Factors Affecting Insect Abundance in a Southwestern Riparian Woodland

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Introduction

Many birds eat arthropods, particularly during the breeding season when adults are foraging to meet the high energy demands of growing nestlings. Hence, spatial variation in arthropod abundance may help explain spatial variation in bird density. Amount of surface water and depth to groundwater are correlated with abundance of several species of riparian-obligate birds. Water may affect arthropod abundance in riparian woodlands via its influence on productivity and forage quality of phreatophytic shrubs and trees. Moreover, foraging behavior of birds may not be evenly distributed. For example, riparian birds may concentrate their foraging on highly productive areas immediately adjacent to the stream channel. Our goal was to determine the effect of water stress experienced by trees and avian foraging pressure on the distribution of arthropods within desert riparian woodlands.

Methods

Study sites

We collected data at one "wet" site (with surface water and shallow ground water) and one "dry" site (without surface water and with deeper ground water)(Fig. 5). We collected data at a total of 24 sampling stations (9 "dry" and 15 "wet"). We selected 3 trees (2 velvet mesquite and 1 Gooding's willow) at each sampling station. We chose the closest mesquite and the closest willow to the stream channel and <50 meters from each sampling station. The 3rd tree was a mesquite approximately 20 meters from the edge of the floodplain shoulder. We selected 4 branches (of approximate equal size and structure) for sampling on each of the 3 trees. We used 1-cm^2 flexible plastic netting to construct bird exclosures for 2 of the branches on each tree. We deployed exclosures between 2-4 June 2008.

Arthropod sampling

We sampled the arboreal arthropods on each exclosed and control branch by quickly placing a plastic trash bag over the branch, clipping the branch from the tree, and spraying the contents of the bag (with the branch inside) with a general insecticide (Ortho Max; 0.0033% Esphenvalerate) to prevent escape of any motile arthropods. We then: 1) sorted the leaf biomass, stem biomass, and arthropods; 2) identified arthropods to Order and measured the length (mm) of each arthropod; 3) dried the stem and leaf samples for 3 days in a drying oven; and 4) weighed the dry biomass of stems and leaves for each branch sample.

Water stress

We measured the water stress of each tree by measuring stem water potential. We took all measurements between 15 minutes before sunrise and 2 hours after sunrise (i.e., before trees were exposed to direct sunlight and before temperatures increased by >7° C). We measured multiple stems at a subset of trees and found that the within-tree variance in water stress was low (less than or equal to +/- 1bar). Therefore, we proceeded to sample water stress from only a single branch collected from each tree due to the limited time available for sampling in the morning. We collected a second branch (and measured water stress) in a few instances where the observer questioned the accuracy of the initial sample measurement.

DATA ANALYSIS

We examined the relative effects of surface water (presence/absence) and several other factors on the total biomass of arthropods collected from branch samples. We removed two outlying values from our dataset prior to analyses. We used a paired t-test to compare mean biomass of arthropods collected from exclosed and control branches on the same tree. We used a linear mixed model to determine the relative effects of: 1) site (wet vs dry), 2) location within the riparian woodland (flood plain vs shoulder), 3) tree type (Velvet mesquite vs Gooding's willow), and 4) tree water potential (water stress) on arthropod biomass. We also investigated the effect of tree location and study site on water stress of individual plants with a linear mixed model after-controlling for tree type.

Figure 1 Arthropod biomass was more than 3 times greater on exclosed branches than paired controls. Error bars represent +/- 1 SE.

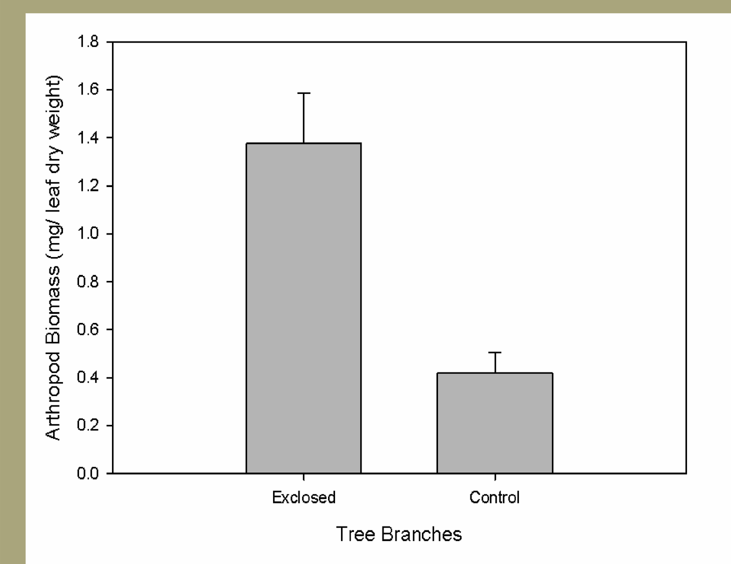


Figure 2 Arthropod biomass was higher on branch samples from trees at our wet site for all 3 tree types. Error bars represent +/- 1 SE.

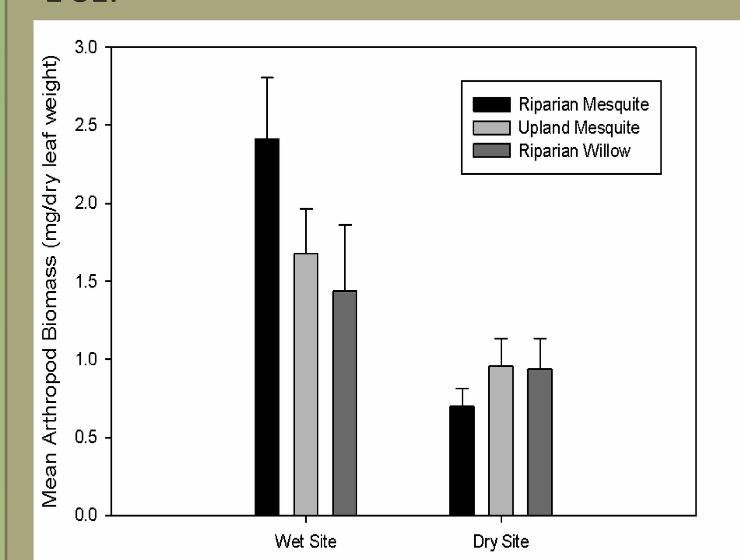


Figure 3 Water stress was lower at our "wet" site for all 3 tree types. Note that the difference was smallest for upland mesquites. Error bars represent +/- 1 SE.

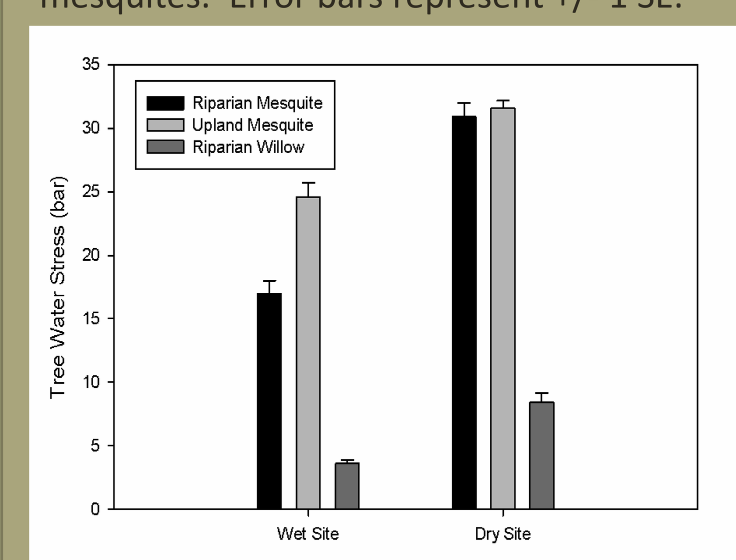
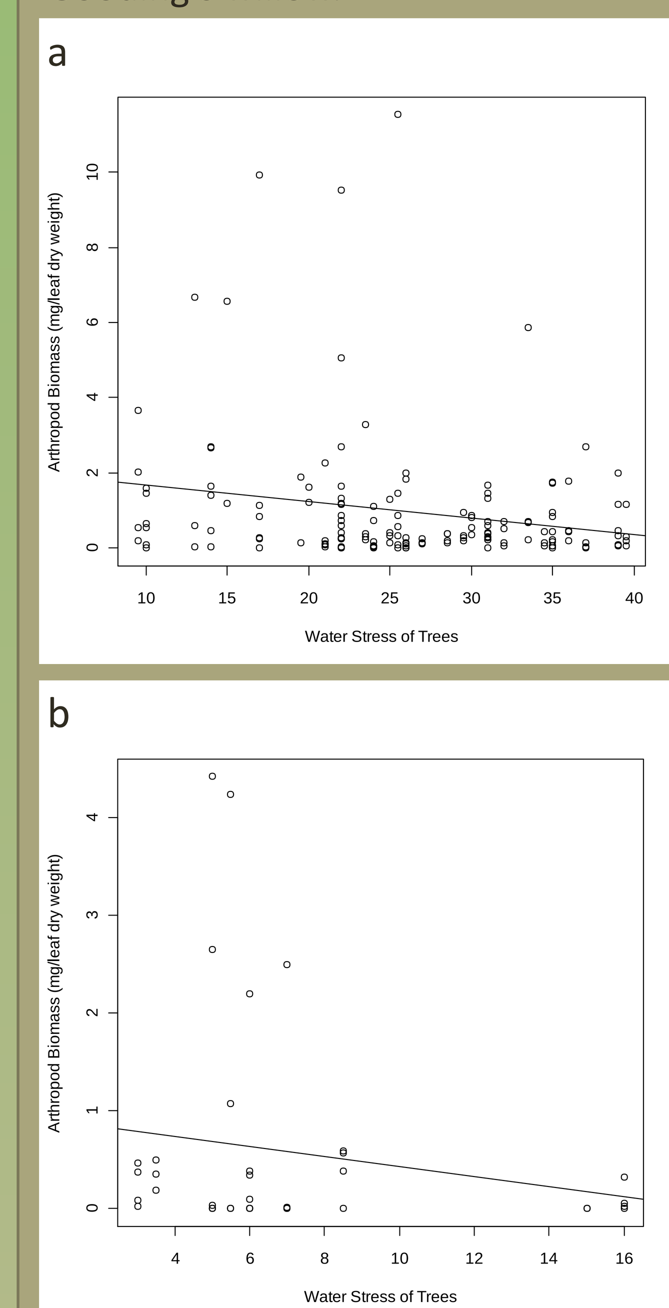
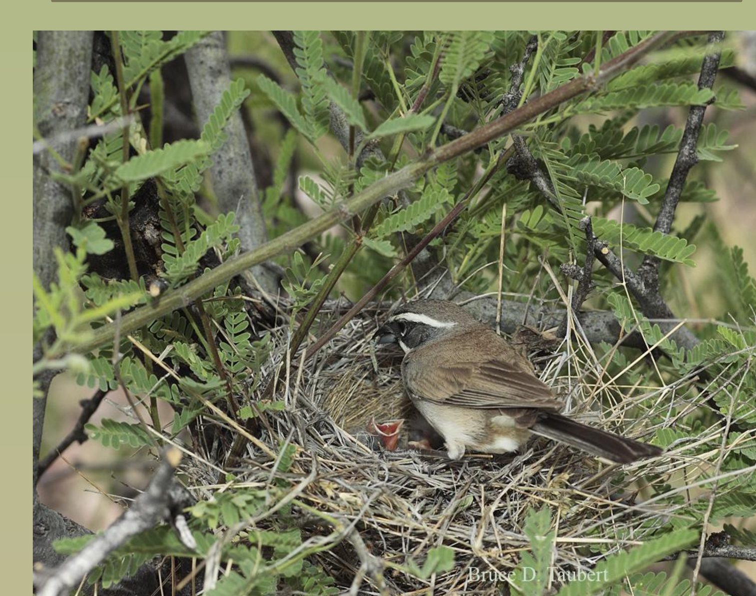


Figure 4 The amount of water stress experienced by trees was negatively correlated with arthropod biomass for both a) velvet mesquite, and b) Gooding's willow.





Results

Branches with predator exclosures had 496% more arthropod biomass than exposed branches (*t* = 3.5, *P* = 0.001) (Fig. 1). Branch samples at our "wet" site had 124% more arthropods than branch samples at our "dry" site after controlling for tree type, sample type, and proximity to the floodplain as random variables (*t*=2.7, *P*=0.004)(Fig. 2). However, this trend greatly diminished when we included a fixed variable for water stress in the model (*t*=1.1, *P*=0.142). Exposed mesquite branches collected from trees located away from the stream channel (i.e., in the upland) had 31% greater arthropod biomass (*t* = 1.4, *P* = 0.083). However, this marginal trend disappeared when we considered only branches with predator exclosures (*t* = 0.3, *P* = 0.380), indicating that the difference was likely due to increased predation pressure on arthropods in riparian woodlands along the stream channel. Arthropod biomass on exposed velvet mesquite branches was 143% greater than on exposed Gooding's willow branches (*t* = -1.8, *P* = 0.040). But again this difference disappeared when we considered only branches with predator exclosures (*t*= 1.2, *P*=0.126) suggesting that birds remove more arthropods from Gooding's willows than they do from velvet mesquites.

The amount of water stress experienced by trees differed between the wet and dry site, and was related to proximity to the floodplain. Trees at our "wet" site had lower water stress (130% lower for riparian willows and 72% lower for riparian mesquites) than those at our "dry" site (*t*=9.9, *P*<0.001)(Fig. 3). Mesquites located in the floodplain had 40% lower water stress than those in the upland (*t*=4.5, *P*<0.001) for both sites. Finally, water stress in trees was negatively associated with arboreal arthropod abundance (*t* = -1.6, *P* = 0.056).

Figure 5 Photos of our "wet" site (Cienega Creek) and our "dry" site (Posta Quemada). The sites were similar in elevation, vegetation composition and structure, and geographic location (< 4km apart).

Conclusions

Birds have a significant impact on arthropod biomass in southwest riparian woodlands. Our data demonstrate greater predation pressure on arthropods in trees along the core of the riparian corridor. We also show higher prey removal rates on willows than mesquites. Trees that are water-stressed provide less arthropod biomass for insectivorous birds. The water stress of trees differed between the wet and dry site and was influenced by proximity to the floodplain; trees in the upland had greater water stress than those in the floodplain. Decreases in available water for plants, as a result of either ground water pumping or a changing climate, has the potential to reduce arthropod abundance even if the structure or plant composition of riparian woodlands is not altered. Habitat suitability of these biologically important areas will depend on maintaining in-stream flow, shallow ground water, or both.

Thank you to Audrey Nelson who volunteered her time to make this work possible by constructing and deploying many, many exclosures in the hot Arizona summer.