Spider predators of lepidopteran eggs in south Texas field crops

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Abstract

Observations were made of spiders attacking lepidopteran eggs in south Texas field crops (cotton, corn, and soybean) from 2001 to 2004. Twelve species of spider from seven families were observed feeding on the eggs during the 4 years. These spiders were primarily cursorial hunting spiders, and they were observed feeding on eggs most frequently in cotton, representing 26.6% of all observations in cotton over the 4 years. Spider predation on eggs was proportionally less frequent in corn and soybean with 6.3% and 15.4% of observed predation in those crops, respectively. Four species of spider were responsible for 86.1% of the predation by spiders. The anyphaenid Hibana futilis (Banks) was the spider most frequently observed feeding on lepidopteran eggs during the 4 years of this study, constituting 45.1% of all spiders observed. Grammonota texana Banks (Linyphiidae), Hibana arunda Platnick (Anyphaenidae), and Cheiracanthium inclusum (Hentz) (Miturgidae) were the 2nd, 3rd, and 4th most frequently observed spiders constituting 15.6%, 12.8%, and 11.7% of all spiders observed, respectively. Most spiders represented taxa that are known to forage without a web. However, G. texana was observed feeding on eggs independent of a web, which is uncharacteristic of linyphiids. Other cursorial hunting spiders feeding on eggs included members of the Clubionidae, Corrinnidae, and Salticidae. Ninety-eight percent of all observations of egg predation by spiders were nocturnal; only the Salticidae were diurnal. It is likely that previous studies of predation in crops have vastly underestimated the importance of spiders as predators of lepidopteran eggs due to inadequate evaluation of nocturnal predation.

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1. Introduction

Spiders have been reported to feed on lepidopteran eggs in the field (review by Nyffeler et al., 1990; Ruberson and Greenstone, 1998; Pfannenstiel and Yeargan, 2002); however, in many cases these reports were anecdotal, and, with the exception of the more recent studies, there was little reason to suspect that spiders might be important predators of the egg stage of lepidopteran pests in agricultural settings.

Despite the frequency of anecdotal observations, there are few data on the propensity for most spiders to accept eggs as prey, or quantifying egg predation by spiders in either natural or agricultural settings. Sessile pests such as scale insects and sessile life stages such as eggs are believed to be less vulnerable to predation by spiders than motile stages. Recently, however, evidence has been accumulating that certain spider taxa may frequently prey on lepidopteran eggs. Studies in cotton using radioactive markers (McDaniel and Sterling, 1979, 1982) indicated that spiders may have been feeding on eggs. Nevertheless, these data were not definitive because the markers could have been acquired through intraguild predation. Using a more definitive antibody-based technique, Ruberson and Greenstone (1998) found that the winter spider Cheiracanthium inclusum (Hentz) (Miturgidae) was a frequent predator of eggs. C. inclusum has also been reported feeding on eggs in cotton (McDaniel and Sterling, 1982) and in apple orchards (Miliczky and Calkins, 2002). The clubionid Clubiona abbotti Gertsch has been observed feeding on eggs relatively commonly in soybean and corn (Pfannenstiel and Yeargan, 2002).
Lepidopteran pests of field crops are subject to significant mortality from predation and often do not attain pest status unless the natural enemy complex is reduced through the application of pesticides. Unfortunately, there have been few studies to document predation on eggs in the field that specifically addressed nocturnal events [with the exception of Pfannenstiel and Yeargan, 2002; Pfannenstiel, 2005]. Also, many previous studies on egg predation in the field may suffer from bias due to unequal sampling of predator groups or potential contamination due to intraguild predation on other predators that might contain prey markers, particularly in studies using radioactive labeling of eggs. When nocturnal predation has been characterized, invariably there are taxa identified that were not recognized as contributing significantly to mortality (Pfannenstiel, 2005). The contribution of spiders, which are predominantly nocturnal, may be underrepresented in many studies due to their cryptic activity patterns and therefore may play a greater role here than previously recognized. In south Texas, spiders were the most frequently observed predators of lepidopteran eggs in cotton (Pfannenstiel, 2004, 2005).

To address the gaps in our knowledge of the predators causing mortality of lepidopteran eggs in south Texas field crops, I conducted several studies in the Lower Rio Grande Valley of Texas from 2001 to 2004 to evaluate egg predation on two common lepidopteran pests. Spiders committed an unexpectedly large percentage of the predation events that were observed. This report summarizes the observations of spiders feeding on lepidopteran eggs found in cotton, corn, and soybean.

2. Materials and methods

This report summarizes data on spider predation on eggs of Helicoverpa zea (Boddie) and Spodoptera exigua Hübner (both Lepidoptera: Noctuidae) from several studies using similar techniques to address the effects of crop type, egg type, and crop diversity on predation rates and predator complexes in south Texas. Cotton, corn, and soybean plots or fields were established using commonly accepted production practices with 1-m row spacing. Most plantings were watered with drip irrigation; however, some cotton plots were flood-irrigated in 2003. Crops were planted between 15 February and the 30 March in each year. Only one pesticide application was made during the 4 years of study, comprising a single application of Lannate (methomyl) in the very early spring of 2002 against a severe thrips infestation in seedling cotton. Predation was not evaluated in this plot until 47 days post-treatment. A 3-m buffer of bare ground separated all plots.

Deployment of eggs and observation techniques were as described by Pfannenstiel and Yeargan (2002) and slightly modified in Pfannenstiel (2004). In studies conducted only in cotton, sentinel egg masses (S. exigua) or egg groups (H. zea, 10 eggs per sheet—described below) were placed in the field and then monitored at 3-h intervals for the next 24 h. In studies involving cotton, corn, and soybean plots only sentinel H. zea eggs were used. H. zea and S. exigua colonies were maintained in the laboratory by modified methods of Ignoffo (1965). Adults were placed in 3.8 L ice cream cartons lined with green florist paper for oviposition; a 10% sucrose solution was provided as a food source. Florist paper on which eggs had been deposited were collected daily; paper on which eggs had been laid was cut into small (3–20 cm²) sections (“egg sheets”) containing either 10 H. zea eggs or one S. exigua egg mass each. Egg groups or masses were then placed in a refrigerator at 4 °C to stop development until used or discarded after 4 d. Groups of 10 H. zea eggs (as opposed to 1 egg) were used to extend the amount of time that a predator feeds, thus increasing the probability of observing predation events. All eggs in each S. exigua egg mass (range 20 to ~160 eggs/mass) were counted and recorded before placement into the cotton field.

Eggs were transported to the field in an ice chest with cold packs and then attached to plants at 1500 h by stapling the egg sheets in the upper canopy. Afternoon was used for deployment of eggs for purely logistical purposes. H. zea eggs typically take 2.5 or more days to develop in the field in Texas and would be available to predators throughout this time (personal observation). Paper sections containing eggs were not used if any of the eggs were dislodged during transportation. In cotton and soybean, egg sheets were attached in the upper part of the canopy at about 50–80% of plant height and this relative location was maintained as the plants developed. In corn, the egg sheet was attached to one of the small leaves (husk terminals) directly adjacent to the silks on the primary ear of a corn plant or if in pre-reproductive corn at the base of a true leaf. Lepidopteran pests of field crops such as cotton often deposit their eggs on the foliage of the middle to upper parts of the plant (Terry et al., 1987; Sappington et al., 2001) although often on the undersides of leaves. Placing the eggs on the top of leaves was done to facilitate observation. Neussly and Sterling (1994) found no differences in predation on H. zea eggs between the upper and lower leaf surfaces in cotton in central Texas, and this pattern was corroborated in this study (unpublished data).

Egg groups were observed at consecutive 3-h intervals from 1800 h onward CDT for the following 24 h. This distribution of sampling times results in 4 daytime samples (0900, 1200, 1500, and 1800 h) and 4 nighttime samples (2100, 2400, 0300, and 0600 h). Sunrise occurred just as the 0600 h sample was being completed, and sunset occurred just prior to initiation of the 2100 h sample, allowing for equal numbers of day and night samples despite a photophase of about 14 h. Individual egg sheets were replaced whenever all eggs on a sheet had been consumed. All spiders observed feeding were collected and reared to adulthood in the laboratory on a diet of H. zea eggs to facilitate identification. Adult spiders that could not be identified by the author were sent to an expert on Texas spiders for identification (Allen Dean, Texas A&M University).
Overnight trials were conducted on 8–12 dates between the months of April and August in each year from 2001 to 2004. A total of 200–350 sites with sentinel eggs were observed on any one date. Because the data summarized here comes from several studies, the distribution of data varies. Cotton was included in all of the studies that were used to collect the data presented here. Corn and soybean were included in half of the studies and these were conducted over a shorter time frame due to their shorter growing season.

Observations of spider predation on lepidopteran eggs in south Texas are summarized here with the primary goal of characterizing the egg-feeding spider community. Additionally, I compared the frequency of spider predation in cotton, soybean, and corn, the frequency of spider predation on *H. zea* and *S. exigua* eggs in cotton, and characterized the diel periodicity of spider predation by species or other suitable taxa. To determine if there was an effect of year on observations of predation by crop or by egg type, statistical comparisons on observations of predation by year for these data were conducted using the \( G \) test of Independence (Sokal and Rohlf, 1994) when the sample size was sufficient. If the analysis showed no significant effect of year, or if there was insufficient sample size to test for a year effect, then the data from all years was pooled and the main effects (crop) tested with the \( G \) test for Goodness of Fit (McDonald, 2007–2008). All pair-wise tests of differences among cotton and soybean and in predation on the two egg types were analyzed using the Exact Binomial Goodness of Fit Test (McDonald, 2007–2008) against the \( a \ priori \) hypothesis that no differences in spider observations would exist between either crop or egg type. It should be noted that this test provides a \( P \) value but no explicit test statistic.

### 3. Results

Out of 1565 total observations of predation, 23.4% was committed by spiders. A total of 366 spiders were observed feeding on eggs over the 4 years (77, 123, 83, and 83 in 2001–2004, respectively) Many other arthropods were also feeding on eggs over the 4 years (77, 123, 83, and 83 in 2001–2004, respectively) Many other arthropods were also feeding on eggs over the 4 years (77, 123, 83, and 83 in 2001–2004, respectively) Many other arthropods were also feeding on eggs over the 4 years (77, 123, 83, and 83 in 2001–2004, respectively) Many other arthropods were also feeding on eggs over the 4 years (77, 123, 83, and 83 in 2001–2004, respectively).

### Table 1

<table>
<thead>
<tr>
<th>Spider</th>
<th>Frequency observed</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anyphaenidae</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Hibana futilis</em> (Banks)</td>
<td>165</td>
<td>45.1</td>
</tr>
<tr>
<td><em>Hibana arunda</em> Platnick</td>
<td>47</td>
<td>12.8</td>
</tr>
<tr>
<td>Lyniphidae</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Grammomona texana</em> (Banks)</td>
<td>57</td>
<td>15.6</td>
</tr>
<tr>
<td>Miturgidae</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Cheiracanthium inclusum</em> (Hentz)</td>
<td>43</td>
<td>11.7</td>
</tr>
<tr>
<td>Clubionidae</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Clubiona kiowa</em> Gertsch</td>
<td>11</td>
<td>3.0</td>
</tr>
<tr>
<td><em>Clubiona maritima</em> L. Koch</td>
<td>3</td>
<td>0.8</td>
</tr>
<tr>
<td>Salticidae</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Hentzia palmarum</em> (Hentz)</td>
<td>4</td>
<td>1.1</td>
</tr>
<tr>
<td>Others/unidentified</td>
<td>5</td>
<td>1.4</td>
</tr>
<tr>
<td>Dictynidae</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Phantyna segregata</em> (Gertsch &amp; Mulaik)</td>
<td>3</td>
<td>0.8</td>
</tr>
<tr>
<td><em>Dictyna bellans</em> Chamberlin</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td><em>Emblyna</em> sp.</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>Corinnidae</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Meriola decepta</em> Banks</td>
<td>4</td>
<td>1.1</td>
</tr>
<tr>
<td><em>Trachelus volutus</em> Gertsch</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>Unidentified/Escaped/Died</td>
<td>19</td>
<td>5.2</td>
</tr>
<tr>
<td>Total</td>
<td>366</td>
<td></td>
</tr>
</tbody>
</table>

Observations are pooled from all crops.

Of the egg predation events observed, 26.6% in cotton, 15.4% in soybean, and 6.3% in corn were by spiders. When considering only those studies where the frequency of observed predation events can be directly compared among the crops, there were twice as many observations of spiders preying on eggs in cotton than in corn or soybean which is significant at the \( \alpha = 0.1 \) level (\( G = 5.08; df = 2; P = 0.079 \)) (Fig. 1a). When spider predation in cotton is compared to just soybean over its longer growing season (than corn), there was no effect of year on the pattern of predation (\( G = 0.926, df = 3, P = 0.819 \)), however the difference in observations by crop were more significant (\( P < 0.0001 \)) (Fig. 1b). The association of observations of the four most frequently observed spiders with cotton and soybean is consistently biased towards cotton although there were only large enough sample sizes to analyze *Hibana futilis* and *G. texana* (Fig. 2).

The cursorial hunting spider *H. futilis* (Banks) (Anyphaenidae) was the spider most frequently observed preying upon eggs in three of the 4 years (2001–2003) and the second most common in 2004, constituting 45.1% of all spiders observed feeding on eggs (Table 1, Fig. 3). *Hibana arunda* Platnick was the second most frequently observed in 2001 and 2002 and was the third most frequently
observed spider overall (12.8% of all observations). However, neither Hibana species has been previously mentioned in the literature as a predator of insect eggs.

Grammonota texana (Linyphiidae) was the second most frequently observed spider feeding on eggs. However, this spider had been rare in 2001 and 2002, accounting for less than 1% of observations before becoming the most frequently observed spider in 2004 (Fig. 3). Whereas most species of Linyphiidae typically forage using webs (Kaston, 1972), none of the observations of G. texana feeding were in association with a web. In laboratory containers, G. texana did construct a rudimentary space web, but it is not known what proportion of time it allocates to active foraging vs. foraging with a web.

Another wandering spider, C. inclusum (Miturgidae), was the fourth most common spider observed feeding on eggs overall and the second most frequently observed in 2003 (Fig. 3). C. inclusum is widely distributed in North America and has been implicated as a potentially important predator of lepidopteran eggs in other studies of egg predation in cotton (McDaniel and Sterling, 1982; Ruberson and Greenstone, 1998) and apples (Miliczky and Calkins, 2002). Several of the other spider taxa observed feeding on eggs have natural histories similar to the anyphaenids including the Clubionidae and the Corinnidae. Clubiona kiowa Gertsch was observed feeding on eggs in all years.

Almost all observations of feeding by spiders were nocturnal (Fig. 4). Only the Salticidae were day-active with all nine individuals observed feeding on eggs between noon and sunset. Of the nocturnally active spiders, H. futilis, H. arunda, and C. inclusum were active primarily from 2100 h to 0300 h while the activity of G. texana increased later in the scotophase peaking from 0300 to 0600 h (Fig. 4).

In a study conducted in cotton alone, I compared predation on H. zea and S. exigua eggs. Only the sum of total observations of spiders preying on each egg type had consistently enough samples sizes to test for an effect of year; and no significant effect of year was found (G = 3.70, df = 3, P = 0.296). Therefore, observations of predation for each spider species were pooled across the 4-year observation period for further analysis. Of the individual spider species, only H. futilis and G. texana had sample sizes large
enough to test even when pooled; in both of these species there were significantly more observations of predation on *H. zea* than on *S. exigua* eggs (Fig. 5). *H. arunda* was not observed feeding often enough in this study to evaluate predation, however in this case feeding on the two egg types was equal. Similarly, there were not enough observations of *C. inclusum* to analyze statistically, however this was the one species observed feeding on *S. exigua* more frequently than on *H. zea* in this study.

4. Discussion

Most observations of spiders feeding on eggs have been anecdotal, the results of studies using indirect methods, or made under laboratory no-choice conditions. Laboratory studies using no-choice tests on egg feeding by spiders, such as those conducted by Miliczky and Calkins (2002), and Pearce et al. (2004), suggest potential efficacy, but field studies are necessary to ensure that feeding observations are not artifacts of confinement. These are the first detailed field studies to document that spiders may act as important predators of the egg stage of lepidopteran pests. In the case of cotton, the spiders were particularly important and comprised 26.6% of all observations of egg predation during the 4 years. Little is known about the ecology or behavior of most of the spiders observed feeding on eggs during this study. Three of the most frequently observed species (*H. futilis*, *H. arunda*, and *G. texana*) have no references outside of the taxonomic literature and checklists of occurrence in different localities. However, there is building evidence that *Hibana* species may be important predators in agricultural systems. Recently, *H. velox* has been reported as an important predator in Florida citrus (Amalin et al., 2001), and *H. incursa* has been recently implicated as a predator in pecans and cotton in New Mexico (Richman, 2003). The only spider commonly observed in south Texas that has been previously studied is *C. inclusum*. This species has been implicated as a predator of lepidopteran eggs in cotton (McDaniel and Sterling, 1982; Ruberson and Greenstone,
Egg type did significantly affect the likelihood of observing predation with approximately twice as many observations of predation by *H. futilis* and *G. texana* on *H. zea* as on *S. exigua* eggs. This was unexpected because there was some thought that predation would be more easily observed on the larger *S. exigua* egg masses. Both of these species are relatively smaller than *H. arunda* and *C. inclusum* and would be less likely to consume all of the eggs in a short time, particularly in a *S. exigua* egg mass. It is possible that the *S. exigua* eggs are less palatable; in a laboratory study, *H. futilis* developed more slowly, had lower survival rates and lower fecundity when reared on *S. exigua* eggs in comparison to *H. zea* eggs (unpublished data). Information on the ecology and biology of many of these species is sorely lacking, we know virtually nothing of their prey range.

It is likely that the cursorial spiders are an important source of mortality for numerous pests in field crops such as cotton, and possibly in many other crop systems as well. During the period when these studies were conducted, egg mortality (24 h) ranged from 25% to near 100% and spiders were among the most important predators in all three crops (Pfannenstiel, 2005). Although this study has focused on the predation of lepidopteran eggs, spiders preyed on other pests including various lepidopteran larvae and the cotton fleahopper, *Pseudomatoscelis seriatus* (Reuter) (Hemiptera: Miridae). These spiders are very active searchers and can cover large areas of crop canopy while foraging (personal observation). Additionally, several of these wandering spiders can consume many eggs on a daily basis (>200 *H. zea* eggs/day for adult female *H. arunda*, *H. futilis*, and *C. inclusum* [unpublished data]) suggesting that they could not only consume many single eggs (e.g., *H. zea*) but also entire egg masses of those lepidopteran that deposit their eggs in large masses (e.g., *S. exigua*, *Choristoneura rosaceana* [Tortricidae] etc.).

In summary, a guild of cursorial hunting spiders were commonly observed feeding on lepidopteran eggs in three field crops in south Texas, although to a greater degree in cotton than in corn or soybeans. The anyphaenid *H. futilis* dominated the guild in most years (3 of 4), but three other species in the families Anyphaenidae (*H. arunda*), Linyphiidae (*G. texana*) and Miturgidae (*C. inclusum*) were frequently observed in one or more years. Absent careful nocturnal observations, most of these spiders pass unrecognized as important biological control agents of lepidopteran pests, much less predators of lepidopteran eggs. Quantification of nocturnal predation and the predators responsible, including the cursorial hunting spiders, is warranted in all agricultural systems to improve our understanding of the natural enemies responsible for the natural control of crop pests.

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References


