti*, *Lampropholis mustelina*, and *Nannoscincus maccoyi* (Jones, 1985) and subsequently reassigned to *Cylindrotaenia* by Jones (1987). It has been reported from the skink species *Emoia jakati*, *Emoia longicauda*, *Emoia obscura*, *Emoia pallidiceps*, *Emoia popei*, *Sphenomorphus aignanus*, and *Sphenomorphus louisianensis* from Papua New Guinea (Goldberg et al., 2008, 2009) as well as *E. caeruleocauda* from the Marianas (Goldberg, Bursey, Hamilton et al., 2011). This cestode was found in two skink species in our sample, and *E. erronan* and *E. sanfordi* represent new host records for *C. hickmani*. Vanuatu is a new locality record.

Ophiotaenia greeri was originally described as *Adenobrechmos greeri* from *Sphenomorphus aignanus* (Scincidae) collected in Papua New Guinea (Bursey et al., 2006), but was reassigned to *Ophiotaenia* by de Chambrier et al. (2009). It has also been reported from the Papua New Guinean populations of 6 additional skink species: *Carlia eothern*, *Carlia luctuosa*, *E. jakati*, *E. obscura*, *E. pallidiceps*, and *S. louisianensis* (Goldberg et al., 2008, 2009, 2010a). *Ophiotaenia greeri* was present in only 1 species examined and this species, *E. nigra* (Scincidae), represents a new host record. Vanuatu is a new locality record.

Hedruris hanleyae was described from the gecko *Hemidactylus garnotii* collected in the Cook Islands (Bursey and Goldberg, 2000) and is common in lizards (Scincidae and Gekkonidae) from Oceania and Papua New Guinea (Goldberg et al., 2005, 2008). This nematode is now known from 15 species of skinks from 2 genera (*Carlia* and *Emoia*) and 10 species of geckos from 5 genera (*Gehyra*, *Gekko*, *Hemidactylus*, *Lepidodactylus*, and *Nactus*); a complete host list will be found in Goldberg et al. (2010a). *Hedruris hanleyae* has the broadest taxonomic distribution of hosts for the endoparasite species found in our sample, and is present in 6 of the 7 host species examined (Table 4). This nematode was previously reported from Vanuatu in *N. multicarinatus* and *N. pelagicus* (Goldberg et al., 2011). *Emoia erronan* and *G. vittatus* represent a new host record for *H. hanleyae*.

Maxvachonia chabaudi was described from Australian lizards by Mawson (1972) and has been reported from gekkonid hosts from Oceania (*Gehyra mutilata*, *G. oceanica*, *Lepidodactylus lugubris*, and

L. paurolepis) and Papua New Guinea (*Cyrtodactylus sermowaiensis* and *Gekko vittatus*). This nematode was found in 2 species in our sample: *G. vittatus* (Gekkonidae) and *E. sanfordi* (Scincidae). *Gekko vittatus* as a host was previously reported by Goldberg et al. (2010b). *Emoia sanfordi* represents a new host record for *M. chabaudi* and is the first non-gekkonid host species identified. Vanuatu is a new locality record.

Parapharyngodon maplestoni was described from the lizard *Calotes versicolor* (Agamidae) collected in Burma by Chatterji (1933). This endoparasite has previously been reported from hosts representing 4 families of squamate reptiles (Agamidae: *Bronchocela* and *Calotes*; Anguillidae: *Pseudopus*; Gekkonidae: *Cyrtodactylus*, *Gekko*, *Hemidactylus*, and *Nactus*; Scincidae: *Emoia*, *Eremiascincus*, and *Sphenomorphus*) from Asia the Australo-Papuan region, and Oceania, as well as the Palearctic (Goldberg et al., 2009). More detailed information regarding previously reported hosts can be found in Bursey et al. (2005a) and Goldberg et al. (2009, 2010a, 2010b, 2011). *Parapharyngodon maplestoni* was previously reported from Vanuatu in the gekkonids *N. multicarinatus* and *N. pelagicus* (Goldberg et al., 2011) but was not previously reported from scincid hosts within Vanuatu. The skinks *Caledoniscincus atropunctatus*, *E. erronan*, and *E. sanfordi* and the gecko *Gehyra oceanica* represent new host records for *P. maplestoni*.

Spauligodon gehyrae was originally described from *G. oceanica* collected on Guam and subsequent research indicates that this is a common helminth in *G. oceanica* from widely scattered populations across Oceania (Bursey and Goldberg, 1996). It has also been reported from *Emoia trossula* and *L. lugubris* (Goldberg and Bursey, 2002; Goldberg et al., 2005). *Spauligodon gehyrae* was present in 4 of the 9 *G. oceanica* examined and was not present in any other host species examined in this study. Vanuatu is a new locality record.

Spauligodon zweifeli was described from *Lepidodactylus novaeguineae* (Gekkonidae) from Papua New Guinea by Bursey et al. (2005b). Two species of lizard from Vanuatu were infected with *S. zweifeli*. *Gehyra oceanica* is the second gecko host reported. *Emoia sanfordi* (Scincidae) is the third host species (and first non-gekkonid host) reported for *S. zweifeli*. Both *E. sanfordi* and *G. oceanica* represent new host records for *S. zweifeli*. Vanuatu is a new locality record.

Juvenile nematodes assigned to Filarioidea have previously been reported from *N. multicarinatus* from

Table 4. Number of helminths, prevalence (%), mean intensity \pm 1 SD, and range for 11 species of helminths in 2 gekkonid species (*Gehyra oceanica* and *Gekko vittatus*) and 5 scincid species (*Caledoniscincus atropunctatus*, *Emoia cyanogaster*, *Emoia erronan*, *Emoia nigra*, and *Emoia sanfordi*) from Vanuatu, Oceania.

	Gekkonidae					
	<i>Gehyra oceanica</i>		<i>Gekko vittatus</i>		<i>Caledoniscincus atropunctatus</i>	
	No. and prevalence (%)	Mean intensity \pm SD (range)	No. and prevalence (%)	Mean intensity \pm SD (range)	No. and prevalence (%)	Mean intensity \pm SD (range)
Digenea						
<i>Mesocoelium microon</i>	1; 1/9 (11)*	0 (0)	—	—	—	—
Cestoda						
<i>Cylindrotaenia hickmani</i>	—	—	—	—	—	—
<i>Gekkotaenia novaequinaensis</i>	1; 1/9 (11)*	0 (0)	—	—	—	—
<i>Ophiotaenia greeri</i>	—	—	—	—	—	—
Nematoda						
<i>Hedruris hanleyae</i>	50; 3/9 (33)	16.7 \pm 10.0 (9–28)	21; 2/3 (67)*	10.5 \pm 6.4 (6–15)	—	—
<i>Maxvachonia chabaudi</i>	—	—	10; 2/3 (67)	5.0 \pm 1.4 (4–6)	—	—
<i>Parapharyngodon maplestoni</i>	4; 1/9 (11)*	0 (0)	—	—	1; 1/1 (100)*	0 (0)
<i>Spauligodon gehyrae</i>	15; 4/9 (44)	3.8 \pm 2.8 (2–7)	—	—	—	—
<i>Spauligodon zweifeli</i>	5; 1/9 (11)*	0 (0)	—	—	—	—
<i>Physocephalus</i> sp. (larvae)	—	—	—	—	—	—
Filarioidea gen. sp.	—	—	—	—	—	—

*New host records.

Vanuatu (Goldberg, Bursey, Hamilton et al., 2011). The gross morphology of these specimens is different from previously described Australo-Papuan species, and these specimens may represent an undescribed species. *Emoia sanfordi* represents a new host record for juvenile Filarioidea.

Physocephalus sp. (larvae in cysts) have previously been found in both *N. multicaarinatus* and *N. pelagicus* from Vanuatu (Goldberg et al., 2011). Adults of *Physocephalus* typically occur in the stomachs of pigs, and dung beetles serve as intermediate hosts (Anderson, 2000). Lizards likely become infected with *Physocephalus* by ingesting infected insects. Since development beyond the larval stage does not occur, lizards are likely transport hosts. *Emoia sanfordi* represents a new host record for larvae of *Physocephalus* sp.

Twenty-seven species of lizards have been recorded for Vanuatu (Hamilton et al. 2009; Goldberg et al., 2011; Ineich, 2008). With the addition of this study, 392 individuals representing nearly half of the recognized species (12 species, or 44%) have now been examined for helminths (although for some species, only a few individuals have been examined). From the data collected to date, it appears that with the exception of *Falcaustra tannaensis*, the lizards of

Vanuatu are infected by generalist helminths (helminths that infect more than a single host species). The lizards of Vanuatu are infected by helminth species previously known from Asia, Australia, and New Guinea as well as species commonly found in lizards from the islands of Oceania. Of the cestodes and nematodes found in Vanuatu lizard hosts in this work and previous studies that are identifiable to species level, 50% have a broad “pan-Oceania” distribution, occurring in Papua New Guinea and ranging north and northeast across many of the islands of the Pacific (*Hedruris hanleyae*, *M. chabaudi*, *Oochoristica javanensis*, *Parapharyngodon maplestoni*, and *S. gehyrae*). We postulate that they reached Vanuatu and islands in other regions of the Pacific Ocean by rafting and their establishment was fortuitous. An additional species (*Cylindrotaenia hickmani*) is also a cestode of the Pacific islands, but its range is much narrower; this species has not been reported from any island groups east of Vanuatu. A significant portion of the helminth fauna known from the lizards of Vanuatu is absent from the isolated island groups of the eastern Pacific. Thirty percent of the cestodes and nematodes found in our study were previously known only from Papua New Guinea (*Gekkotaenia novaequinaensis*, *Ophiotaenia greeri*,

Table 4. Extended.

Gekkonidae		Scincidae					
<i>Emoia cyanogaster</i>		<i>Emoia erronan</i>		<i>Emoia nigra</i>		<i>Emoia sanfordi</i>	
No. and prevalence (%)	Mean intensity \pm SD (range)	No. and prevalence (%)	Mean intensity \pm SD (range)	No. and prevalence (%)	Mean intensity \pm SD (range)	No. and prevalence (%)	Mean intensity \pm SD (range)
—	—	—	—	1; 1/3 (33)*	0; 0	1; 1/12 (8)*	0 (0)
—	—	2; 1/1 (100)*	0 (0)	—	—	8; 6/12 (50)*	1.3 \pm 0.5 (1–2)
—	—	—	—	—	—	—	—
—	—	—	—	2; 2/3 (67)*	1 \pm 0 (0)	—	—
1; 1/1 (100)	0 (0)	8; 1/1 (100)*	0 (0)	78; 3/3 (100)	0 (0)	135; 7/12 (58)	26.0 \pm 28.8 (6–59)
—	—	—	—	—	—	1; 1/12 (8)*	0 (0)
—	—	2; 1/1 (100)*	0 (0)	—	—	3; 2/12 (17)*	1.5 \pm 0.7 (1–2)
—	—	—	—	—	—	—	—
—	—	—	—	—	—	16; 3/12 (25)*	5.3 \pm 4.5 (1–10)
—	—	—	—	—	—	1; 1/12 (8)*	0 (0)
—	—	—	—	—	—	1; 1/12 (8)*	0 (0)

and *S. zweifeli*). To date, only a single species of nematode, *F. tannaensis*, is unique to the lizard fauna of Vanuatu.

Burse et al. (2001) introduced the concept of importance (*I*), an estimate of the fitness (relative survival and reproductive success) of a species within a community calculated as $I = \text{relative prevalence} + \text{relative abundance} \times 100$. By this measure, the most important parasites to the supracommunity are *P. maplestoni* ($I = 73$) and *H. hanleyae* ($I = 63$); remaining helminth species have an *I* value less than 20.

Although the life cycles of most of the helminth species found in this study have not been examined, life cycles of congeners are available. Species assigned to Pharyngodonidae, i.e., *Parapharyngodon maplestoni*, *S. gehyae*, and *S. zweifeli*, have direct (monoxenous) life cycles and infection most probably occurs when contaminated substrate is ingested. Members of the Cosmoceroidea, i.e., *M. chabaudi*, also have direct life cycles and infect either orally or by skin penetration (Anderson, 2000). The other species reported in this study require intermediate or transport hosts. Given the identity of the two species with high importance values, it would appear that both diet (the intake of infected food items enabling infection by *H.*

hanleyae) and habitat (substrate licking for environmental clues leading to infection by *P. maplestoni*) are important for the establishment of helminth infection in Vanuatu lizards.

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