DEVELOPMENT AND FECUNDITY OF *DERAEOCORIS NEBULOSUS* (HETEROPTERA: MIRIDAE) ON *BEMISIA ARGENTIFOLII* (HOMOPTERA: ALEYRODIDAE)

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ABSTRACT

The developmental and reproductive biology of the native predaceous mirid *Deraeocoris nebulosus* was studied in the laboratory using immatures of the whitefly *Bemisia argentifolii* as prey. Nymphs were kept individually in ventilated Petri dishes and provided with a constant supply of prey colonized on excised sweet potato leaves rooted in hydroponic solution and kept at 27°C. Females were kept similarly and daily egg production was recorded. There were five nymphal instars. Mean development from first instar to adult was 13.3 d; there were no significant differences in development rate between the sexes. After a 3-d preoviposition period, females produced about 10-14 eggs per day for nearly 20 days before oviposition rate declined with age. Females lived an average of 32.8 d (range 3-58 d), and mean fecundity was 242.3 eggs per female (range 0-392).

Key Words: predator, whitefly, biological control, biology, rearing

RESUMEN

La biología reproductiva y el desarrollo del mírido depredador nativo *Deraecoris nebulosus* se estudiaron en condiciones de laboratorio utilizando ninfas de la mosquita blanca, *Bemisia argentifolii,* como presas. Las ninfas del mírido se mantuvieron individualmente en cajas de Petri ventiladas y a una temperatura constante de 27°C. Las presas fueron constantemente presentadas a los depredadores en hojas de camote enraizadas en tubos de plástico conteniendo una solución hidropónica. Las hembras de los depredadores se mantuvieron en condiciones ambientales similares a las de las ninfas y la producción de huevecillos se registró diariamente. Se detectaron 5 estadíos

ninfales. El promedio del tiempo de desarrollo del primer estadío al adulto fue de 13.3 días; no se detectaron diferencias significativas en el tiempo de desarrollo entre machos y hembras. Después de un período pre-oviposicional de 3 días las hembras produjeron diariamente de 10 a 14 huevecillos por casi 20 días continuos, disminuyendo después debido a la edad. El promedio de longevidad de las hembras fue de 32.8 días con una fluctuación de 3 a 58 días y el promedio de fecundidad por hembra fue de 242.3 huevecillos con una fluctuación de 0 a 392 huevecillos.

The dramatic increase in the economic importance of the *Bemisia tabaci* (Gennadius) species complex has been attributed to the virtual replacement of the sweetpotato whitefly, *B. tabaci* (= biotype A), with a new species, the silverleaf whitefly, *B. argentifolii* Bellows & Perring (= sweetpotato whitefly *B. tabaci*, biotype B). The appearance of this new pest has generated widespread activity aimed at developing management methods that minimize additional pesticide load in the environment. Manipulative biological control methods are being investigated for application in greenhouse and field crops. Certain predaceous Miridae might have potential for managing pest whiteflies, particularly in affected greenhouse crops (e.g. Malausa et al. 1987, Alomar et al. 1990, Fransen 1994). Research has been conducted in Europe on various biological aspects of predaceous mirids in the genera *Cyrtopeltis*, *Dicyphus,* and *Macrolophus* (e.g. Fauvel et al. 1987, Malausa 1989, Fransen 1994). *Macrolophus caliginosus* Wagner is currently sold commercially for whitefly control (van Schelt et al. 1996. Hunter 1997). *Deraeocoris* spp. have also been recognized as efficient predators of whiteflies, and their potential has recently been evaluated against *B. tabaci* (Susman 1988, Kapadia & Puri 1991). The North American species *D. brevis* (Uhler) is sold commercially for whitefly management (Hunter 1997).

Deraeocoris nebulosus (Uhler) occurs throughout most of the United States and Canada (Carvalho 1957, Henry & Wheeler 1988). Its value as a predator was recognized over a century ago (Uhler 1876, Howard 1895). Field populations of *D. nebulosus* can be high. This predator was observed in commercial cotton fields in association with aphids in west-central Mississippi, even under heavy insecticide use (Snodgrass 1991) and has been associated with whitefly infestations in cotton there in recent years (G.L.S., unpublished). Aspects of the biology of *D. nebulosus* have been studied previously with the oak lace bug *Corythucha arcuata* (Say) (Wheeler et al. 1975) and the cotton aphid *Aphis gossypii* Glover (Snodgrass 1991) as prey. Wheeler et al. (1975) critically reviewed the literature concerning *D. nebulosus* and summarized the various host and habitat associations of this well-known predator; whiteflies (Aleyrodidae) and other sessile Homoptera are prominently mentioned. The goals of the present study were to determine if *B. argentifolii* is a suitable prey for development and reproduction of *D. nebulosus*, and to provide basic information for further investigations on the potential of this predator as a management tool against the *Bemisia* spp. complex and other whiteflies.

Materials and Methods

Insects were colonized from several dozen nymphs and adults collected in cotton near Stoneville, Washington County, in west-central Mississippi in August 1996. The duration of each immature stage was measured on F_1 progeny from the field-collected insects. Fecundity was derived for females from the development rate observations. To obtain eggs, about 10 unsexed adults from the initial field collection were placed to-

gether in each of several 120mm × 25 mm ventilated plastic culture dishes. Each dish contained a whitefly-infested sweet potato leaf. Leaves had previously been excised and placed individually in floral aquapics where they readily rooted in hydroponic solution (Aqua-Ponics International, Los Angeles, CA 90041). Prior observations indicated that eggs are deposited primarily in the leaf petioles and main leaf veins. First instar nymphs were obtained on the day of eclosion by daily examination of each leaf assembly containing eggs. Because preliminary observations also suggested that nymphs sometimes prey on each other when confined, these studies used isolated individuals. Thirty, newly emerged, nymphs were placed individually in a 120mm × 25 mm ventilated plastic culture dish with a rooted sweet potato leaf containing about 250 *B. argentifolii* nymphs of various ages. All tests were conducted at 27 ± 2°C, 55 ± 10% RH, and a photoperiod of 16:8 (L:D). Test insects were examined daily for change to the next instar or stage. Leaves with host nymphs were changed every 3-4 days. The sex of each insect was determined when it reached the adult stage.

Fecundity was measured by placing individual, teneral females with one or two males of mixed age, in dishes with infested leaves as described above. Males were not replaced after death. Leaves were examined daily for eggs. Eggs deposited over each 24-hr period were marked with colored ink so that one day's egg production could be distinguished from the next. Viability was not determined. Leaves were kept with each female for 3-4 days before replacement. A continuous series of infested leaves was kept with each female until her death. Some qualitative behavioral observations on mating, oviposition, and foraging were also made.

Developmental data were analyzed by ANOVA, and compared by sex using a t-test. Mean developmental time per instar and sex were subjected to Tukey's HSD test ($P < 0.05$) (SYSTAT, Inc. 1992).

Results and Discussion

Eggs were usually found embedded in plant tissue with only the long hairlike micropylar process protruding as described by McCaffrey & Horsburgh (1980); the cap was usually visible through the oviposition slit. Occasionally, eggs protruded from the plant surface or were not embedded at all. Unembedded eggs were not observed for eclosion. Although not specifically recorded, eggs sometimes were observed to be deposited in small groups. Generally, more eggs were deposited in the leaf petiole than in the leaf veins. McCaffrey & Horsburgh (1980) previously reported that eggs of *D. nebulosus* were deposited in leaf mid-veins of apple, but not in petioles or twigs. Other predaceous mirids have been reported to deposit their eggs in major leaf veins and leaf petioles (Cobben 1968, Khristova et al. 1975, Ferran et al. 1996).

There were five nymphal stages, as previously reported by Wheeler et al. (1975). Kapadia & Puri (1991) reported that a *Deraeocoris* sp. in India had six nymphal stages. Twenty-four of 30 nymphs reached adult, 16 males and only 8 females; at least two deaths were due to injury during handling. Total time from egg eclosion to adult at 27°C averaged 13.3 d (Table 1). There was no significant difference in development rate by sex (df = 22; $P = 0.69$). Wheeler et al. (1975) reported development of *D. nebulosus* to take 19.8-d at 21-22°C; Westigard (1973) recorded *D. brevis piceatus* Knight to have a mean development time of 25 days at 21°C. Susman (1988) reported the nymphal duration of *D. pallens* Reuter to be 11.1 days at 25-28°C. Differences among reported development rates is at least partially a function of the different temperatures and species used.

Mean egg deposition per female was 1.5 on day four, then ranged between 9.5-13.9 eggs per day until day 22, whereupon egg production began to decrease with increasing age (Fig. 1). Daily egg production was calculated on the basis of the number of fe-

TABLE 1. DEVELOPMENT TIME FOR EACH INSTAR OF *DERAEOCORIS NEBULOSUS* NYMPHS FED NYMPHS OF *BEMISIA ARGENTIFOLII*.

	Mean Development time (days ± SE)		
Instar	Male	Female	Male + Female
I	2.5 ± 0.18	2.8 ± 0.25	2.6 ± 0.15
II	2.0 ± 0.12	2.0 ± 0.19	2.0 ± 0.10
III	2.3 ± 0.14	2.1 ± 0.35	2.2 ± 0.15
IV	2.2 ± 0.10	2.8 ± 0.25	2.4 ± 0.12
V	4.4 ± 0.24	3.5 ± 0.19	4.1 ± 0.19
Total	13.3 ± 0.30	13.1 ± 0.30	13.3 ± 0.22

males surviving for a given day. One individual lived 58 days, depositing its last eggs at day 57. Mean fecundity was 242.3 eggs per female, ranging from 0-392. No *D. nebulosus* deposited eggs before the third day as an adult. Fecundity and female longevity were greater than that previously reported for any other predaceous mirid. Fecundity in *D. nebulosus* has not previously been reported. The oviposition period of an Indian species of *Deraeocoris* fed with *B. tabaci* averaged 11.3 days, with females living an average of 13.4 days at about 24°C (Kapadia & Puri 1991); *D. pallens* females deposited 23-268 eggs per female over an average lifespan of 14-34 days when fed with *B.*

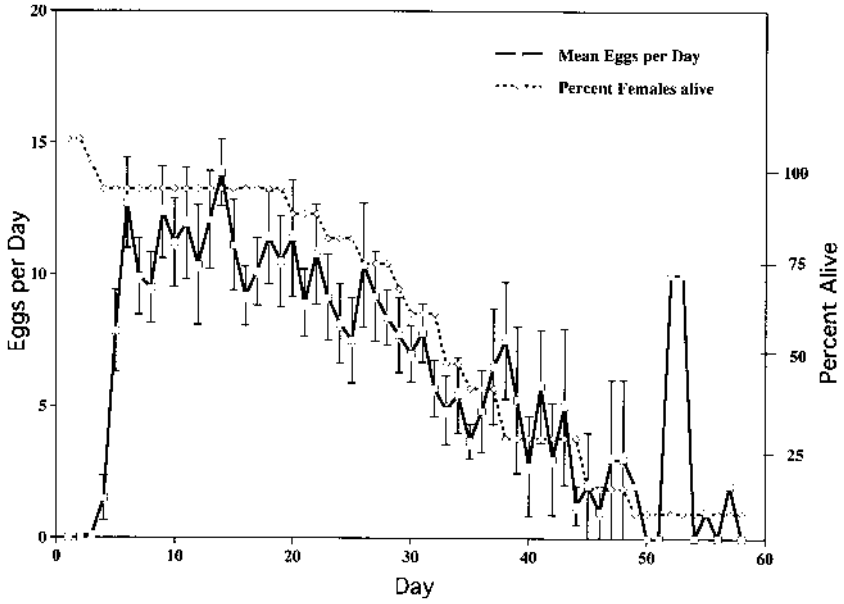

Fig. 1. Mean daily egg production per female (solid line), and daily survival (dotted line) of female *D. nebulosus*.

tabaci (Susman 1988). The commercially available predator *M. caliginosus*, when fed whitefly immatures, had a preoviposition period of 4 days at 23°C, and began oviposition at two eggs per day, which increased to over seven eggs per day for the rest of a 15-d study on fecundity (van Schelt et al. 1996).

Qualitative observations suggested that most foraging may not take place during daytime hours. Nymphs and especially adults were usually found resting under leaves or under the filter paper. When maintained in the greenhouse, these insects were primarily found within leaf litter of potted plants. Nevertheless, it was difficult keeping enough whitefly immatures to maintain the colony. Mating and oviposition was rarely witnessed.

Our preliminary observations showed that nymphs probably prey on each other when confined. Thus, the possibility of production for release against whiteflies may require special rearing conditions that minimize cannibalism.

These results demonstrate that *D. nebulosus* can survive, develop, and reproduce normally using *B. argentifolii* immatures as prey, and that the fecundity of this predator is greater than that of other predaceous mirids previously tested on any host. There is no evidence that this species is also partially phytophagous, as is the case with certain other predaceous mirids studied for their potential in managing whiteflies. Further studies are warranted to measure the efficacy of *D. nebulosus* against *Bemisia* spp., as well as other pests that are potential prey of this mirid.

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