European Fire Ant Presence Decreases Native Arboreal Insect Abundance in Acadia National Park, Maine, USA

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RESEARCH NOTE

European Fire Ant Presence Decreases Native Arboreal Insect Abundance in Acadia National Park, Maine, USA

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ABSTRACT: This study examines the impacts of European fire ants on arboreal insect abundance and diversity in Acadia National Park, Maine. Abundance and diversity were quantified via arboreal pitfall traps that were checked every three days for 21 days from May to June 2009. In areas infested with European fire ants, arboreal insect abundance declined, but arboreal insect species richness remained unchanged. This study illustrates the importance of examining the ecological links between canopies and leaf litter and demonstrates the breadth of impacts that biological invasions can have in an ecosystem.

Index terms: community ecology, exotic, Formicidae, invasive species, *Myrmica rubra*

INTRODUCTION

European fire ants (Hymenoptera: Formicidae, *Myrmica rubra* L*)* are invasive and exotic ants in the northeastern United States (Wheeler 1908). First reported in Maine in 1968, these ants occur patchily in and around Acadia National Park, Maine, USA, in high densities as compared to their native range (1.24 nests/m^2; Groden et al. 2005), and appear to be slowly expanding their North American range (Wetterer and Radchenko 2011). European fire ants are small ground-dwelling ants that demonstrate low intracolony aggression and form polygynous and polydomous nests in humid cryptic locations such as rotting logs, along tree roots, and in moist leaf litter (Elmes 1973, 1974; Groden et al. 2005; Garnas et al. 2007).

Other studies in Maine have found that fire ants significantly reduce ground-nesting ant diversity (Groden et al. 2005), interfere with lady beetle consumption of pest aphids (Finlayson et al. 2009), and increase homopteran diversity (McPhee et al. 2012); however, the effects of European fire ants on forest canopy insects remain unexplored. In Oklahoma, the presence of high densities of another ground-nesting invasive and exotic species, the red imported fire ant (*Solenopsis invicta* Buren), correlated with decreased arboreal arthropod diversity (Kaspari 2000); we sought to test whether this pattern also occurred in Acadia National Park. We measured arboreal insect species richness and abundance in infested and uninfested patches of forest within Acadia National Park. We predicted that patches of forest infested with fire ants would have lower arboreal insect diversity and abundance than uninfested patches.

MATERIALS AND METHODS

We conducted arboreal ant inventories in ten forest patches (sites) within the boundaries of Acadia National Park. Sites were selected by the presence of mature trees, tree species composition, researcher accessibility, and presence/absence of *M. rubra* (Groden et al. 2005; E. Groden, Professor of Entomology, University of Maine, pers. comm.). Within each patch, ten trees were randomly chosen for sampling; diameters at breast height (DBH, cm) were measured for all trees. Traps were placed within trees at two different height positions: "low" and "high." "High" traps were placed >10 m from the ground. "Low" traps were placed 5–10 m from the ground. At each site, five traps were placed at "high" positions and five at "low" positions; trap heights were chosen randomly. We collected canopy arthropods from each of the ten trees per patch (total n = 100) using arboreal pitfall traps per the design and methods of Kaspari (2000). Traps were checked, emptied, and refilled every three days from 22 May to 19 June 2009. Samples were preserved in 95% ethanol and identified to morphospecies using published keys. In addition, we conducted climbing surveys in one tree per site. During climbing surveys, a researcher ascended the tree to >10 m from ground level using a single rope technique (Perry 1978) and visually observed and collected insects recruiting to baits. Baits consisted of canned tuna in oil and crumbled Pecan Sandies™ cookies. Each of the ten trees was climbed twice for one hour. The trees that were climbed also had arboreal pitfall traps installed to account for species that may not have been attracted to the baits.

We used nested analyses of variance (ANOVA) to analyze the effects of sites, fire ant presence, tree size, and tree species on arboreal insect abundance and species richness (JMP 2014). In addition, we examined the effect of trap height on arboreal insect abundance and species richness (JMP 2014). Finally, we compared the results of climbing surveys and arboreal pitfall traps.

RESULTS

We collected a total of 1110 individual insects representing 12 native morphospecies during this study. Morphospecies collected were exclusively from three orders, Diptera (abundance $n = 987$; species richness $n = 3$), Hymenoptera (abundance $n = 124$; species richness $n = 8$), and Coleoptera (abundance $n = 1$; species richness $n = 1$). Climbing surveys yielded no new species, so results were analyzed using arboreal pitfall traps only. No arboreal ant species were found in traps in *M. rubra* infested areas, and often, *M. rubra* was found in these traps (though we excluded it from species richness analyses). In areas without *M. rubra,* the three most commonly recorded ant species were *Camponotus herculeanus* L.*,* *Formica aserva* Forel*,* and *F. subsericea* Say (Oullette et al. 2010).

Species richness did not differ between treatments (infested with *M. rubra*, uninfested), sites nested within treatments, and tree species (Table 1); however, insect abundance differed between treatments, but not sites nested within treatments or tree species (Table 2, Figure 1). Tree diameter at breast height (DBH) did not correlate with arboreal insect abundance ($R^2 = 0.01$, $P = 0.33$) or species richness ($R^2 = 0.01$, $P = 0.93$). Trap height also did not influence native species richness ($P = 0.95$) or abundance ($P = 0.30$).

Table 1. Insect species richness among treatments, sites (treatments), and tree species. DF = degrees of freedom, MS = mean squares.

	DF	MS	*F*	*P*
Treatment	1	0.0006	0.0016	0.9683
Site (Treatment)	8	4.1012	1.4401	0.1927
Tree Species	9	2.1651	0.6758	0.7285
Error	81	0.3559		

DISCUSSION

Native arboreal insect species richness was not significantly reduced by the presence of European fire ants; however, arboreal insect abundance declined as a result of fire ant infestation. In his study, Kaspari (2000) found similar decreases in ant abundance in forests infested with red imported fire ants, but he also found a decrease in species richness associated with red imported fire ant infestations. Connections between arboreal and leaf litter species are often not well understood (but see: Yanoviak and Kaspari 2000; Kaspari and Yanoviak 2001), and few studies have examined this relationship in temperate forests. European fire ants may be influencing arboreal insect abundance directly through competitive interference and aggression, or indirectly through consumption of limiting resources and/or destruction of habitat. These mechanisms remain to be tested, though given the presence of *M. rubra* in several of the arboreal pitfall traps, it appears that direct interference may be likely.

In this study, tree species and tree size did not influence arboreal insect species richness or abundance; while some studies report similar trends (Southwood et al. 1982), others have found host and tree specificity in arboreal insects (Moran and Southwood 1982; Basset 2008). Compared with other techniques, our arboreal pitfall traps caught relatively few insects and few species (e.g., insecticide fogging, Paarman and Stork 1986, Basset 1990; insecticide fogging and epiphyte sampling, Yanoviak et al. 2003; baits and hand collection, Yanoviak et al. 2007). Further, these traps select for highly mobile and cursorial insects and do not capture the full array of species occupying an arboreal ecosystem (Gotelli et al. 2010); thus, they may not be the best choice for future studies of community diversity and structure.

In conclusion, the effects of invasive species such as European fire ants may not always be directly evident and may extend past their immediate habitat and community. Future studies should examine the mechanisms by which arboreal insect diversity is impacted by European fire ants, the extent to which arboreal insect communities can recover from these invasions, and the broader cascade of effects that may result from decreases in arboreal insect community diversity.

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Table 2. Insect abundance among treatments, sites (treatments), and tree species. DF = degrees of freedom. MS = mean squares. * = statistically significant at alpha = 0.05.

	DF	MS	*F*	*P*
Treatment	1	7.6298	9.4963	0.0028*
Site (Treatment)	8	8.4406	1.3132	0.2488
Tree Species	9	1.8203	0.2517	0.9851
Error	81			

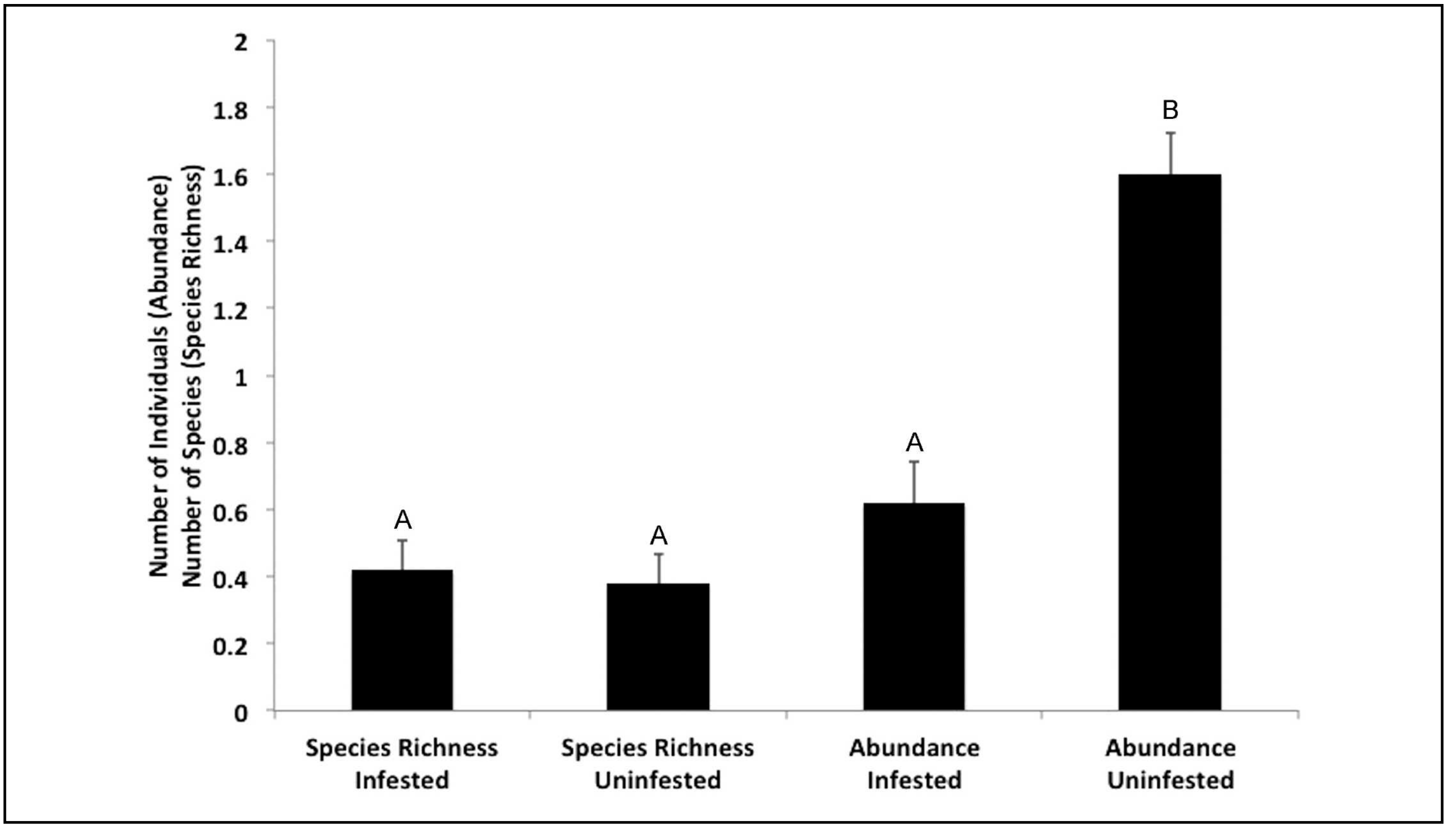

Figure 1. Arboreal insect abundance and species richness between European fire ant infested sites and uninfested sites. The y axis scale is mean number of individuals for the abundance bars and mean number of species for the richness bars. An analysis of variance was used for both abundance (DF = 1, *F* = 0.0016, *P* = 0.9683) and species richness (DF = 1, *F* = 9.4963, *P* = 0.0028). Letters indicate significant differences (alpha = 0.05). Bars represent standard error. Comparisons were made within species richness and abundance only.

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