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DEVELOPMENT AND REPRODUCTION OF COTTON APHIDS IN THE FIELD

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Abstract

Life history parameters of the cotton aphid, *Aphis gossypii* Glover were investigated under field conditions in Lubbock, Texas. Newly emerged aphid nymphs (n=30) were reared singly in aphid cages on the fifth mainstem node leaf in cotton and followed through all life stages until the last individual from the cohort died. Instar-specific nymphal duration consisted of 37, 42, 35, and 33 degree-days (>5.8 °C developmental threshold) for first, second, third, and fourth instars, respectively. Cotton aphid mortality began at 432 degree-days and the last aphid died at 924 degree-days. Aphid reproduction began at 142 degree-days and the daily fecundity peaked at 266 degree-days; reproduction ceased at 773 degree-days. The cotton aphids produced an average of 63 offspring in the 30-day reproductive lifespan for the cohort. The gross reproductive rate, net reproductive rate, and finite rate of increase were 62.24, 59.06, and 1.4326, respectively.

Introduction

The cotton aphid, *Aphis gossypii* Glover, is an intermittent problem in the Texas High Plains; in some years the aphid is a secondary pest (Leser 1994), while in other years, years in which widespread outbreaks occur, the aphid is a severe and economically significant pest (Leser et al. 1992). Currently, there are no accurate methods of predicting the density to which aphid populations will develop in cotton fields. The inability of population prediction in the field is partly due to the lack of population growth parameters from the field. The objective of this study was to describe life history parameters from the field and establish a relationship between field-generated life history parameters and field population dynamics.

Materials and Methods

Life history characteristics of the cotton aphid were described in a cotton field near Lubbock during the 2003 cotton growing season. The cotton variety PM 2326RR was planted on May 14, 2003 in 40" rows. Crop and land management followed a standard practice recommended for furrow-irrigated cotton production for the Texas High Plains.

Newly emerged aphid nymphs (n=30) were reared singly in small ventilated 1x1x1 inch aphid cages on the fifth mainstem node (from top of plant) leaf in cotton and followed through all life stages until the last individual from the cohort died. Only one aphid was deployed on one cotton plant. To standardize the leaf quality among plants that received aphid treatment, aphids were transferred to a new fifth leaf within the same plant when the plant produced new leaves. Aphids were checked every 24 h and developmental stage, fecundity, and mortality recorded. During the reproductive stage, newborn aphids were counted and removed every day.

Age-specific fecundity (m_x) and survivorship (l_x) schedules were constructed for the cotton aphid cohort, and life history parameters were calculated following the methods of Andrewartha and Birch (1954). For the analysis, the first day of the nymph was set as the first pivotal age with age increments of one d. The intrinsic rate of increase (r) was computed by iteratively solving the Euler equation:

$$\sum_x e^{-rx}\, l_x m_x = 1$$

where l_x is the proportion of individuals alive at time x of an original cohort and m_x is the mean number of offspring produced per surviving aphid during the age interval x (1 d). Values of m_x were obtained by dividing the mean number of aphids produced per aphid per day. Life table statistics, such as the gross reproductive rate (GRR = $\sum m_x$), the net reproductive rate ($R_o = \sum l_x\, m_x$), and the finite rate of increase ($\lambda = e^r$, a discrete form of the intrinsic rate of increase), were also calculated as described by Andrewartha and Birch (1954). The jackknife procedure (Meyer et al. 1986) was used to estimate the standard error of the calculated life table statistics.

Temperatures were recorded on the undersurface of the cotton leaf to determine the actual temperature experienced by the aphid. Degree-days were calculated above the developmental threshold of 5.8 °C (Parajulee and Sapkota, unpublished data). Natural population of cotton aphids was also monitored by inspecting aphids on 32 randomly selected plants in the same cotton field. Sampling was conducted daily from July 1 to September 30, 2003.

Results and Discussion

Instar-specific nymphal developmental duration did not significantly vary among instars. Nymphal durations consisted of 37, 42, 35, and 33 degree-days (>5.8 °C) for first, second, third, and fourth instars, respectively. Cotton aphid mortality began at 432 degree-days (19 days from birth) and the last aphid died at 924 degree-days (46 days from birth) (Figure 1). Xia et al. (1999) reported developmental threshold of 7.1 °C from their laboratory study and the estimated aphid longevity from their data was about 275 degree-days. Aphid survivorship in our study was more than three times to that of the Xia et al. (1999) study. We speculate that the plant quality in our study was superior to the rearing substrate used in their laboratory study. Kersting et al. (1999) reported a developmental threshold of 6.2 °C, but the longevity reported in their study was about one-half of what we observed in this study. These data indicate that cotton aphids do better in their natural habitat (cotton plants in the field) than in a laboratory setting.

Aphid reproduction began at 142 degree-days (6 days from birth) and the daily fecundity peaked at 266 degree-days (12 days from birth); reproduction ceased at 773 degree-days (35 days from birth) (Figure 2). Cotton aphids produced an average of 63 offspring in a 30-day reproductive lifespan (Figure 3). Because survivorship was 100% when 80% of the reproduction had been completed (day 19), the net reproductive rate was only slightly lower than the gross reproductive rate. The gross reproductive rate, net reproductive rate, and finite rate of increase were 62.24, 59.06, and 1.4326, respectively. Xia et al. (1999) reported maximum gross and net reproductive rates of 28.3 and 24.4, respectively, at 25 °C.

Although the field temperature fluctuated during the study period, degree-days accumulated by caged aphids remained between 20 to 25 degrees per day when 95% reproduction occurred (Figure 4). Data reported from laboratory studies indicated that aphids showed the best performance on cotton seedlings in the laboratory at 25-27 °C (Akey and Butler 1989) that is only slightly lower temperature regime compared with our temperatures during July-August in the Texas High Plains. Therefore, the discrepancy in aphid performance between our field study and previously published laboratory research could be largely attributed to the host substrate quality.

Under natural infestation, cotton aphid presence in the study site was detected in mid-July and it took about 6 days (equivalent to nymphal developmental duration in the field) to increase its population toward peak (Figure 5). The natural field population fluctuated around the mean population of 3.5 aphids per plant for about 45 days and the population then declined to undetectable level by September 30.

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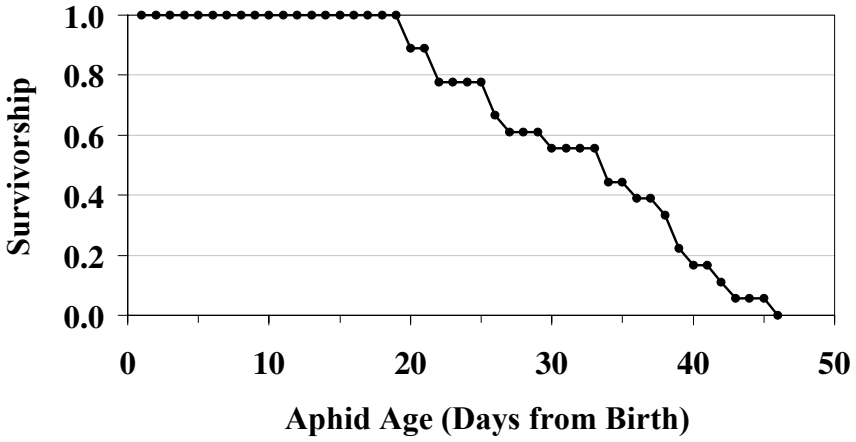

Figure 1. Daily average survivorship of cotton aphids in the field, Lubbock, Texas, 2003.

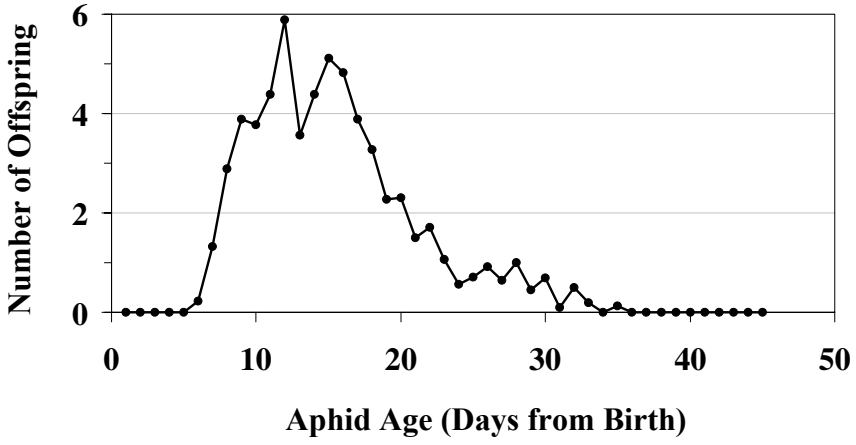

Figure 2. Daily average fecundity of cotton aphids in the field, Lubbock, Texas, 2003.

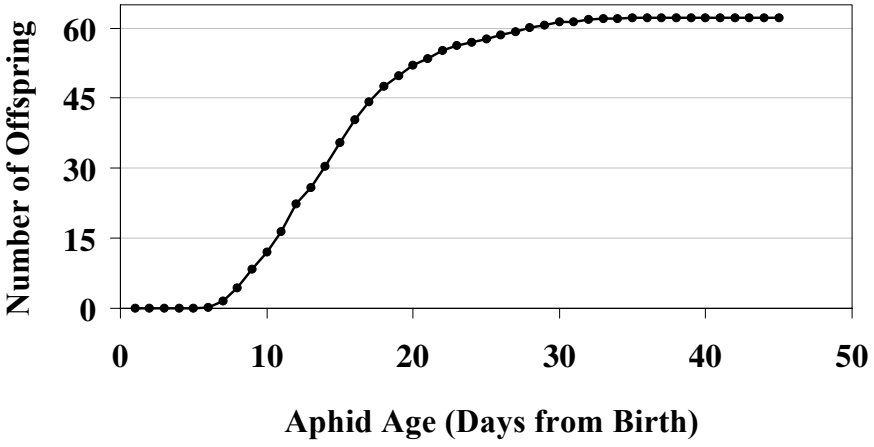

Figure 3. Average cumulative (lifetime) fecundity of cotton aphids in the field, Lubbock, Texas, 2003.

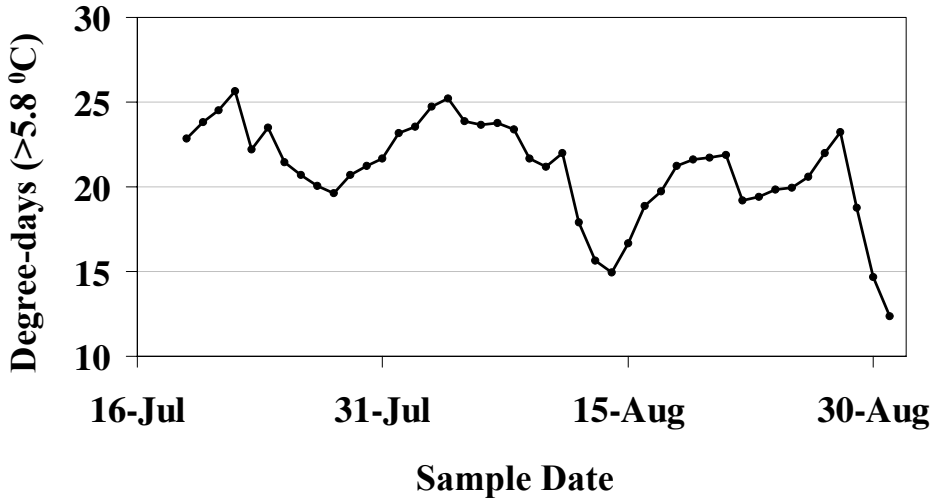

Figure 4. Daily degree-days (>5.8 °C) accumulated under the leaf surface where individual cotton aphids were enclosed for life table study, Lubbock, Texas, 2003.

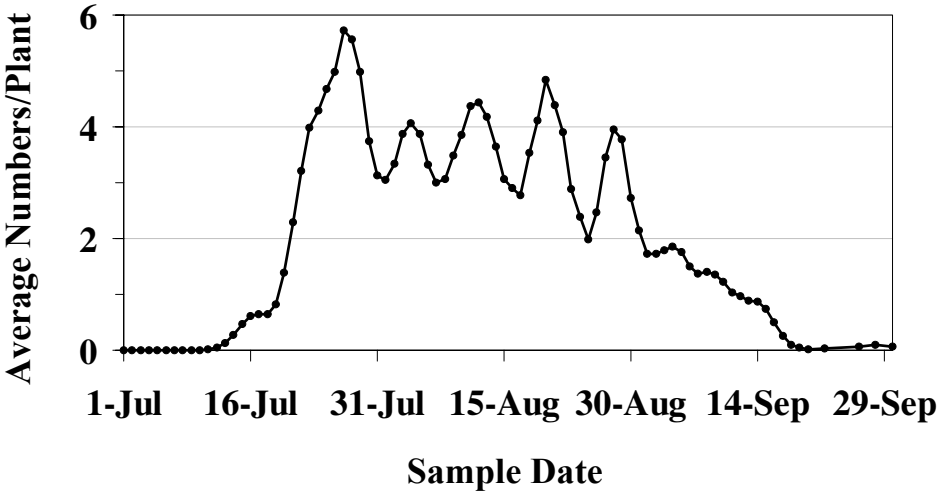

Figure 5. Daily abundance of cotton aphids detected by visual inspection of 32 cotton plants from July 1 to September 30, Lubbock, Texas, 2003.