Native Dragonflies as Pest-Consumers in Organic Gardens and Farms of North-Central Florida: A Preliminary Assessment

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The goal of this study was to explore the possibility that dragonflies may play positive functional roles in agroecosystems as predators on pest insects. Specific objectives included: 1) to compare species richness of dragonflies in organic farm fields and gardens, 2) to determine patterns of microhabitat use by different species of dragonflies in cropped areas, and 3) to determine prey types taken and foraging behaviors exhibited by the Eastern pondhawk (*Erythemis simplicicollis*), the most common species observed. A total of 170 observations of dragonfly individuals were made across 4 sampling locations in Alachua County, and 6 species were detected. Species richness of dragonflies was significantly greater in gardens than farm fields. Foraging heights (microhabitats) varied significantly among species, and the abundant Eastern pondhawk was most dominant at the crop level where it commonly used both ground and crop substrates for perching/hunting. Because of its abundance and foraging microhabitat preferences, we conclude that the Eastern pondhawk is most likely to have an effect on pests.

Introduction

Integration of biodiversity conservation on farmlands is a high priority for achieving sustainable food production (Thrup 2000). Greater understanding of native wild species' positive roles in food production is needed to support integration of biodiversity in farming systems (Vandermeer 1997). Because they are simplified in structure and managed for few plant species, most croplands, by nature, support a low diversity of insects with large populations. Pest insects certainly follow this pattern; their outbreaks in response to the rapid growth of crops that they feed on have been the focus of a great deal of research (Bach 1980, Bezdicek and Granatstein 1989, Gurr et al. 2003). Studies relating to the dynamics of native, locally occurring predators that may feed on pest insects, before or during outbreaks, has not been very extensive, but the research that has occurred suggests native predators may play significant roles in pest control. Native vertebrates such as birds and bats clearly feed on arthropod pests within agroecosystems (Greenberg et al. 2000, Jones et al. 2006, Wickramasinghe et al. 2004). In addition, the economic effects of their consumption of pest prey are beginning to be understood through a variety of experimental approaches. For example, insectivorous birds, by controlling agricultural pests in coffee plantations, can cause significant decreases in frequency of herbivore damage (Greenberg et al. 2000).

Although invertebrate predators have long been considered important parts of biological control and Integrated Pest management (IPM) programs, more attention has been paid to introducing exotic, specialized predators into agroecosystems on an "as needed" basis than has been directed at fostering diverse native invertebrate predators (Elliot et al. 1996, Linteren et al. 2006). Given the hazards of introducing exotic species, there is a need to fully ascertain the potential pest control of native predators in agroecosystems. Even though they are widely recognized for their predatory habits, little attention has been paid to species of the dragonfly families (Smith and Capinera 2005) regarding their potential impact on pests. In a study occurring throughout Thailand, the Philippines, and Hong Kong, dragonflies were found to feed on common pests in rice fields; gleaning prey from the leaves of rice plants and consuming large numbers of stem borers (Cambidae) and leaf hoppers (Jassidae) (Corbet 1999). While the impacts on plant growth arising from dragonfly predation on pests has not been assessed, current evidence suggests that consumption of pests by dragonflies is significant and should be assessed as sustainable (biodiversity-friendly) agricultural practices are developed. In this study, we sought evidence that dragonflies may play important positive functional roles as pest predators in gardens and vegetable farms of North-Central Florida.

Study Design and Methods

Specific objectives of this study were: 1) To determine species richness of dragonflies in organic farms and gardens in Alachua County, Florida, and determine if species richness differs between small gardens (< 1 ha in area) and organic farm fields (> 1 ha in size); 2) To determine the

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partitioning patterns of microhabitats by the different species of dragonflies in cropped areas, i.e., airspace and perching substrates; 3) To determine what kinds of prey and foraging behaviors were most often used by the Eastern pondhawk, the most common species observed foraging at the crop level.

We used descriptive and comparative methods to achieve stated goals, observing dragonflies on two organic gardens on the UF campus and on two small organic vegetable farms in Alachua County, during the summer of 2007. We made repeated visits to the study sites between 1200-1700 hours during 4 June 2007–9 August 2007. Within the cropped areas at each site, 182 focal observations were conducted at arrays of 4-6 sampling points. For each site visit, a minimum of 10 to 30 minutes per sampling point was spent observing activity. Observations occurred in a circle of radius 4 m around the observer, generally. For each site, date, time, cloud cover, temperature, and wind speed were recorded. For each sample point, initiation time and duration were recorded. Lastly, for each observation we recorded species, sex, perch height, perch type, and behavior. When necessary, binoculars were used to identify species inside and outside the sample points. The species observed in this study are all classified as perch-hunters, which enhanced identification and ease of observation since individuals remained on or near single perches throughout observation sessions.

Objective 1) Determinations of species richness (total number of species observed in crops) were made by tabulating all species seen in or out of sample circles over the course of all visits to each site. Then we calculated the mean number of species detected for farms and for gardens and compared the total species richness between the two types of sites using a Kruskal-Wallis test.

Objective 2) Each time an animal was observed, the substrate type (ground, on crop plants, posts, edge of crops, or in flight) and height of the perch was recorded. To determine whether different species used different microhabitats, we compared heights of the different species using a 1-way ANOVA and post multiple comparisons tests.

Objective 3) The Eastern pondhawk was the numerically dominant species in the fields, so we focused foraging observations on this species. We calculated summary statistics and present the dominant foraging substrates used by this species in pie diagrams.

Results

Objective 1) A total of 170 observations of dragonfly individuals were made across all 4 locations and 6 species were detected (Fig. 1). Species richness of dragonflies was significantly greater in gardens than farm fields (K-W Chi-square = 19.4, DF = 1, P < 0.001); gardens had a mean of 2.2 species (SD = 1.1, N = 36) and farm fields had a mean of 0.63 species (SD = 0.07, N = 16; Fig. 2).

Objective 2) Foraging heights (or, microhabitats) varied significantly among the 6 species (ANOVA; F = 45.9, P < 0.001, DF = 5; See Fig. 3). Multiple comparisons among the mean perch heights of the different species indicated the following important results (statistical significance at 0.05); Eastern pondhawks foraged significantly lower than 3 species (FSPE, GWSK, and ROSK; see letters in Figure 3). The Four-spotted pennant foraged significantly higher than all 5 other species.

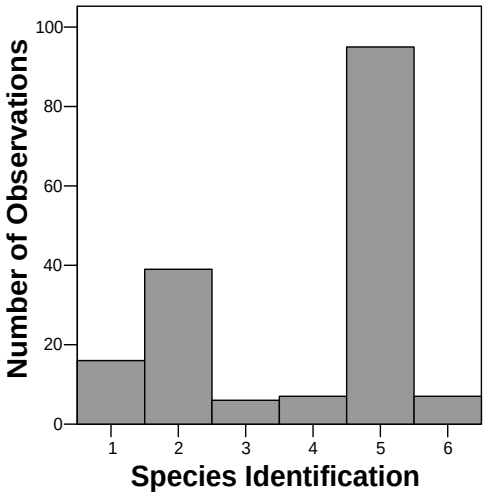

Figure 1: *Total number of dragonflies of 6 different species observed on farms and gardens during the study. Species ID: 1-Golden-Winged Skimmer (GWSK); 2-Roseate Skimmer (ROSK); 3-Eastern Amberwing (EAMB); 4-Blue Dasher (BLDA); 5-Eastern Pondhawk (EPON); 6-Four-Spotted Pennant (FSPE).*

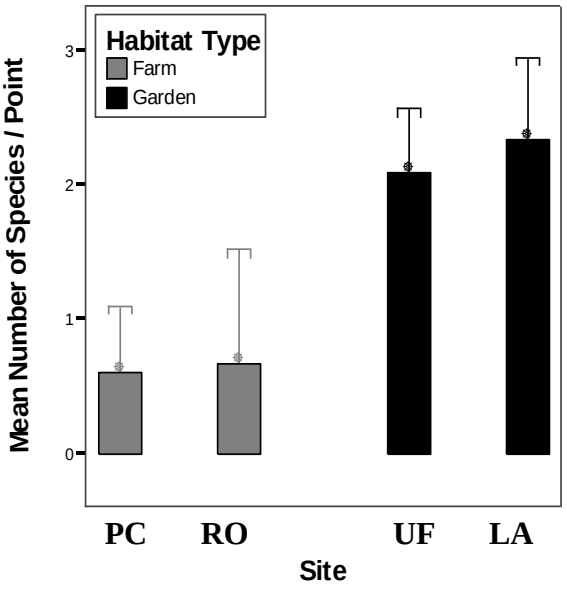

Figure 2: *Mean number of species detected on gardens versus farm fields over the course of the study. Site ID: PC = Pat Carlisle (farm); RO = Rosie's Organics (farm); UF = UF Organic Gardens (garden) and LA=Lake Alice Student Gardens. Error bars represent one SE.*

Objective 3) The Eastern pondhawk was most dominant at the crop level. The ground and crop were the most common perch types exhibited by the Eastern pondhawk (see Fig. 4). Feeding by the pondhawk was witnessed twice but no identification of prey could be made. Both prey items were captured on the wing and brought back to a perch to consume.

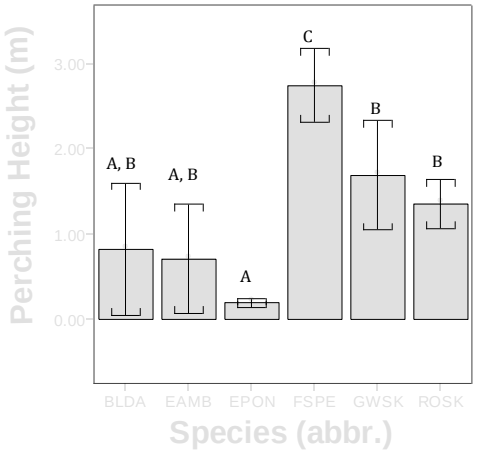

Figure 3: *Mean perching and foraging heights of individuals of the study species in farms and gardens. See Fig. 1 legend for key to species abbreviations. Letters above bars signify significant differences between mean perching heights (bars with the same letters are not significantly different from each other). Error bars represent one SE.*

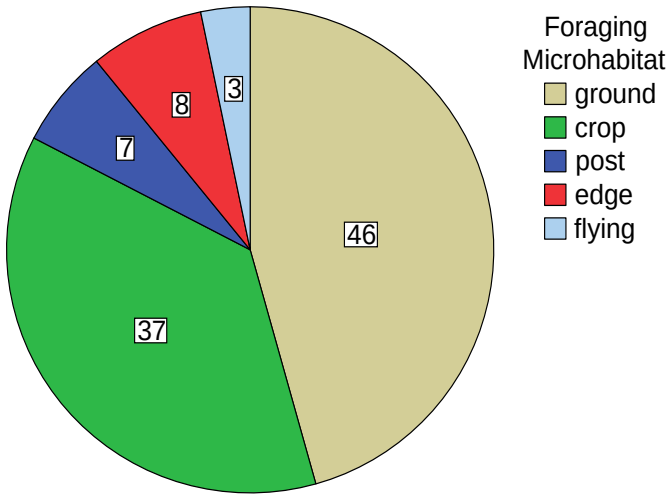

Figure 4*: Perch types exhibited by the Eastern pondhawk. Numbers indicate the number of observations of individuals using each perch type.*

Discussion

Pest control potential of dragonflies. We determined what species of dragonflies are likely to be common on agro-ecosystems in North-central Florida. Of the 6 species detected, only 2 appeared abundant enough to potentially play significant functional roles on farms; Eastern pondhawk and Roseate skimmer. Of those 2, the Eastern pondhawk was particularly abundant, and we would recommend future research of this kind be focused on that species. Because the Eastern pondhawk nearly always foraged at the crop level, or close to the ground, they are the most likely to have an effect on pests. Among other predatory insects known to operate at the crop level, certain non-web building species of spiders have been noted for their potential to participate in pest control. For example, spiders are known to narrow their feeding niche significantly when a suitable prey species reaches high numbers relative to other prey groups (Nyffeler et al. 1994). This trait is also thought to be exhibited by most dragonfly species; though they are highly opportunistic foragers, they are able to become temporary specialists in response to high availability of one kind of prey (Corbet 1999). Therefore, Eastern pondhawks have a high likelihood of function as pest-controllers in the small cropped areas we studied, when outbreaks of characteristic invertebrate pests occur. As we observed in this study, dragonfly territories and hunting perches are occupied with great consistency throughout the growing season, suggesting that if the prey changed, the dragonflies must change their prey preferences to take advantage of incident prey. Temporary specialization offers the benefit of reducing time devoted to searching and recognition. Therefore, it is quite possible that dragonflies, as generalized predators, may moderate fluctuations of prey populations if, as is likely, they respond to prey in a density-dependent way with shifting search images that are frequency-dependent (Corbet 1999). Though more research is needed, we propose the hypothesis that dragonflies could help contain or prevent pest outbreaks, thus achieving a central aim of integrated pest management.

Although we were not able to effectively identify prey species in the field, it is clear that dragonflies forage in cropped fields and may be foraging on pests. To properly identify prey, future studies should include dragonfly capture and dissection of the gut contents and identification of prey using microscopes. As a first assessment of pest-eating potential of dragonflies in agroecosystems, this study strongly suggests that taking the next steps to begin identifying prey taken and measuring impacts of prey consumption on crops would be a fruitful line of study.

Fostering dragonflies and other forms of biodiversity on farms. The diversity of predatory insects within crop fields is significantly related to vegetative diversity whether from adjacent non-crop habitats or a greater diversity of crop plants (Dennis et al. 1992, Kajak 2007). Fur-

thermore, increasing vegetative diversity is found to sustain populations of other beneficial animals such as birds, spiders, and even wild pollinating species in agroecosystems (Asteraki et al. 2004, Benjamin et al. 2008, Thomas et al. 1991, Winfree et al. 2008). This study confirms previous work; we found dragonfly diversity to be significantly greater in gardens and, in general, the gardens had a greater diversity of crop plants, and more non-crop habitats than farms. Identifying specific habitat requirements for beneficial invertebrates that are locally occurring could help support integration of biodiversity in management of agricultural landscapes. Further research is needed to refine such strategies across scales and systems for the future of sustainable food production.

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