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# Depauperate Parasite Faunas in Introduced Populations of *Podarcis* (Squamata: Lacertidae) Lizards in North America[1]

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ABSTRACT.—**We surveyed all four extant North America populations of introduced *Podarcis* (*Podarcis muralis* and *Podarcis sicula*) for helminths and hematozoans; both parasite groups infect these lizards in their native European habitats. We found only small numbers of helminths and no hematozoans. We conclude that either these two *Podarcis* species did not bring many parasites with them, appropriate intermediate hosts are lacking, or that these populations have not been in North America long enough for new parasite faunas to become established.**

Introduced species may not be exposed to the same predators, pathogens, or parasites in their novel habitats as in their native habitats. This is especially likely to occur if parasites have complex life cycles, and one or more intermediate hosts or vectors are not present in the introduced habitat. Occasionally, this results in a competitive advantage over native host species (enemy release hypothesis) that can potentially allow them to out compete native species (Torchin et al., 2001, 2003; Colautti et al., 2004). Conversely, invasive species have also been documented bringing parasites to new areas, sometimes with detrimental effects on native/naïve hosts (e.g., Bauer and Hoffman, 1976). Finally, introduced species can also sometimes serve as new hosts for parasites present in their new habitat (e.g., Krakau et al., 2006).

Two species of lacertid lizards, the Italian Wall Lizard (= "Ruin" Lizard), *Podarcis sicula*, and the Common Wall Lizard, *Podarcis muralis*, have been introduced into five urban and suburban locations in North America (reviewed by Burke and Deichsel, in press). These introductions all occurred between 1950 and 1970 (Gossweiler, 1975; Deichsel and Gist, 2001; Deichsel and Schweiger, 2004), and each apparently originated with a small number of individuals that were probably wild-caught in Italy for the pet trade (Burke and Deichsel, in press). Populations in Garden City, New York (*P. sicula*), Topeka, Kansas (*P. sicula*), Cincinnati, Ohio (*P. muralis*), and Vancouver, British Columbia (*P. muralis*) now contain thousands of individuals each; however, the Philadelphia, Pennsylvania, introduction apparently went extinct in the mid-1970s (Burke and Deichsel, in press). Here we report the results of surveys of both gut and blood parasites from the four extant North American populations of *Podarcis*.

## MATERIALS AND METHODS

Fifty-two *P. muralis* from the Saanich Peninsula, Capital Regional District, Victoria, British Columbia, Canada (collected in 2001), 43 *P. muralis* from Cincinnati, Hamilton County, Ohio (collected in 2000), 37 *P. sicula* from Topeka, Shawnee County, Kansas (collected in 2001), and 189 *P. sicula* from Hempstead, Nassau County, New York (collected in 1998) were examined for helminths. The digestive tracts were excised; the esophagi, stomachs, small and large intestines opened, and digestive contents were examined under a dissecting microscope. Nematodes were cleared in a drop of glycerol and identified. Cestodes and acanthocephalans were stained in hematoxylin. Helminths were deposited in the United States National Parasite Museum (Beltsville, Maryland).

For the hematozoan surveys, 27 *P. muralis* from Ohio (collected in 2000), 22 *P. muralis* from Kansas (collected in 2001), and 51 *P. sicula* from New York (collected in 2005) were sampled. No fresh blood samples were available from the British Columbia *P. muralis* population. Blood smears were prepared from each lizard by clipping off the end of a toe and applying the resulting drop of blood to a microscope slide. The thin smears were fixed in methanol for 1 min and allowed to air dry and then stained with either Giemsa or Hema3® (Fisher Scientific). Each slide was scanned at 1000× for 3 min, allowing inspection of approximately 5,000 blood cells.

## RESULTS AND DISCUSSION

Data on prevalence and mean helminths density are presented in Table 1 (terminology follows Bush et al., 1997). *Podarcis sicula* from British Columbia, Canada, contained no helminths whatsoever. *Podarcis muralis* from Ohio and *P. sicula* from Kansas and New York contained larvae of species assigned to the Family Acuariidae (Nematoda) encysted in their stomach walls and free in their large intestines. Members of the Acuariidae are parasites of terrestrial birds (Anderson, 2000). It would appear that the lizards are paratenic (= transport) hosts in which development to the adult stage does not occur, but upon ingestion of an infected *Podarcis* by an avian predator, the larvae could potentially complete their development to

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TABLE 1. Prevalence (number infected/number examined × 100) and mean intensity (mean number helminths per infected individual ± 1 SD and range) for helminths in introduced populations of *Podarcis muralis* and *Podarcis sicula*.

| Parasite Taxon | *P. muralis* Ohio ($N$ = 43) | *P. sicula* Kansas ($N$ = 37) | *P. sicula* New York ($N$ =189) |
|---|---|---|---|
| Cestoda | | | |
| *Mesocestoides* sp. | 2%, 182.0 | none | none |
| Nematoda | | | |
| *Parapharyngodon* sp. | none | 3%, 2.0 | none |
| *Physaloptera* sp. | 12%, 3.0 ± 3.5, 1–9 | 5%, 1.0 | 1%, 1.0 |
| Acuariidae | 74%, 7.0 ± 7.3, 1–29 | 43%, 2.4 ± 1.2, 1–5 | 6%, 8.3 ± 17.2, 1–59 |
| Acanthocephala | | | |
| Unidentified acanthocephalan | none | none | 1%, 1.0 |

maturity. Third-stage larvae of *Physaloptera* (Nematoda, Physalopteridae) were found in the stomachs of all three populations (Table 1). *Physaloptera* larvae and adults are commonly found in lizards (e.g., Goldberg et al., 1993). They are acquired by ingesting infected insects, which serve as paratenic hosts. Whether introduced species of *Podarcis* can serve as definitive hosts will require further collection and examination. Larval cestodes (*Mesocestoides* sp.) were found in gut mesenteries of one *P. muralis* from Ohio. Tetrathyridia of *Mesocestoides* sp. are commonly found at low prevalence in lizards (McAllister, 1988), which probably represent paratenic hosts. No blood parasites of any kind (e.g., hematozoa, trypansomes, microfilariae) were observed in any individual of the North American *Podarcis*. All of the helminths found were immature forms and could not be identified to species; thus, it was not possible to determine whether they are of Old World or New World origin.

Overall, North American *Podarcis* were characterized by depauperate parasite faunas, suggesting either that *P. muralis* and *P. sicula* did not bring many parasites with them, appropriate intermediate hosts are lacking, or that they have not been in North America long enough for new parasites to become established. However, our results indicate that *Podarcis* lizards have apparently acquired some helminths from their new locales, although the importance of these infections and the role of *Podarcis* in the transmission of the infections have yet to be determined. In their native ranges in Europe, *Podarcis* spp. are infected with a variety of helminths (e.g., Casanova et al. 2003; Garcia-Adell and Roca, 1988; Kirin 2002; Roca Velasco and Navarro Gomez, 1983; Roca and Garcia-Adell, 1988a,b) as well as haemogregarines (Apicomplexa: Haemogregorinidae), which are vectored by mites (Amo et al., 2005). However, despite four separate introductions, it does not appear that the imported *P. muralis* or *P. sicula* transported any of these parasites to North America. This is in contrast to the invasive Brown Anole (*Anolis sagrei*), which transported helminths to Hawaii (Goldberg and Bursey, 2000) and lineages of *Plasmodium floridense* to Florida (Perkins et al., unpubl. data) from its native range in the Caribbean. It is possible that because the founding *Podarcis* individuals came from the pet trade or existed in small numbers that they possessed too few parasites for the parasites to become established in the new site. The limited number of species of parasites may also be in part a reflection of the isolation of these introduced populations from other *Podarcis* species. It has been shown that the parasite communities vary based on the degree of isolation of the host *Podarcis* populations, with populations showing frequent contact harboring up to 12 different helminth species but isolated hosts having as few as three species (Roca, 2004).

Although haemogregarines have been reported in North American lizards and snakes from various locales (e.g., Perkins and Keller, 2001; Telford et al., 2001), none is currently known from the specific areas, urban and suburban, where *Podarcis* populations are found. Presumably there is no overlap of either haemogregarines or their vectors where *Podarcis* have been introduced in North America. Indeed, despite the fact that many North American lizards have conspicuous mite faunas (e.g., Goldberg and Bursey, 1991; Klukowski and Nelson, 2001), mites are exceedingly rare on invasive *Podarcis* spp. (RLB, pers. obs.). The prevalence of haemogregarines and mites on other reptiles in the same immediate habitats as the North American *Podarcis* is unknown.

Our results are consistent with Torchin et al (2003), who found that introduced populations of many species across a wide range of taxa had low parasite loads, especially in comparison to these same species in their native habitats. Unfortunately, data comparable to those presented here have not been reported for *P. sicula* and *P. muralis* in their native habitats. However, these results present baseline data on the establishment rate of helminth and hemoprotozoan infections in newly colonized lizard populations, which is important because few data are available on the rate with which these parasite populations become established. It would be fruitful to resurvey these populations in the future to quantify establishment rates. In addition, *P. muralis* and *P. sicula* have been introduced into many locations in Europe (reviewed in Burke and Deichsel, in press), and these populations provide more opportunities for study of the speed with which parasites become established in invasive lizard populations.

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