Development of the Cursorial Spider, *Cheiracanthium inclusum* (Araneae: Miturgidae), on Eggs of *Helicoverpa zea* (Lepidoptera: Noctuidae)

R. S. Pfannenstiel

Beneficial Insects Research Unit, USDA-ARS, Weslaco, Texas 78596 USA

Abstract

Development of the cursorial spider, *Cheiracanthium inclusum* (Hentz) (Araneae: Miturgidae), from emergence to maturity on a diet of eggs of the lepidopteran pest *Helicoverpa zea* (Boddie) (Lepidoptera: Noctuidae) was characterized. *Cheiracanthium inclusum* developed to adulthood with no mortality while feeding on a diet solely of *H. zea* eggs and water. The number of instars to adulthood varied from 4-5 for males and from 4-6 for females, although most males (84.6%) and females (66.7%) required 5 instars. Males and females took a similar time to become adults (54.2 ± 4.0 and 53.9 ± 2.0 days, respectively). Egg consumption was similar between males and females for the first 4 instars, but differed for the 5th instar and for the total number of eggs consumed to reach adulthood (651.0 ± 40.3 and 866.5 ± 51.4 eggs for males and females, respectively). Individual consumption rates suggest the potential for high impact of *C. inclusum* individuals on pest populations. Development was faster and survival greater than in previous studies of *C. inclusum* development.

Key Words

spider development, egg predation

Spiders have been observed feeding on lepidopteran eggs in several crops (reviewed by Nyffeler et al. 1990), but only recently has the frequency of these observations (Pfannenstiel and Yeargan 2002, Pfannenstiel 2005, 2008) suggested that lepidopteran eggs may be a common prey item for some families of cursorial spiders. One of these spiders, *Cheiracanthium inclusum* (Hentz) (Araneae: Miturgidae), has been observed in many crops feeding on lepidopteran eggs, primarily *Helicoverpa zea* (Boddie) (Lepidoptera: Noctuidae) (Nyffeler et al. 1990, Ruberson and Greenstone 1998, Pfannenstiel 2005, 2008). Peck and Whitcomb (1970) determined the basic biology of *C. inclusum* in the laboratory, for which they recorded development times and 34% survival on a diet of *Drosophila melanogaster* Meigen (Diptera: Drosophilidae) adults supplemented with a variety of prey. Studies of *C. inclusum* feeding on an exclusive diet of citrus leafminers [*Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae)] demonstrated shorter development times than Peck and Whitcomb (1970) (Amalin et al. 2001). The objective of this study was to determine if *C. inclusum* could develop through adulthood on a diet of only *H. zea* eggs.

1Received 10 December 2007; accepted for publication 18 February 2008.
2Address inquiries (email: Bob.Pfannenstiel@ars.usda.gov).
Materials and Methods

Spiderlings were obtained from 4 *C. inclusum* females collected from a cotton field at the research farm of the USDA laboratory in Weslaco, TX. Field-collected females were placed in a 150 x 25 mm plastic Petri dish with a moistened dental wick and fed *H. zea* eggs ad libitum. Soon after collection these females laid egg masses that were monitored for spiderling emergence. Spiderlings that were freshly emerged from the egg cell were placed individually within a 50 x 9 mm plastic Petri dish with *H. zea* eggs and a moistened dental wick. Emerging spiderlings were considered first instars as compared with the work of Peck and Whitcomb (1970) where these would be considered 2nd instars because of a stage spent inside the egg sac. All comparisons between these data and data from Peck and Whitcomb (1970) have been corrected for this difference. Petri dishes containing spiderlings were placed in an environmental chamber at 25 ± 1°C and 14:10 photoperiod (L:D) for monitoring of spider development. All spiders were checked daily for molting and to ensure an adequate supply of eggs.

Spiders were fed *H. zea* eggs that were collected from a laboratory colony reared by the modified methods of Ignoffo (1965) and freshly frozen at -4°C. Eggs used for feeding were always less than 1 month old. Excess eggs were placed in each dish to ensure that spiders were not food limited. Eggs were counted before placement in the dish and the number consumed determined 3 times per week for the first 3 instars. Eggs were provided and egg consumption determined daily for 4th and later instars to maintain an ad libitum feeding status. Upon reaching the 5th instar, spiders were transferred to 150 x 25 mm Petri dishes to allow placement of more eggs inside the dish. The dental wick was also moistened 3 times per week.

Data collected included survival to maturity, the number of instars needed to complete development, instar-specific development times, and the number of eggs consumed during each instar. Comparisons of development and egg consumption by males and females were conducted using t-tests adjusted as necessary for unequal variances by using Satterthwaite’s procedure. The data analysis used for this paper was generated using SAS software, version 9.1 of the SAS System for Windows; Copyright © 2002-2003, SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA.

Results and Discussion

*Helicoverpa zea* eggs were suitable for development of *C. inclusum*; all spiderlings in this study (*n = 28*) developed to adulthood. No more than 38% of *C. inclusum* matured on a diet of the citrus leafminer (Amalin et al. 2001). Survival on a diet of *D. melanogaster* adults was significantly lower at about 5%. Peck and Whitcomb (1970), likewise, also commented on low rates of survival obtaining an average of 32% surviving to maturity. Spider development on eggs has been studied on only one other occasion where a clubionid *Clubiona abbotii* (Araneae: Clubionidae), was reported to develop to maturity on a diet of *H. zea* eggs (Dixon 1997). However, survival was not reported in that study. One study of development of a spider on lepidopteran larvae reported survival of 87% for the related species *Cheiracanthium mildei* L. Koch (Araneae: Miturgidae) feeding on a diet of *Spodoptera littoralis* (Boisduval) larvae (Lepidoptera: Noctuidae) alone (Mansour et al. 1980).
Development to maturity by *C. inclusum* took 54.2 ± 4.0 and 53.9 ± 2.0 days for males and females, respectively (Table 1), which was not significantly different (*t* = 0.05, df = 18, *P* = 0.9611). The time to develop to maturity was less than half that reported by Peck and Whitcomb (1970), whose mean development times for males and females in the control treatments (26 ± 4°C, 14:10 L:D) were 132.1 and 135.8 days, respectively (corrected from their manuscript to remove 9 d for time spent in the egg sac and calculated from individuals described in Appendix Table 4). The temperatures used in this study (25 C) were only slightly different from Peck and Whitcomb (1970) (26 C), suggesting that any differences in results were due to diet alone. These results (high survival and reduced development time) were an improvement over even the “higher quality” mixed-prey diet used in that study. The number of instars required to reach maturity was variable with 4-5 instars for males and 4-6 instars for females, with most individuals becoming adults after 5 instars (84.6 and 66.7% for males and females, respectively). Among females, 13.3 and 20% needed 4 and 6 instars, respectively, to mature. Although determination of fecundity by the resulting adults was not part of this study, a laboratory colony was maintained on a diet of only *H. zea* eggs for 11 generations (pers. obs.), which strongly suggests that a diet of *H. zea* eggs alone adequately supports reproduction.

To reach adulthood, developing *C. inclusum* consumed an average of 651.0 ± 40.3 or 866.5 ± 51.4 eggs for males and females, respectively, with females consuming 33% more eggs on average than males (*t* = 3.23, df = 26, *P* ≤ 0.005). Instar-specific egg consumption was similar for all juvenile instars except the 5th and usually penultimate instar, where females consumed more eggs than males (Fig. 1). During the first several instars egg consumption was similar per instar to another egg-feeding spider, *C. abbotii* (Dixon 1997), but consumption became much greater in the later instars because *C. inclusum* reaches a much larger size as an adult (pers. obs.). Feeding by developing spiders usually did not occur during the first night following a molt and for a day or two prior to molting. Prey consumption data are uncommon for

<table>
<thead>
<tr>
<th>Stage</th>
<th>Development Time (Days ± SE)</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instar 1</td>
<td></td>
<td>8.4 ± 0.2</td>
<td>8.8 ± 0.2</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>8.8 ± 0.3</td>
<td>9.1 ± 0.4</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>12.0 ± 1.5</td>
<td>10.2 ± 0.6</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>14.6 ± 2.0</td>
<td>12.5 ± 1.4</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>12.2 ± 0.8</td>
<td>12.3 ± 1.0</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>12.3 ± 0.3</td>
</tr>
<tr>
<td>Spiderling to maturity</td>
<td></td>
<td>54.2 ± 4.0</td>
<td>53.9 ±  2.0</td>
</tr>
</tbody>
</table>

All comparisons of development for males and females were not significant by *t*-test at *a* = 0.05 (SAS Institute, 2002-2003).

n = 13 males and 15 females.
many predators, but it gives an indication of the upper limit of the potential impact of individual predators on pests. Although impact of any predator taxa depends on many factors, the egg consumption data presented here suggest that *C. inclusum* might have a role in reducing lepidopteran populations in the field through egg predation.

Spiders have been theorized to need diverse diets to adequately develop and reproduce (Greenstone 1979). However, conflicting results have been observed with some studies showing improved spider performance on diverse diets (Uetz et al. 1992) and others on either diverse diets or single high quality prey (Toft and Wise 1999). The observation that *C. inclusum* can develop so well on a single-species diet suggests that prey quality may be the most important factor in their development, and prey diversity may be important when prey quality is low or inadequate. Survival of spiders in many rearing studies is low; to obtain 100% survival as in this study, albeit with a relatively low sample size (*n* = 28), is unusual for spiders. The ability to rear consistently high quality *C. inclusum* on an easily-reared prey will allow researchers to study more intricate aspects of its ecology and behavior than might have otherwise been possible.

**Acknowledgments**

Thanks to J. Patt (USDA-ARS), R. Taylor (Ohio St. Univ.), Wayne Gardner (Univ. of Georgia) and two anonymous reviewers for reviewing drafts of this manuscript. Laboratory studies would not have been possible without the assistance of F. De La Fuente.

**References Cited**


