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Temporal variation in the arthropod community of desert riparian habitats with varying amounts of saltcedar (*Tamarix ramosissima*)

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ABSTRACT

We used Malaise traps to examine the aerial arthropod community in riparian habitats dominated by native willow, exotic saltcedar, or a mixture of these two tree species in central Arizona, USA. Over the course of three sampling periods per year in 2003 and 2004, native habitats had significantly greater diversity (Shannon–Wiener) and supported different arthropod communities compared to exotic habitats, while mixed habitats were intermediate in terms of diversity and supported an arthropod community statistically indistinguishable from the exotic site. The composition of arthropod communities varied significantly between the two years, and there was an approximately two-fold difference in richness and diversity. Overall, we documented complex interactions indicating that differences among the arthropod communities of riparian habitats may be driven not only by the composition of native and exotic tree species making up these habitats, but also by year and season of arthropod sampling.

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1. Introduction

Invasion by non-native species into ecosystems has been ranked as the second greatest ecological threat worldwide, second only to habitat destruction, and has negatively impacted natural habitats across the globe (Levine et al., 2003; Vitousek et al., 1997). Invasion by exotic plants can reduce native plant species diversity and may also have consequences for organisms at higher trophic levels (Knops et al., 1999). However, relatively little is known about the effects of most alien plants on diversity of native insects (Samways, 2005).

Throughout the southwestern United States, many riparian areas formerly dominated by native cottonwoods (*Populus* spp.) and willows (*Salix* spp.) have transitioned to habitats dominated by exotic saltcedar (*Tamarix* spp.), now covering an estimated 500,000–650,000 ha across the American West (Zavaleta, 2000). Studies of the higher trophic level effects of saltcedar have focused primarily on vertebrates, especially birds (Brode and Bury, 1984; Cross, 1985; Ellis, 1995; Ellis et al., 1997; Hunter et al., 1988; Johnson et al., 1977; Knopf et al., 1988; Sogge et al., 2008; Szaro, 1991). However, because arthropods are an important food source for many amphibians, reptiles, mammals, and birds, the influence of saltcedar on the arthropod community could indirectly influence insectivorous vertebrates utilizing these riparian habitats. Although multiple studies have examined the arthropod communities of exotic saltcedar habitats (Cohan et al., 1978; Ellis et al.,

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2000; Liesner, 1971; Nelson and Andersen, 1999; Stevens, 1985; Wiesenborn, 2005; Yard et al., 2004), these studies have reached different conclusions suggesting that the effects of saltcedar on arthropod communities may be confounded by wide geographic separation of native and exotic habitats.

We reviewed previous studies of arthropod community responses to saltcedar to identify three hypotheses about how aerial arthropod communities in habitats dominated by saltcedar could differ from those in native willow habitats in areas where these habitats are in close proximity: (1) saltcedar habitats have arthropod communities lower in biomass and diversity compared to willow habitats (DeLoach et al., 2000; Dudley and DeLoach, 2004; Liesner, 1971; Yong and Finch, 1997); (2) saltcedar habitats support high arthropod biomass but the community is dominated by the saltcedar obligate *Opsius stactogalus*, an Old-World leafhopper co-introduced with saltcedar (Carothers and Brown, 1991; Liesner, 1971; Wiesenborn, 2005), and is not as diverse as native habitats (Stevens, 1985; Wiesenborn, 2005; Yard et al., 2004); or (3) saltcedar habitats support a community as diverse and potentially higher in biomass compared to native habitats because saltcedar's profuse and long-lasting flower and nectar resources attract "tourist" species from surrounding riparian and upland habitats (Drost et al., 2003; Nelson and Andersen, 1999).

Understanding the arthropod community associated with saltcedar habitats is made more complex because although saltcedar has formed extensive monocultures in many areas, in others saltcedar co-occurs with native willows and cottonwoods resulting in mixed habitats with both native and exotic components (Shafroth et al., 2005). Although there could be a fundamentally different response of arthropod communities to habitats with a mixture of native willow and exotic saltcedar compared to purely native and exotic habitats, few studies of arthropod abundance and diversity have considered this habitat type. In addition to the hypotheses we presented on how the arthropod communities may differ between purely native and exotic habitats, we propose two alternate hypotheses about arthropod community response in mixed habitats where saltcedar and willow intermingle compared to purely native or exotic habitats: (1) biomass and community composition are intermediate in mixed habitats compared to native and exotic dominated sites because elements of the arthropod community found in of both native and exotic habitats are present (Haddad et al., 2001); or (2) biomass and diversity are higher in mixed habitats because of the increased vegetation diversity compared to native or exotic monocultures (van Riper et al., 2008).

In this study, we examined the biomass, diversity, and community composition of aerial, diurnal arthropods inhabiting riparian habitats in a single drainage with areas dominated by native willow, exotic saltcedar, and mixed areas where these dominant riparian trees co-occurred. We focused on the aerial arthropod community because this group is potentially less tied to the dominant vegetation of a habitat and may be able to exploit different spatially and temporally abundant resources in riparian habitats, like the flowering of saltcedar (McGrath and van Riper, 2005). Although previous studies that compared arthropod communities of native willow and exotic saltcedar habitats often lumped samples across season and year, or examined seasonal or year effects without considering interactions with habitat (Cohan et al., 1978; Ellis et al., 2000; Mund-Meyerson, 1998; Wiesenborn, 2005; Yard et al., 2004), we accounted for temporal variation in the arthropod community by sampling across three seasonal periods during two consecutive years because environmental variation in primary productivity through time could also influence the arthropod community (Boag and Grant, 1984; Cody, 1981; Grant and Grant, 1987; Noy-Meir, 1973).

2. Materials and methods

2.1. Study site

We conducted this study at the Salt River inflow to Roosevelt Lake in central Arizona, USA (33°39′N, 110°58′W) during May–July in 2003 and 2004. The Salt River inflow rests in a broad floodplain ranging from 635 to 650 m in elevation, dominated primarily by approximately 200 ha of patchily distributed mosaic of riparian forest composed of Goodding's willow (*Salix gooddingii*) and saltcedar (*Tamarix ramosissima*). We classified riparian forest patches composed of >90% willow or saltcedar canopy as "native" and "exotic," respectively; and those patches with intermediate levels of willow and saltcedar canopy cover as "mixed". Patch boundaries were delimited by non-riparian vegetation or by different classification of riparian vegetation. Uplands surrounding the riparian floodplain are classified as Sonoran Desert Arizona Upland.

2.2. Arthropod sampling

Since we were interested in characterizing the aerial arthropod community, we used Malaise traps (model 2875AG, BioQuip Corporation, Gardena, CA) in contrast to previous studies that compared the arthropod communities associated with native willow and exotic saltcedar using pitfall trapping (to sample terrestrial arthropods; Ellis et al., 2000) and branch-sampling techniques (to sample arboreal arthropod; Cohan et al., 1978; Mund-Meyerson, 1998; Wiesenborn, 2005). Malaise traps effectively sample flying insects, especially Diptera, Hymenoptera, and Lepidoptera, although they may be biased against groups like Coleoptera and Homoptera that tend to fall to the ground when they encounter a barrier (Owen, 1983). We sampled the arthropod community in the largest native (7.4 ha), mixed (33.6 ha), and exotic (42.8 ha) habitat patches within the Salt River inflow with four Malaise traps during sampling periods in May, June, and July (hereafter