NOTE

INFECTION OF YARROW'S SPINY LIZARDS (*SCELOPORUS JARROVII*) BY CHIGGERS AND MALARIA IN THE CHIRICAHUA MOUNTAINS, ARIZONA

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ABSTRACT—We measured prevalence of malaria infection and prevalence and intensity of chigger infection in Yarrow's spiny lizards (*Sceloporus jarrovii*) from three sites in the Chiricahua Mountains of southeastern Arizona. Our primary objective was to compare parasite load among sites, sexes, and reproductive classes. We also compared our findings to those of previous studies on malaria and chiggers in *S. jarrovii* from the same area. Of lizards examined, 85 and 93% were infected by malaria and chiggers, respectively. Prevalence of malaria was two times higher than previously reported for the same area, while prevalence of chiggers was similar to previous findings. Intensity of chigger infection was variable among sites, but not among reproductive classes. The site with the highest intensity of chigger infection also had the most vegetative cover, suggesting that this habitat was more favorable for non-parasitic adult chiggers.

RESUMEN—Medimos la frecuencia de infección por malaria y la frecuencia e intensidad de infección por ácaros en la lagartija espinosa *Sceloporus jarrovii* de tres sitios en las montañas Chiricahua del sureste de Arizona. Nuestro objetivo principal fue comparar la carga de parásitos entre sitios, sexos y clases reproductivas. Adicionalmente comparamos nuestros hallazgos con estudios previos sobre malaria y ácaros para esta especie en la misma área. De las lagartijas examinadas, el 85 y 93% estaban infectadas por malaria y ácaros, respectivamente. La frecuencia de infección por malaria fue dos veces mayor de lo reportado previamente para la misma área, mientras que la frecuencia de infección por ácaros fue similar a registros anteriores. La intensidad de infección por ácaros fue variable entre sitios, pero no entre clases reproductivas. El sitio con la mayor intensidad de infección por ácaros también presentó la mayor cobertura vegetal, sugiriendo que este hábitat fue más favorable para ácaros adultos en etapa no-parasítica.

Parasites often are significant factors influencing health of their hosts by impeding important physiological and behavioral processes (Oppliger et al., 1996; Oppliger and Clobert, 1997; Schall, 1983, 1990). Parasitism can reduce reproductive success of hosts (Schall, 1983, 1990) and, in turn, greatly affect dynamics of populations of hosts (Begon et al., 1990). Lizards are hosts to a wide array of parasites, including gastro-intestinal (Goldberg et al., 2003), skin (Goldberg and Bursey, 1991), and blood parasites (Schall, 1990). Parasites can have detrimental effects on lizards. For instance, infection of red blood cells by malaria (*Plasmodium*) reduces hemoglobin content of cells, which reduces the oxygen-carrying capacity of blood (Schall, 1990). In lizards, consequences of infection by malaria include reduced running stamina, reduced stores of lipids, and smaller testes (Schall, 1990). Additionally, blood parasites can slow regeneration of tails in lizards (Oppliger and Clobert, 1997). Skin infection by chiggers can cause lesions, inflammation, and blood loss (Goldberg and Bursey, 1991; Goldberg and Holshuh, 1992). Lasting effects of chigger infection on lizards, however, remains unknown.

The Yarrow's spiny lizard (*Sceloporus jarrovii*) is an alpine lizard in southeastern Arizona, southwestern New Mexico, and northwestern Mexico (Degenhardt et al., 1996). This species was reported to host malaria (*Plasmodium chiricahua*; Mahrt, 1989; Telford, 1970) and chiggers (*Eu-*

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TABLE 1—Intensity and prevalence (infected/size of sample) of chiggers and prevalence (infected/size of sample) of malaria in *Sceloporus jarrovii* in the Chiricahua Mountains, Arizona.

Site	Reproductive class	*n*	Chiggers		Malaria
			Mean intensity (*SE*)	Prevalence	Prevalence
Barfoot	Female	5	22.6 (12.8)	4/5	5/5
	Juvenile	3	4.3 (2.2)	2/3	3/5
	Male	7	14.3 (5.7)	7/7	6/7
Road Side	Female	1	25	1/1	1/1
	Juvenile	5	13.8 (4.2)	5/5	5/5
	Male	8	76.1 (9.7)	8/8	8/8
South Fork	Female	6	9.5 (3.8)	6/6	5/6
	Juvenile	4	16.5 (4.4)	4/4	3/4
	Male	3	14.3 (5.9)	3/3	1/3

trobicula lipovskyana; Goldberg and Bursey, 1993). During 1979–1986, prevalence of the malarial parasite *P. chiricahua* in *S. jarrovii* in Arizona was 32–58% (Mahrt, 1989). In 1990, prevalence of the chigger *E. lipovskyana* in *S. jarrovii* from Arizona was 100%, while intensity of infestation was 3–99 chiggers/lizard (Goldberg and Bursey, 1993). Here, we report changes in prevalence of malaria and prevalence and intensity of chigger infection in three populations of *S. jarrovii* from the same geographical area.

In October 2006, we studied lizards at three sites in the Chiricahua Mountains, Coronado National Forest, Cochise Co., Arizona. The first site (South Fork) is a open rock talus along a riverbed at an elevation of 1,575 m (31°51′41.4″N, 109°11′20.3″W). The second site (Barfoot Park) is also an open rock talus at an elevation of 2,500 m (31°55′06.7″N, 109° 16′44.9″W). The third site (Roadside) is a rocky outcrop along forest road 42 d and is 1.2 km from Barfoot Park (31°54′53.3″N, 109°16′02.5″W; elevation 2,485 m). Lizards ($n = 42$) were captured opportunistically by noose and fishing pole. Upon capture, we measured snout–vent length with a digital calliper (±0.01 mm). We identified males by enlarged femoral pores, enlarged base of tail, and extensive blue patches on throat and venter. Individuals without secondary sexual characters of males were considered females if they were >52 mm snout–vent length and juveniles if they were ≤52 mm snout–vent length (Degenhardt et al., 1996).

For each lizard, we counted number of parasitic mites attached in the mite pockets; skin invaginations that may have evolved to circumscribe damage to tissue caused by parasitic mites (Arnold, 1986). On *S. jarrovii*, mite pockets are on both sides of the gular region (Goldberg and Bursey, 1993). To document presence of malaria, we made blood smears with blood obtained from toe clips. Blood smears were air dried in the field. Once in the laboratory, we fixed smears in 100% methanol and stained them in a Giemsa solution. To determine presence of malaria, we scanned each smear for 25 min at 1,000× magnification with an oil-immersion lens. If no infected red blood cell was detected, the lizard was considered to be free of malaria.

There was a high prevalence of malaria infection. Of lizards examined, 85% were infected with *Plasmodium*. Prevalence of *Plasmodium* infection did not differ among reproductive classes (Chi-square Goodness-of-Fit test: $\chi^2 = 0.6$, $P = 0.74$), but differed significantly among sites ($\chi^2 = 6.6$, $P = 0.03$) with Barfoot and South Fork having lower prevalence than Roadside (Table 1). Prevalence we observed was 27–53% higher than reported by Mahrt (1989) for the same area, which may indicate an increasing prevalence. Unfortunately, because our study only encompassed a small proportion of the area covered by Mahrt (1989) and included only one season (autumn), we could not determine statistically whether prevalence of *Plasmodium* was increasing in the area. More extensive sampling such as that conducted by Mahrt (1989) would be valuable to identify patterns in this disease, especially because transmission of malaria is expected to increase with rising environmental temperatures (Martens et al., 1997).

Similar to prevalence of malaria, prevalence of chigger infection also was high. Overall, 93% of lizards were infected, with no significant differ-

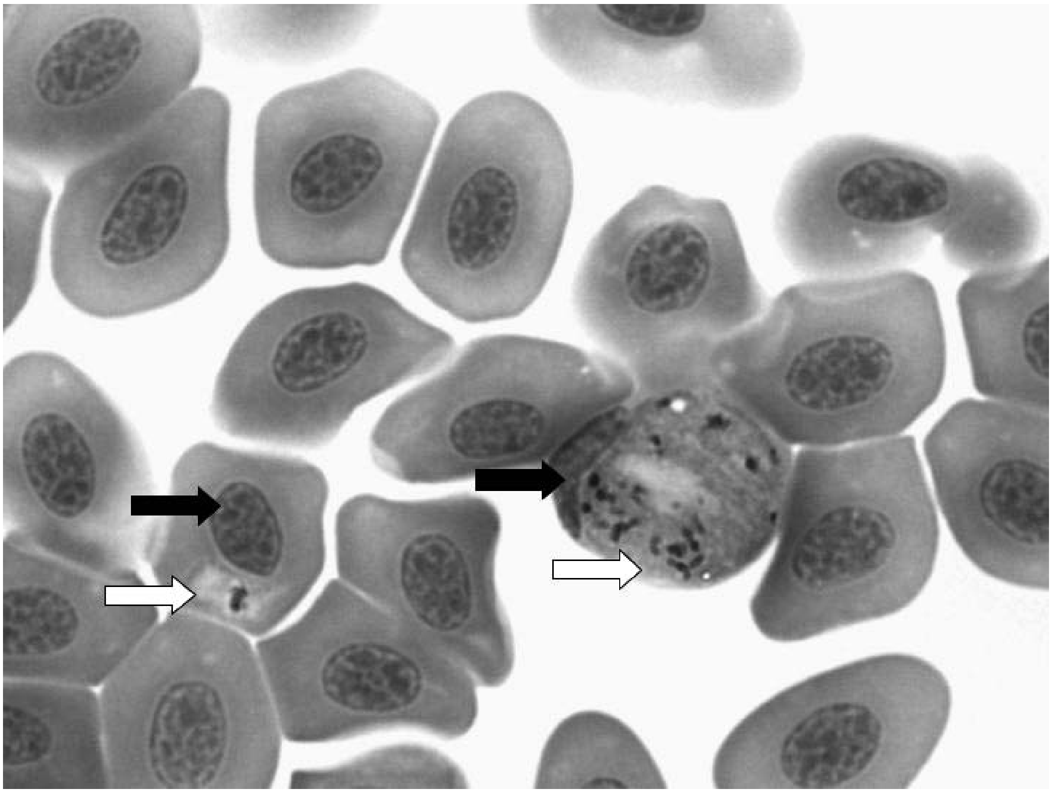

FIG. 1—*Plasmodium* (white arrows) infecting red blood cells (black arrows) of *Sceloporus jarrovii* from Arizona (magnification is 1,000×).

ence among reproductive classes ($\chi^2 = 0.12$, $P = 0.94$). Prevalence of chigger infection differed significantly among sites ($\chi^2 = 6.6$, $P = 0.03$), with Barfoot having a lower prevalence than Roadside and South Fork (Table 1). Intensity of chigger infection was variable and was 0–120 mites/individual (mean = 26, SE = 4.6). We used a non-parametric Kruskall-Wallis test to compare effect of reproductive class and site on intensity of chigger infection because our data were heteroscedastic. Intensity of chigger infection tended to be higher at Roadside relative to the two other sites (Table 1), but this difference was non-significant ($H_{(2,33)} = 5.15$, $P = 0.07$). Reproductive class and interaction between class and site (class*site) were not significant predictors of intensity of chigger infection (reproductive class: $H_{(2,33)} = 2.83$, $P = 0.24$; reproductive class*site: $H_{(2,33)} = 5.59$, $P = 0.23$). Overall, our findings for prevalence and intensity of chigger infection were concordant with those of Goldberg and Bursey (1993) for the same geographical area.

In summary, lizards at the Roadside site harbored more chiggers than lizards from Barfoot and South Fork. Roadside is different structurally from Barfoot and South Fork, which were both rock taluses with no vegetation. Roadside is a rocky outcrop interspersed with patches of trees and shrubs. This site had notably more vegetation and soil than the other two sites. Adult chiggers are non-parasitic and live in the leaf litter (Klukowski, 2004). Thus, it is likely that habitat at Roadside was more suitable for chiggers to complete their life cycle, which would result in a greater density of parasites. Zippel et al. (1996) detected a similar association between intensity of chigger infection on three species of *Anolis* lizards and habitat type, with lizards in moist habitats having a greater prevalence and intensity of infection.

The animal care committee of the University of Ottawa approved the protocol (PL-179) for this study. Permits (SP 741189) were provided by the Arizona Game and Fish Department. We are thankful to M.-A. Carrière, B. J. Howes, and S. Poulin for their able help with collection of lizards, and to A. Ochalski for providing microscopy expertise. Muchas gracias a H. Vázquez Rivera por la traducción del resumen. Funding for this study was provided by grants to GBD from Natural Sciences and Engineering Research Council and Canada Foundation of Innovation, and scholarships to GB from Natural Sciences and Engineering Research Council.

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