

RESEARCH ARTICLE

## TIME SINCE FIRE AFFECTS ECTOPARASITE PREVALENCE ON LIZARDS IN THE FLORIDA SCRUB ECOSYSTEM

Earl D. McCoy\*, Joseph M. Styga, Carol E. Rizkalla, and Henry R. Mushinsky

Department of Integrative Biology, University of South Florida,  
SCA 110, 4202 East Fowler Avenue, Tampa, Florida 33620, USA

\*Corresponding author: Tel.: 001-813-974-5219; e-mail: edm@mail.usf.edu

### ABSTRACT

Prevalence of parasites can be an indicator of individual and population health of hosts. Populations of parasites can be affected by habitat management practices, however, which in turn can affect prevalence on hosts. We assessed the influence of varying fire histories on the prevalence of ectoparasites, primarily chiggers (mite larvae of the genus *Eutrombicula*), on the three most common lizard species resident in the Florida scrub ecosystem. Few individuals of the Florida sand skink (*Plestiodon reynoldsi*) harbored ectoparasites. The Florida scrub lizard (*Sceloporus woodi*) and the six-lined racerunner (*Aspidoscelis sexlineata*) had the highest prevalence of ectoparasites in recently burned (within 3 years) plots. Change in habitat structure or increased mobility of hosts following a recent burn may increase the host-parasite encounter rate.

**Keywords:** ectoparasites, Florida, Florida sand skink, Florida scrub Lizard, habitat structure, scrub ecosystem, six-lined racerunner, time since fire

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### INTRODUCTION

Parasite prevalence is used in wildlife management and ecological studies to gauge population health (Schultz *et al.* 1993). Prevalence can vary with habitat conditions, landscape fragmentation, the host's habitat use patterns (Thamm *et al.* 2009), the host's population size (Schall and Marghoob 1995), and the degree of host stress (Esch *et al.* 1975, Karr 1981, Krist *et al.* 2004). Among the consequences for individuals of parasite infestations, especially when infestations are heavy, are increased immune response and decreased ability to acquire resources, which in turn may lead

to decreased weight gain, stamina, activity, and longevity, and increased reproductive failure (Main and Bull 2000, Reardon and Norbury 2004, Curtis and Baird 2008, Hare *et al.* 2010).

Lizards harbor a variety of ectoparasites. Most numerous among these ectoparasites are ticks. After ticks (Acari: Ixodidae), larvae of mites within the genus *Eutrombicula* (Acari: Trombiculidae), chiggers, are the most frequent ectoparasite of wild lizard species (Walter and Shaw 2002). These larval mites are barely macroscopic, but can form masses of individuals of considerable size on hosts (Walter and Shaw 2002). They also are found on

terrestrial amphibians (Duellman and Trueb 1994), snakes (Hyland 1950), and the tuatara (*Sphenodon punctatus*; Godfrey et al. 2008). All life stages of ticks are parasitic, and individuals may require as many as three different hosts to complete their lifecycles (Baker and Wharton 1952). In contrast, only the larval stage of members of the genus *Eutrombicula*, which are closely related to ticks, are parasitic, and individuals may require only one host to complete their lifecycles (Baker and Wharton 1952). Adults of the genus *Eutrombicula* occur in soil and litter.

Fire often is used as a tool to reduce the population sizes of ectoparasites, although not typically ectoparasites of wildlife. Fire has been shown to reduce tick populations in many locations by direct mortality and by reducing tall grass cover (e.g., Cully 1999, Fyumagwa et al. 2007). The effect of fire on mites is less definitive. Fire appears to reduce population sizes of soil mites in some cases (e.g., Camaan et al. 2008), but increase population sizes in others (e.g., Krasnoshchekov et al. 2004). Regardless of their immediate response to burning, populations of soil mites often return to pre-burn numbers quickly (e.g., Krasnoshchekov et al. 2004, Barratt et al. 2006). The objective of the current study was to determine if time since fire in a naturally pyrogenic habitat could be shown to affect ectoparasite prevalence on resident lizards. Not much is known about the potential effects of fire on ectoparasite prevalence on lizards, particularly in naturally pyrogenic ecosystems. We examined ectoparasite prevalence on three lizard species inhabiting an area of the Florida scrub ecosystem that is maintained by planned burning to determine if prevalence is related to time since fire.

## METHODS

We conducted the study at Archbold Biological Station during spring 2011. Archbold Biological Station, which is located on the

Lake Wales Ridge in Highlands County, Florida, USA (27°10'50" N, 81°21'00" W), contains more than 2000 ha of mostly xeric, naturally pyrogenic habitats. Included in this study are three habitat types within the Florida scrub ecosystem: flatwoods, scrubby flatwoods, and rosemary balds (Abrahamson 1984). Regular planned burning of these habitats has been carried out at Archbold Biological Station beginning in the mid-1970s, with full implementation in the mid-1980s (Main and Menges 1997). The management staff strives to maintain a natural fire regime while, at the same time, promoting habitat that will support the many rare and unique organisms living there (Main and Menges 1997). Plots used in this study were last burned 1, 2, 3, 7, 9 to 10, 12, or 25 years prior to the study.

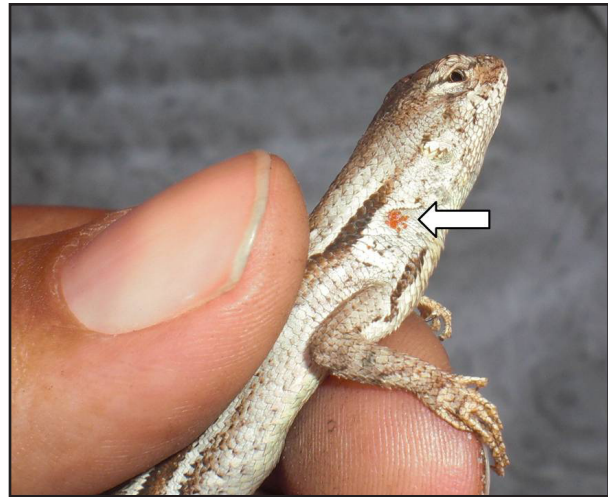
The host species were the Florida sand skink (*Plestiodon reynoldsi*), the Florida scrub lizard (*Sceloporus woodi*), and the six-lined racerunner (*Aspidoscelis sexlineata*). These species are the most common lizards in the Florida scrub ecosystem (Ashton and Knipps 2011, McCoy et al. 2012). They are known to harbor many different types of internal and external parasites (Telford 1959, Telford and Bursey 2003, McCoy et al. 2010). Chief among the ectoparasites are small, bright orange mites of the genus *Eutrombicula* (Telford 1959, Telford and Bursey 2003). The Florida sand skink is a threatened species precinctive (Frank and McCoy 1990) to the ridges of central Florida (USFWS 1999), which occupies a variety of xeric scrub habitats (Greenberg et al. 1994, Sutton 1996, USFWS 1999, Chrisman 2005). The Florida scrub lizard occupies habitats similar to those of the Florida sand skink on the central ridges of Florida, but also occupies coastal scrubs of the peninsula (Jackson 1973, Hokit and Branch 2003). The six-lined racerunner is more widely distributed, both ecologically and geographically, than the other two species, and is common in most xeric habitats within its broad geographic range (Hoddenbach 1966, Hokit et al. 1999).

We collected data within a set of 36 enclosures used for a variety of other studies (e.g., Schrey *et al.* 2011). Enclosures were constructed of aluminum flashing and measured 20 m × 20 m. Each enclosure contained 76 pitfall traps, which were 3.8 L plastic buckets buried in the sand to their openings. Twelve of the pitfall traps were spaced evenly around the inside of the enclosure boundary, and the remaining 64 were arranged in 16 arrays evenly spaced within the enclosure. Each array was composed of four pitfall traps, two at each end of a 2 m strip of aluminum buried to the same depth as the enclosure boundary. The flashing directed lizards into the pitfall traps.

We conducted preliminary surveys for ectoparasites on the Florida scrub lizard in late winter within a subset of the enclosures. We transported individuals captured by noosing to the laboratory at Archbold Biological Station for examination. Examination consisted of brushing the entire surface of each individual over a piece of white paper, followed by location of remaining ectoparasites with a hand lens (see Huyghe *et al.* 2010). After examination, we measured snout-vent length (SVL), sexed, weighed, and released each individual at its point of capture.

Once pitfall traps were opened in the spring, we checked each one every three days for captures. We measured and marked captured individuals of the Florida scrub lizard and six-lined racerunner, and examined them for ectoparasites in the field. The preliminary surveys indicated that careful examination of individuals was enough to establish ectoparasite presence, so we did not brush individuals. We marked individuals by toe-clipping, to avoid double-counting. After examination for ectoparasites and marking, we released each individual near its point of capture. We transported captured individuals of the Florida sand skink to the laboratory to be measured, marked (if necessary, as many had been marked previously), and examined for ectoparasites. We used the brushing technique described previ-

ously to locate ectoparasites. We marked individuals with visible implant elastomer, VIE (Penney *et al.* 2001). Subsequently, we released each individual near its point of capture. We did not count the number of ectoparasite individuals per host individual (parasite load) for two reasons: (1) every host individual captured later in the trapping season that harbored ectoparasites was heavily infested with them (Figure 1), and (2) previous recapture results (E.D. McCoy, University of South Florida, unpublished data) indicated that the additional handling time required could have been detrimental to the health of host individuals.



**Figure 1.** An individual of the Florida scrub lizard with mites crowded into a nuchal pocket (arrow).

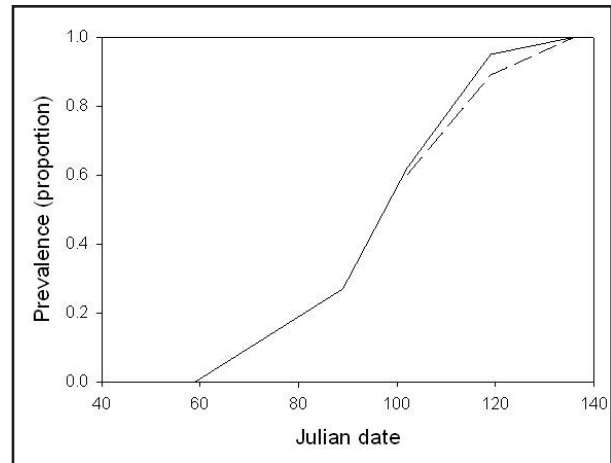
We used chi-squared tests of independence to determine if a difference in ectoparasite prevalence existed between individuals captured from enclosures with different times since fire. We employed an exploratory data analysis approach. Keeping the chronological ordering intact, we compared all possible pairs of groups of sites. Thus, one comparison was sites with a 1 yr time since fire versus all others; a second comparison was sites with 1 yr plus 2 yr since the last burn versus all others, and so on. We then chose the comparison with the greatest difference. We performed the analysis in SigmaPlot, version 11.2 (Systat

Software, Chicago, USA). We also used chi-squared tests of independence to determine if sex ratio differed between groups of enclosures with different times since fire. We used logistic regression analysis ( $Z$ -statistic) to determine if a relationship existed between the presence of ectoparasites and weight or sex. Because SVL and weight were strongly related ( $r = 0.88$ ,  $P < 0.01$ , Florida scrub lizard;  $r = 0.71$ ,  $P < 0.01$ , six-lined racerunner), we did not include SVL in the model. We performed the analysis in R, version 2.12.2 (R Development Core Team, Vienna, Austria). We used the Mann-Whitney U-Test ( $T$ -statistic) to determine relationships among weight, sex ratio, and time since fire. We performed the analysis in SigmaPlot, version 11.2.

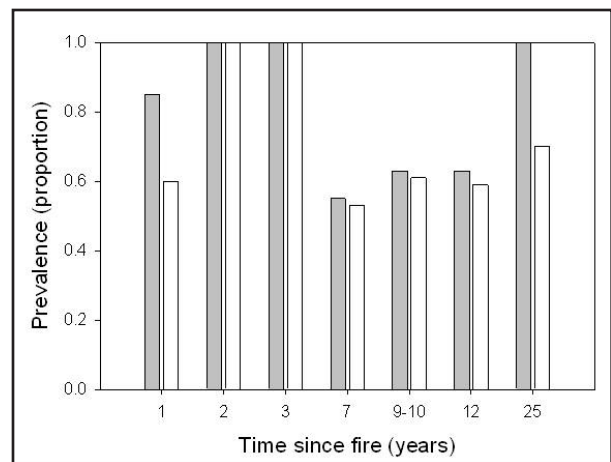
## RESULTS

Ectoparasite prevalence varied over time and among species. None of the 20 individuals of the Florida scrub lizard examined during the preliminary surveys in late winter had ectoparasites. Trapping in the spring revealed overall ectoparasite prevalence of 3% (4 of 117 individuals) for the Florida sand skink, 64% (44 of 69 individuals) for the Florida scrub lizard, and 78% (31 of 40 individuals) for the six-lined racerunner. Except for an unidentified tick species found on one individual of the Florida sand skink, the ectoparasites encountered all were larval mites of the genus *Eutrombicula*. Because of the low prevalence of ectoparasites on the Florida sand skink, we did not use the species in any further analyses. Ectoparasite prevalence increased over time for both the Florida scrub lizard and six-lined racerunner (Figure 2).

Ectoparasite prevalence was related to time since fire. Prevalence on the Florida scrub lizard and six-lined racerunner showed similar responses to time since fire (Figure 3); therefore, we combined the data for analysis. The greatest difference was between times since fire of 1 yr + 2 yr + 3 yr versus longer times



**Figure 2.** Prevalence of ectoparasites on the Florida scrub lizard (solid line) and the six-lined racerunner (dashed line) over the course of the study at Archbold Biological Station.



**Figure 3.** Prevalence of ectoparasites on the six-lined racerunner (filled bars) and the Florida scrub lizard (open bars) in plots of different times since fire.

since fire. Ectoparasite prevalence tended to be higher in more-recently burned plots ( $\chi^2 = 3.20$ ,  $P = 0.07$ ;  $n = 53$  and  $56$ ). When the most recent burn was excluded, the relationship improved (Fischer's Exact Test,  $P = 0.02$ ).

The relationship between ectoparasite prevalence and time since fire was not a spurious result of differences in morphology or sex ratio among lizards living in habitats with different times since fire. Although the logistic

regression models, which were well supported (Residual deviance 52.23 on 57 df, Florida scrub lizard; 34.72 on 34 df, six-lined racerunner), revealed a strong association between ectoparasite prevalence and weight for both the Florida scrub lizard ( $Z = 2.16$ ,  $P = 0.03$ ) and the six-lined racerunner ( $Z = -1.93$ ,  $P = 0.05$ ), we could detect no strong difference in weight of individuals between groups of plots with different times since fire for either species ( $T = 485.0$ ,  $P = 0.40$ ,  $n = 46$ , Florida scrub lizard;  $T = 189.5$ ,  $P = 0.18$ ,  $n = 34$ , six-lined racerunner). Neither weight ( $T = 327.5$ ,  $P = 0.70$ ,  $n = 41$ , Florida scrub lizard;  $T = 212.0$ ,  $P = 0.28$ ,  $n = 31$ , six-lined racerunner) nor ectoparasite prevalence ( $Z = 0.69$ ,  $P = 0.49$ , Florida scrub lizard;  $Z = 0.65$ ,  $P = 0.52$ , six-lined racerunner) was strongly related to sex for either species. We could detect no strong difference in sex ratio between groups of plots with different times since fire ( $\chi^2 = 0.06$ ,  $P = 0.81$ , Florida scrub lizard;  $\chi^2 = 0.07$ ,  $P = 0.93$ , six-lined racerunner).

## DISCUSSION

Individuals of one of the three species examined, the Florida sand skink, were remarkably devoid of ectoparasites. The fossorial habit of this species likely accounts for this result. Individuals are not often exposed to ectoparasites in the first place, and their smooth surfaces being repeatedly abraded by the sand through which they “swim” likely promotes removal of virtually all ectoparasites that do manage to attach. However, the other two species, the Florida scrub lizard and six-lined racerunner, commonly harbored ectoparasites. We found ectoparasite individuals in abundance on the abdomen of the six-lined racerunner and in the nuchal pockets (Arnold 1986, Bauer *et al.* 1990) of the Florida scrub lizard. Both species showed high ectoparasite prevalence; in fact, ten times higher than prevalence recorded for individuals farther north, at Ocala National Forest (Telford and Bursey 2003).

Prevalence increased with time during the lizards’ active season, the onset of which coincides with the onset of the ectoparasite’s active season (Koehler *et al.* 2011). The mite’s relatively rapid lifecycle, combined with the long periods of warm temperatures and abundant rainfall in southern Florida, allow production of several generations per year (Koehler *et al.* 2011; e.g., Badejo 1990, Schall *et al.* 2000, Klukowski 2004, Rubio and Simonetti 2009).

The six-lined racerunner tended to have greater ectoparasite prevalence than the Florida scrub lizard. The former species generally is more active than the latter (Jackson and Telford 1974, Paulissen 1988). The former species also likely has a greater capacity to move through a wide range of habitat types, including types with the dense structure favored by mites (Curtis and Baird 2008), whereas the latter species prefers open habitats with substantial bare ground (Hokit and Branch 2003). Finally, the former species tends to remain on the surface, whereas the latter may temporarily burrow in the sand when disturbed (E.D. McCoy, J.M. Styga, C.E. Rizkalla, and H.R. Mushinsky, University of South Florida, personal observations). Within species, prevalence was related to body weight. Heavier individuals of the Florida scrub lizard and lighter individuals of the six-lined racerunner had higher prevalence. We have no ready explanation for these patterns. Also, we could not detect a strong tendency for individuals to be either lighter or heavier in plots with different times since fire. Nor could we determine sex ratios to be different among plots with different intervals. Size and sex do not appear to influence differences in ectoparasite prevalence among plots.

The general relationship of ectoparasite prevalence to time since fire was similar between the Florida scrub lizard and the six-lined racerunner. A tendency existed for prevalence to be higher in more recently burned plots, although prevalence did tend to increase in plots burned at the longest time since fire (25 yr;

Figure 3). Based on what is known about mite densities, we might have expected prevalence actually to be higher in plots burned less recently, because of the denser vegetation there. Mites favor areas with relatively dense vegetation structure and shading over their soil refugia (Dobson *et al.* 1992, Roy and Roy 2006), which provide conditions of relatively low temperature, high humidity, and high host density (Rubio and Simonetti 2009, Koehler *et al.* 2011). The higher prevalence in more recently burned plots, therefore, may be attributable more to host biology than to parasite biology. One possible explanation is that host density is greater in more recently burned plots, resulting in an increased encounter rate between host and parasite. However, we could detect no strong difference in the abundance of host individuals among plots (McCoy *et al.* 2012). Other possible explanations stem from the changes in vegetation structure accompanying burning (cf., Ashton and Knipps 2011). More recently burned plots are structurally simplified, which may enhance host mobility. More recently burned plots support mainly sparse clumps of grassy vegetation, which may concentrate parasites in areas where the host seeks

shelter. Either of these potential explanations based on change in vegetation structure also would account for an increase the encounter rate between host and parasite.

Some evidence concerning responses of individuals to fire suggests the importance of mobility in influencing ectoparasite prevalence. Studies of the Florida sand skink (Schrey *et al.* 2011; C.E. Rizkalla *et al.*, University of South Florida, unpublished data) have indicated that individuals move increased distances in response to burning, effectively reshuffling local populations. If similar responses to burning occur for the Florida scrub lizard and the six-lined racerunner, then the tendency that we noted for prevalence to be higher in plots burned one year ago versus plots burned two or three years ago may be explained by such movements. However, the Florida scrub lizard is a relatively poor disperser (Hokit *et al.* 1999); therefore, the mobility explanation may not be a complete one. The causes of differences in prevalence accompanying differences in time since fire is a subject in need of further research, employing a more sophisticated experimental design (cf., Godfrey *et al.* 2008).

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