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The influence of ambient conditions and space on the phenological patterns of a *Solenopsis* phorid guild in an arid environment

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Abstract

We observed the diurnal distribution of a phorid parasitoid guild of *Solenopsis* fire ants across five sites in an arid region of western Argentina over 17-months. We found a rich assembly of 15 taxa, of which 7 species were found each month of the year and over most times of the day. The majority of species were found most frequently in the evening. A Canonical Correspondence Analysis of the hourly abundances of the flies in relation to field meteorological conditions suggested that two broad groups of species existed, one of which had flight periods associated with hotter, drier conditions than the second. The first group was most commonly represented by *Pseudacteon tricuspis*, the *P. obtusus* complex and *P. cultellatus*, while some members of the second group, such as the *P. nocens* complex and *P. litoralis* were the most abundant and commonly found flies. The range of conditions in which these flies were found suggests that all of the common taxa represent populations that might be suitable for introduction into similarly arid environments of Texas.

Keywords: Argentina; Climate; Fire ants; Parasitoid guild; Niche partitioning; Seasonal activity; *Microselia aduncus*; *Pseudacteon borgmeieri*; *Pseudacteon bulbosus*; *Pseudacteon comatus*; *Pseudacteon convexicauda*; *Pseudacteon cultellatus*; *Pseudacteon curvatus*; *Pseudacteon litoralis*; *Pseudacteon nocens*; *Pseudacteon* nr. *nocens*; *Pseudacteon nudicornis*; *Pseudacteon obtusus*; *Pseudacteon* nr. *obtusus*; *Pseudacteon solenopsidis*; *Pseudacteon tricuspis*; *Solenopsis electra*; *Solenopsis macdonaghi*; *Solenopsis invicta*; *Solenopsis richteri*; Biological control

1. Introduction

Decisions involving the selection of a natural enemy for employment in a classical biological control program center around issues of safety, efficacy and practicality (Carruthers and D'Antonio, 2005). These concerns have certainly been in the foreground for the biological control of imported fire ants in the southern United States, specifically with respect to the phorid parasitoids in the genus *Pseudacteon* (Porter et al., 2004; Gilbert and Patrock, 2002; Graham et al., 2003; Vazquez et al., 2005; Vogt and Streett, 2003). There is an abundance of species choices associated in the native range of these pest ants in South America where over 20 species of *Pseudacteon* utilize *Solenopsis* fire ants as hosts in this region (Disney, 1994; Porter and Pesquero, 2001; Folgarait et al., 2005a). To help ensure on-target management of the imported species, host specificity tests have exploited phylogenetic relationships within the host genus (Porter and Gilbert, 2004 and references therein) whereby populations of *Pseudacteon* species that do not discriminate between the South American *saevissima* complex and the North American *geminata* complex of the *Solenopsis* fire ant group (Trager, 1991) are considered too host generalist to safely admit for releasing. The best taxonomic focal unit for introduction is considered to be the population (Folgarait et al., 2006) because there is extensive known inter-populational variation in host

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choice or preference (Porter and Briano, 2000; Patrock et al., 2006) and because there is evidence for populations of size related morphs or cryptic species for at least two species, *P.* nr. *obtusus* (Folgarait et al., 2005b; Kronfurst et al., submitted) and *P.* nr. *nocens* (Folgarait et al., 2006). In addition, there is informed suspicion (Gilbert and Patrock, 2002; Folgarait et al., 2003, 2006) that species ranging from the wet tropics to dry savannahs probably vary across populations with respect to physiological tolerances (Folgarait et al., 2005a). Local guilds, or communities of fire ant *Pseudacteon* are typically composed of 5–10 species (Orr et al., 1997; Folgarait et al., 2003) so there can be abundant choices of taxa. We use the term 'guild' here because of its connotation of functional similarity (Root, 1967), as well as given the fact the larger local community of phorids attacking ants includes many other taxa of both the flies and host ants.

The investigation of the temporal activity patterns is one research approach that Folgarait et al. (2003) used to explore interspecific variation of these flies and they laid out their assumptions about how this information could be used to help decide upon candidates. Their basic premise was and is that there should be a firm understanding of the fit, as well as mismatches in abiotic conditions between source and potential release sites of candidates. Their explicit assumption was that historical climatic conditions experienced by the populations could be used as guidelines for predicting possible tolerances and activity patterns of the flies under conditions that might be encountered in the adopted range. We continue this approach in this study and document the activity patterns of the guild of *Pseudacteon* in an arid area of western Argentina, Santiago del Estero. Our intended release areas for candidates found in this study are in central and south Texas with a focus on the south Texas plains phytogeographic region. Gilbert and Patrock (2002) discuss reasons why this area climatically matches well with that in Santiago del Estero, namely, correlations with low rainfall and high temperatures.

Several factors would seem to tightly tie activity patterns of these flies with ambient conditions. They are soft bodied and tiny, for the most part being a few mm in length and must struggle with the demands of surface–volume conditions in this size range. Their adult life span is short (around a week or less, Fadamiro et al., 2005) and the presence of female flies attacking the ants indicates an active ovipositional phase that is constrained by its host's activities. Diurnal activities of the flies are tied to solar period in two respects; adult emergence is just before sunrise or during the morning (Wuellner et al., 2002; Folgarait, personal observation) and oviposition extends only while there is available light (Pesquero et al., 1996; Morrison et al., 1999; Orr et al., 1995) and if temperatures are suitable (Fowler et al., 1995; Morrison et al., 1999, 2000; Wuellner et al., 2003; Folgarait et al., 2003).

Our goals were to describe the daily, seasonal and spatial phenological patterns of a *Pseudacteon* guild from an arid environment in relationship to measured meteorological conditions. These results could be used as guidelines for species husbandry and facilitating collections of species for rearing or post-release monitoring. In addition, we wished to compare the activity patterns of the flies in this area with those found for the Argentine S. *richteri* host guild (Folgarait et al., 2003) to better understand interpopulational variation in climatic tolerances of the different fly species, specifically with respect to being able to match these populations with our field sites in the United States.

2. Materials and methods

We studied the *Solenopsis* fire ant phorid guild in the outskirts of the capital of the Argentina province of Santiago del Estero, near Brea Pozo (S 28.25°, W 63.95°). The area lies in the phytogeographical region of the dry western Chaco, (Cabrera and Willink, 1980), characterized by xerophyllic trees such as the quebrachos *Schinopsis* and *Aspidosperma*, along with brea (*Cercidium praecox* (R. et P.) Harms) and various *Prosopis* such as itin, *P. kuntzei* Harms. We designated five sites for observation in this area because they offered us a useful combination of host-parasitoid availability, habitat variation and logistical access. Sites were located in two distinct localities, one that was composed of four patches of fire ant mounds (Sites 1–4) and the other a single patch (Site 5), each varying according to vegetation cover and proximity to irrigation. Sites 1 and 4 were separated by approximately 300 m, while Sites 2 and 3 were in the approximate midrange of these two and separated by about 10 m and a tree line. Site 5 was approximately 3 km from these. We found two host species, *S. interrupta* Santschi and *S. invicta* Buren existing in mosaics within each of these sites. *Solenopsis invicta* was almost the exclusive *Solenopsis* fire ant in Site 4 and the only one sampled, while *S. interrupta* was more common in the other sites and the only one sampled in Site 1. Identification of *S. saevissima* group spp. can be difficult in their native range and so in addition to employing the keys of Pitts (2002) and Trager (1991), we had specimens identified using the professional services of J. Trager.

From January 2003 through July 2004, we monitored each of these sites on a monthly basis utilizing a 10-min sampling-without-replacement protocol, repeated throughout the day. Sampling typically began in the first or second hour following sunrise and continued at least until sunset. The 10 min sample would include walking along a transect of 5–6 disturbed mounds per site and looking for phorids hovering over, or attacking the fire ants. These would be aspirated, identified to sex or species (Pesquero and Porter, 2001) and after each sampling day returned to the field. Females could normally be identified in the field using a 15–20× magnifying lens but we were unable to discriminate males by species. When identification of females was unclear, we would bring the specimens back to the laboratory in Buenos Aries for confirmation. We disturbed mounds by digging a small hole in its side and after the ants emerged, we placed a small plug of tuna fish inside the hole