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# Recruitment of aphidophagous arthropods to sorghum plants infested with *Melanaphis sacchari* and *Schizaphis graminum* (Hemiptera: Aphididae)

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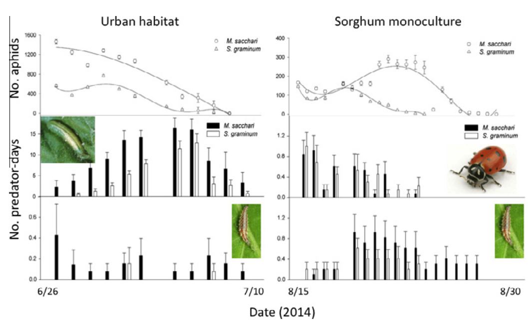
## HIGHLIGHTS

- Sorghum infested with greenbug or sugarcane aphid recruited similar natural enemies.
- Syrphid larvae caused most mortality in open habitat with adjacent trees and flowers.
- Coccinellid adults caused most mortality in a sorghum monoculture with closed canopy.
- Chrysopids and aphelinids were secondary sources of mortality in both cohorts.
- Biological control was successful in preventing alate production by both species.

## GRAPHICAL ABSTRACT

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## ABSTRACT

A significant question in biological control is the extent to which indigenous natural enemies might be pre-adapted to exploit invasive species that constitute novel prey. We observed the recruitment of natural enemies to aphid microcosms – pots containing four sorghum plants infested with either *Melanaphis sacchari* (Zehntner), a newly invasive aphid, or *Schizaphis graminum* (Rondani), an established pest. The first cohort was monitored in open habitat along a tree line near riparian parkland and urban plantings, and the second, within a sorghum monoculture. Both aphid species were eliminated by natural enemies within 13 days in the first cohort, but in the second, *M. sacchari* reached higher numbers than *S. graminum* and survived a week longer. Biological control was successful in both cases; neither aphid produced a generation of alates, nor did plants sustain significant damage. Syrphid larvae, primarily *Allograpta obliqua* (Say), caused most aphid mortality in the first cohort, whereas adult Coccinellidae, primarily *Hippodamia convergens* Guerin-Meneville, caused most mortality in the second. Eggs and larvae of *Chrysoperla carnea* Stephens were present in both cohorts, but appeared to suffer more intraguild predation in the first. Flower flies and velvet mites were present only in the first cohort, and flower bugs, only in the second. *Aphelinus* sp. successfully parasitized both aphids, but *Lysiphlebus testaceipes* Cresson did not develop in *M. sacchari* due to their infection with the secondary endosymbiont *Hamiltonella defensa* (confirmed by DNA analysis). Thus, sorghum infested with *M. sacchari* attracted the same guild of natural enemies as *S. graminum* and had similar biological control outcomes. The findings suggest that the capacity of indigenous aphidophagous guilds to respond to, and ultimately control, invasive aphid species may be underestimated.
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## 1. Introduction

Invasions of exotic agricultural pests have become more frequent with increasing international air travel and the globalization of commerce. Economically damaging outbreaks of invasive pests typically occur during the first few years after their introduction, often leading some to the conclusion that exotic natural enemies will be required to provide biological control. The implicit assumption is that existing guilds of natural enemies will be insufficient, either because they lack specific adaptations to exploit the new pest, or because key niches are unoccupied (e.g., no specialized parasitoid is present). While this may be true in some cases, the preadaptations of many indigenous predators and parasitoids to utilize a new prey/host may be often underestimated, or these species may simply require a period of evolutionary adaptation to achieve their full potential as biological control agents. Aphids are a case in point, as they are vulnerable insects that feed in exposed locations and suffer attack from a broad guild of natural enemies. The taxa that are primarily or exclusively aphidophagous (e.g., Coccinellidae, Syrphidae, Chrysopidae, Braconidae, Aphelinidae) are ubiquitous in agroecosystems worldwide, even though local species composition varies. The present study was conducted to test the hypothesis that natural enemies of aphids in cereal crops on the High Plains possess substantial preadaptations for exploiting a novel aphid pest.

The sugarcane aphid, *Melanaphis sacchari* (Zehntner) (Hemiptera: Aphididae) is a cosmopolitan pest of sugarcane and sorghum capable of attacking a relatively broad range of host plants in the family Poaceae with economic impacts that vary from benign to devastating (Singh et al., 2004). Originally described as *Aphis sacchari* from specimens collected on sugarcane in Java, Indonesia (Zehntner, 1897), it was first reported in North America on sugarcane in Belle Glade, Florida in 1977 (Mead, 1978). Blackman and Eastop (2006) considered *Melanaphis sorghi* as a distinct species, but the morphological distinctions from *M. sacchari* are ambiguous and recent analyses of population genetics revealed clones defined by geography, rather than by host plant utilization (Nibouche et al., 2014). Thus *M. sorghi* is likely a synonym, as argued by Remaudiere and Remaudiere (1997), and *M. sacchari* appears to have arrived in the USA on infested sugarcane material from Hawaii (Nibouche et al., 2014).

The aphid became problematic on sugarcane in Louisiana soon after its detection in 1999 (White et al., 2001), but was not recorded infesting grain sorghum, *Sorghum bicolor* L., until the summer of 2013 in Beaumont, TX, during which highly damaging populations developed in fields throughout the Rio Grande Valley and across the border into Tamaulipas, Mexico (Villanueva et al., 2014). In 2014, *M. sacchari* range expansion occurred to the east and northeast, with sorghum infested in northern Texas, southern Oklahoma, Louisiana, Mississippi, Arkansas and Tennessee. To date, there have been no reports of the aphid west of Interstate 35, a north–south highway that bisects Texas and Oklahoma, but this may simply reflect the prevailing wind patterns during peak periods of aphid flight in 2014.

The primary feature of *M. sacchari* that contributes to its pest status on sorghum is a very high reproductive rate – more than double that of greenbug, *Schizaphis graminum* Rondani, on susceptible sorghum cultivars at 23–24 °C (FC, unpublished observations). Feeding by *M. sacchari* does not damage sorghum plants as quickly as feeding by greenbug, but uncontrolled colonies eventually cause similar chlorosis and death of plant tissues, although this requires a heavier load of aphids feeding for a longer period. Whereas *S. graminum* can feed within the panicle up until flowering and cause some flower sterility, seed weight and quality is usually unaffected, even though yields may be reduced (Harvey and Hackerott, 1974). In contrast, *M. sacchari* can continue feeding through the soft stages of grain fill, impacting both seed weight and quality (Chang and Fang, 1984; Berg et al., 2003). In addition, the thermal tolerance of this particular *M. sacchari* population has not yet been tested, but if it is capable of development and reproduction at temperatures exceeding 25 °C, this could contribute significantly to its pest status during hot summer conditions when high temperatures typically limit greenbug survival and reproduction (Pendleton et al., 2009; Michaud, in press). Another factor that could influence the pest status *M. sacchari* is its ability to utilize a wide range of wild and cultivated grasses, including barnyard grass, *Echinochloa crusgalli* (L.), Burmuda grass, *Cynodon dactylon* (L.) and Johnson grass, *Sorghum halepense* (L.) (Singh et al., 2004).

The literature suggests that a wide range of predators and parasitoids may contribute to biological control of *M. sacchari* throughout its geographic range. Singh et al. (2004) found 47 species of natural enemy reported to attack *M. sacchari*, with all major aphid natural enemy groups represented: Anthocoridae, Aphelinidae, Braconidae (Aphidiinae), Cecidomyiidae, Chamaemyiidae, Chrysopidae, Coccinellidae, Hemerobiidae, Lygaeidae, and Syrphidae. Anecdotal observations in 2014 indicate good initial recruitment of aphidophages to the first large *M. sacchari* infestations in south Texas (R. Villanueva, personal observations). However, there has been no effort yet to catalog the natural enemy species responding or to assess their rates of recruitment to *M. sacchari* in comparison to other aphids regularly infesting sorghum.

Over the past decade, our understanding of how natural enemies locate their herbivore prey by responding to induced plant volatiles has greatly improved (e.g., Takabayashi and Dicke, 1996; Arimura et al., 2005; Turlings and Ton, 2006). Adults of most aphid natural enemies orient to volatile compounds emitted by host plants in response to aphid feeding, (e.g., James et al., 2005; Sasso et al., 2009) and to odors of honeydew or aphid alarm pheromones (Hatano et al., 2008; Verheggen et al., 2008). Although many such compounds are ubiquitous across herbivore-plant associations, their activity is often dosage-dependent (e.g., Li et al., 2008). Furthermore, although variation among plant cultivars in emission profiles is well-recognized (e.g., Scutareanu et al., 2001; Kappers et al., 2011), the extent to which volatile profiles may vary among plants infested with different aphid species is not yet known. If aphid natural enemies must evolve responses to novel signals following new aphid-host plant associations, this could explain the delay in establishment of biological control when aphids are newly invasive in a region. Notwithstanding this, indigenous aphidophagous guilds typically deliver biological control of invasive aphids in time, although this may only be recognized when introduced exotic natural enemies either fail to establish, or have little impact (Michaud, 2002).

With the above considerations in mind, we designed a field experiment to compare the abundance and diversity of aphidophagous species recruited to potted plants of grain sorghum infested with either *M. sacchari* or *S. graminum*. We reasoned that, if *M. sacchari* infestation of sorghum elicits release of a volatile blend similar to that elicited by greenbug infestation, then the diversity and abundance of natural enemies attracted should be similar. However, if there are significant differences in recruitment of some species, but not others, it would suggest that different species may respond to different fractions of the volatile profile. Given that *M. sacchari* was not yet present in the study locality, the results provide an estimate of the extent to which aphidophagous insects on the High Plains are preadapted to discover and exploit *M. sacchari* on sorghum, and whether or not we can expect to eventually obtain levels of conservation biological control similar to those currently established for greenbug on this crop.

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