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Effects of Temperature and Host Plants on Population Dynamics of the Cotton Fleahopper, *Pseudatomoscelis seriatus*

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ABSTRACT

Host plants and temperature had a great influence on population dynamics of the cotton fleahopper, *Pseudatomoscelis seriatus* (Reuter). The longest life expectancy calculated was 4.91 weeks for newly deposited eggs at 23.9 degrees C (75 degrees F). Net reproductive rates per generation (R_o) ranged from about 40 for fleahoppers reared on flowering croton at 26.7 degrees C (80 degrees F) to 1.6 for fleahoppers reared on beans and potatoes at 35.0 degrees C (95 degrees F). The shortest mean generation time (T_c) was 3.87 weeks on flowering croton at 26.7 degrees C, but comparable values were obtained for groups of fleahoppers reared on spotted beebalm at 26.7 degrees C and on beans and potatoes at 29.4 degrees C. A cotton fleahopper population reared on flowering croton at 26.7 degrees C for 10 weeks could theoretically increase to over 13,000 females for each female present at week one.

INTRODUCTION

Many studies have been conducted to determine effects of environmental parameters on insect population dynamics. The effects of temperature on the biology of insects probably have been investigated as thoroughly as the effects of any other environmental parameter. However, most studies to determine effects of temperature on the biology of insects have dealt with effects on developmental rates (Strong and Sheldahl 1970, Philipp and Watson 1971, Siddiqui and Barlow 1972). Fewer papers have reported effects of temperature on growth of insect populations (Birch 1953, Strong and Sheldahl 1970, Philipp and Watson 1971, Siddiqui and Barlow 1972). Effects of temperature on developmental rates, survival, and fecundity of the cotton fleahopper, *Pseudatomoscelis seriatus* (Reuter), were reported by Gaylor and Sterling (1975).

It has long been recognized that food may influence insect biological processes (Andrewartha and Birch 1954). However, quantitative studies dealing with effects of host plants on insect development are fewer than studies dealing with effects of temperature (Van Emden and Way 1971). Brazzel and Martin (1957) found that mortality of young larvae and fecundity of female pink bollworms, *Pectinophora gossypiella,* were influenced by the growth stage of the host plant. Gaylor (1975) found that developmental rates, mortality, and fecundity of the cotton fleahopper were influenced by species as well as growth stage of host plant. Drooz (1971) reported that species and maturity of host plants on which adult elm spanworms, *Ennomos subsignurius,* fed affected fecundity, developmental rates, and size of offspring in the F_2 generation. Maturity of the "ideal" host had less effect than maturity of less ideal hosts.

Birch (1953) reported effects of two kinds of stored grain on entire populations of two species of stored grain pests. However, in Birch's study one pest was not normally found in one of the grains. Similarly, the other pest was not normally found in the second kind of grain. Effects of "normal" hosts on entire populations of insects have not been well studied.

The innate capacity for increase (rm) of insects has been used as an indicator of population change (Birch 1953, Philipp and Watson 1971, Siddiqui and Barlow 1972). Andrewartha and Birch (1954) presented a simple approximation of rm. Laughlin (1965) called the approximation the "capacity for increase," r_c, and showed that it could be used as a valuable indicator of population growth. The statistic, r_c, is calculated by the log formula:

$$r_c = \frac{\log_e R_o}{T_c}$$

where R_o = net reproductive rate per generation and T_c = generation time. Strong and Sheldahl (1970) used r_c to indicate the "fitness" of the genotype to the environment.

Values of r_c for a given population in a given environment depend on fecundity, survival, and developmental rates of individuals in the population. Effects of host plants on cotton fleahopper fecundity, survival, and developmental rates have been investi-

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gated under various constant temperature conditions (Gaylor 1975). However, effects of temperature and host plants on growth of cotton fleahopper populations have not been reported.

METHODS AND MATERIALS

Data used by Gaylor and Sterling (1975) to determine the effects of temperature and host plants on development, fecundity, and mortality were used to develop survivorship and age-specific fecundity curves for the cotton fleahopper. The way these data were obtained has been described (Gaylor and Sterling 1975). Net reproductive rates, R_o, generation times, T_c, capacities for increase, r_c, and finite rates of increase per day, λ, were calculated from survivorship and age-specific fecundity curves.

Curves were developed for populations reared on green beans and potatoes under 23.9, 26.7, 29.4, and 35.0 degrees C constant temperature regimens. Beans and potatoes are not "normal" fleahopper food for naturally occurring field populations. However, developmental rates of fleahoppers reared on beans and potatoes (Gaylor and Sterling 1975) were comparable to developmental rates of fleahoppers reared on the normal hosts, spotted beebalm, *Monarda punctata* L., cutleaf evening primrose, *Oenothera laciniata* Hill, and cotton, *Gossypium hirsutum* L., in pre-flowering growth stages (Gaylor 1975). Survival rates were much higher on beans and potatoes than on "normal" hosts in pre-flowering growth stages. Since survival to the adult stage was very low on pre-flowering spotted beebalm, cutleaf primrose and cotton, fecundity on these hosts was not determined. However, based on survival and developmental rates, it appears that population growth on beans and potatoes would be at least as rapid as on pre-flowering spotted beebalm, primrose and cotton. Survivorship and age specific fecundity curves also were developed for populations reared on flowering croton and flowering spotted beebalm at a constant 26.7 degrees C temperature regimen.

Life expectancy tables were calculated for each population in the manner reported by Deevey (1947) and summarized by Southwood (1966).

RESULTS AND DISCUSSION

Much higher fecundity rates occurred in fleahopper cohorts reared on flowering croton and spotted beebalm than in those reared on beans and potatoes (Figure 1). Peak egg deposition occurred earlier on normal hosts than on beans and potatoes, and high rates of egg deposition were maintained longer on croton than on spotted beebalm. Not only were more eggs deposited on normal hosts than on beans and potatoes, but Gaylor (1975) reported a higher percentage of females (about 75 percent) became adults on flowering croton and spotted beebalm than was reported (Gaylor and Sterling 1975) on beans and potatoes (about 50 percent). Thus, the number of female eggs deposited per female (mx) on beans and potatoes was found by multiplying the total eggs deposited by 0.50. On spotted beebalm and croton mx values were obtained by multiplying the total number of eggs deposited by 0.75.

Peak egg deposition was lower on beans and potatoes under a 29.4 degrees C temperature regimen than under other temperature regimens, but egg deposition occurred earlier under the 29.4 degrees C regimen. Also, the percentage of adult fleahoppers surviving during egg deposition was higher at the 29.4 degrees C regimen than in other temperatures. In all cohorts some adult fleahoppers survived for considerable periods of time after the last egg was deposited. Most of these surviving adults were unmated individuals in individual cages. The unmated individuals were included in survivorship (1x) curves because effects of mating and crowding on fleahopper survival in test cages is unknown.

Gaylor and Sterling (1975) showed that some fleahoppers could survive for more than 10 weeks when reared on beans and potatoes at 23.9 degrees C. However, the longest life expectancy of fleahoppers was obtained for a newly depositied egg on beans and potatoes at 23.9 degrees C (Table 1).

Egg mortality was not determined until hatching. Mean time from deposition to hatching for all cohorts was between 2 and 3 weeks (Gaylor 1975). Thus, no mortality was observed during week 1 in all cohorts. Therefore, life expectancy during week 1 in all cohorts was artificially high (Tables 1-6). Similarly, all egg mortality, as well as early nymphal mortality, was calculated as occurring during week 2. Therefore, life expectancy in all cohorts was artificially low during week 2 (Tables 1-6).

High mortality occurred during egg and early nymphal life in all cohorts except those reared on beans and potatoes at 29.4 degrees C (Figure 1). Thus, life expectancy decreased for nymphs at the beginning of the 2nd week of life and increased during the 3rd

TABLE 1. LIFE TABLE FOR COMPUTING LIFE EXPECTANCY OF COTTON FLEAHOPPERS REARED ON BEANS AND POTATOES AT 23.9°C 1/

X	1x	dx	ex
1	1000	0	4.91
2	1000	341	3.91
3	659	10	4.67
4	649	108	3.74
5	541	82	3.38
6	459	78	2.90
7	381	82	2.39
8	299	119	1.90
9	180	60	1.83
10	120	30	1.50
11	90	60	0.83
12	30	30	0.50

1/ X = pivotal age in weeks; 1x = number surviving at beginning of age interval out of 1000 eggs; dx = number dying in age interval out of 1000 eggs; ex = expectation of further life in weeks.

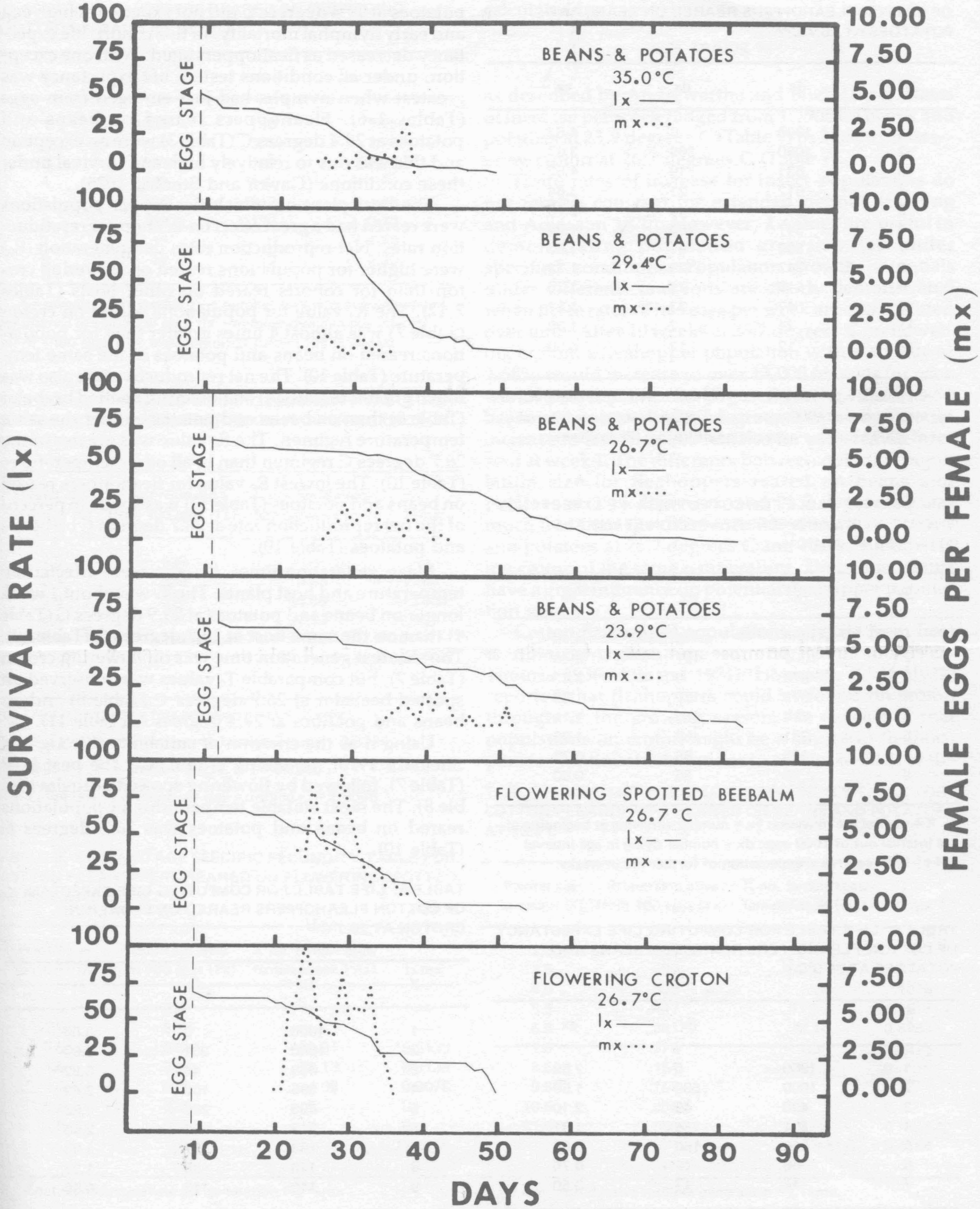

Figure 1.

Effects of temperature and host plants on cotton fleahopper survival and age-specific fecundity rates. The survival rate (1x) is the percentage surviving, and mx values are the number of female eggs deposited per female.

TABLE 2. LIFE TABLE FOR COMPUTING LIFE EXPECTANCY OF COTTON FLEAHOPPERS REARED ON BEANS AND POTATOES AT 26.7°C 1/

X	1x	dx	ex
1	1000	0	4.67
2	1000	369	3.67
3	631	19	4.52
4	612	21	3.64
5	591	44	2.76
6	547	209	1.94
7	338	91	1.83
8	247	129	1.31
9	118	71	1.20
10	47	23	1.27
11	24	12	1.00
12	12	12	0.50

1/ X = pivotal age in weeks; 1x = number surviving at beginning of age interval out of 1000 eggs; dx = number dying in age interval out of 1000 eggs; ex = expectation of further life in weeks.

TABLE 3. LIFE TABLE FOR COMPUTING LIFE EXPECTANCY OF COTTON FLEAHOPPERS REARED ON BEANS AND POTATOES AT 29.4°C 1/

X	1x	dx	ex
1	1000	0	4.40
2	1000	127	3.40
3	873	0	2.82
4	873	159	1.82
5	714	433	1.11
6	281	158	1.06
7	123	88	0.78
8	35	35	0.50

1/ X = pivotal age in weeks; 1x = number surviving at beginning of age interval out of 1000 eggs; dx = number dying in age interval out of 1000 eggs; ex = expectation of further life in weeks.

TABLE 4. LIFE TABLE FOR COMPUTING LIFE EXPECTANCY OF COTTON FLEAHOPPERS REARED ON BEANS AND POTATOES AT 35.0°C 1/

X	1x	dx	ex
1	1000	0	2.59
2	1000	580	1.59
3	420	49	2.10
4	371	155	1.31
5	216	150	0.88
6	66	49	0.76
7	17	17	0.50

1/ X = pivotal age in weeks; 1x = number surviving at beginning of age interval out of 1000 eggs; dx = number dying in age interval out of 1000 eggs; ex = expectation of further life in weeks.

week of life. Fleahopper cohorts reared on beans and potatoes at 29.4 degrees C did not experience high egg and early nymphal mortality. In this cohort, life expectancy decreased as fleahoppers aged. With one exception, under all conditions tested, life expectancy was greatest when nymphs had just emerged from eggs (Tables 1-6). Fleahoppers reared on beans and potatoes at 29.4 degrees C (Table 3) were an exception and this was due to relatively high egg survival under these conditions (Gaylor and Sterling 1975).

The host plant on which fleahopper populations were reared had a great effect on fleahopper reproduction rates. Net reproduction rates per generation (R_o) were higher for populations reared on flowering croton than for cohorts reared on other hosts (Tables 7-12). The R_o value for populations reared on croton (Table 7) was almost 4 times greater than for populations reared on beans and potatoes at the same temperature (Table 10). The net reproductive rate also was much greater (about 2X) on flowering spotted beebalm (Table 8) than on beans and potatoes under the same temperature regimen. The R_o value was greater in the 26.7 degrees C regimen than in all other temperatures (Table 10). The lowest R_o value for fleahoppers reared on beans and potatoes (Table 12) was about 16 percent of the net reproduction rate at 26.7 degrees C on beans and potatoes (Table 10).

Mean generation times, T_c, also were affected by temperature and host plants. The T_c was about 1 week longer on beans and potatoes at 23.9 degrees C (Table 9) than on the same host at 26.7 degrees C (Table 10). The shortest generation time was on flowering croton (Table 7), but comparable T_c values were observed on spotted beebalm at 26.7 degrees C (Table 8) and on beans and potatoes at 29.4 degrees C (Table 11).

Using r_c as the criterion of suitability (Strong and Sheldahl 1970), flowering croton was the best host (Table 7), followed by flowering spotted beebalm (Table 8). The most suitable temperature for populations reared on beans and potatoes was 26.7 degrees C (Table 10).

TABLE 5. LIFE TABLE FOR COMPUTING LIFE EXPECTANCY OF COTTON FLEAHOPPERS REARED ON FLOWERING CROTON AT 26.7°C 1/

X	1x	dx	ex
1	1000	0	3.88
2	1000	361	2.88
3	639	44	3.22
4	595	102	2.42
5	493	280	1.82
6	213	30	2.56
7	183	37	1.90
8	146	36	1.25
9	110	110	0.50

1/ X = pivotal age in weeks; 1x = number surviving at beginning of age interval out of 1000 eggs; dx = number dying in age interval out of 1000 eggs; ex = expectation of further life in weeks.

TABLE 6. LIFE TABLE FOR COMPUTING LIFE EXPECTANCY OF COTTON FLEAHOPPERS REARED ON FLOWERING SPOTTED BEEBALM AT 26.7°C[1/]

X	1x	dx	ex
1	1000	0	3.25
2	1000	363	2.25
3	637	109	2.25
4	528	142	1.62
5	386	217	1.03
6	169	152	0.70
7	17	0	1.50
8	17	17	0.50

1/ X = pivotal age in weeks; 1x = number surviving at beginning of age interval out of 1000 eggs; dx = number dying in age interval out of 1000 eggs; ex = expectation of further life in weeks.

TABLE 7. LIFE AND AGE-SPECIFIC FECUNDITY TABLE FOR COTTON FLEAHOPPERS REARED ON FLOWERING CROTON AT 26.7°C

Pivotal age in weeks (X)	Proportion alive from 100 eggs (1x)	$\overline{X}$ no. female eggs/ female/week (mx)	1xmx
1.5	.639	-----	-----
2.5	.639	0.45	0.288
3.5	.556	43.65	24.2694
4.5	.405	37.13	15.0377
5.5	.222	0.00	0
			R_o = 39.5951

R_o = Net reproductive rate per generation = Σ1xmx

T_c = Generation time in days = Σ1xmxX/Σ1xmx = 3.8725

r_c = Capacity for increase = $\log_e R_o/T_c$ = 0.9500

λ = Finite rate of increase per day = antilog r_c = 2.5856

TABLE 8. LIFE AND AGE SPECIFIC FECUNDITY TABLE FOR COTTON FLEAHOPPERS REARED ON FLOWERING SPOTTED BEEBALM AT 26.7°C

Pivotal age in weeks (X)	Proportion alive from 100 eggs (1x)	$\overline{X}$ no. female eggs/ female/week (mx)	1xmx
1.5	.659	-----	-----
2.5	.661	-----	-----
3.5	.512	29.91	15.3139
4.5	.306	29.13	8.9138
5.5	.076	4.05	0.3078
6.5	.028	0	0
7.5	.028	0	0
			R_o = 24.5355

R_o = net reproductive rate per generation = Σ1xmx

T_c = generation time in days = Σ1xmxX/Σ1xmx = 3.8884

r_c = capacity for increase = $\log_e R_o/T_c$ = 0.8230

λ = finite rate of increase per day = antilog r_c = 2.2773

Finite rates of increase per female per day were calculated by:

$$\lambda = \text{antilog } r_c$$

as described by Andrewartha and Birch (1954). Rates of increase per week ranged from 1.3905 on beans and potatoes at 23.9 degrees C (Table 9) to 2.5856 on flowering croton at 26.7 degrees C (Table 7).

Finite rates of increase for insect populations do not remain constant for extended periods (Sterling and Adkisson 1970). However, λ values are useful in demonstrating population growth rates under specified conditions. Population growth potentials under different conditions are clearly demonstrated when finite rates of increase per week are extrapolated over time. After 10 weeks at 26.7 degrees C on flowering croton, a fleahopper population with a λ value of 2.5856 would increase to over 13,000 females for each female present at week 1 (Figure 2). After 10 weeks on beans and potatoes at 26.7 degrees a population would increase to less than 200 females for each female present at week 1. The difference between potential population size for fleahoppers reared on beans and potatoes at 35.0 degrees C and 26.7 degrees C was much less than the difference when reared on beans and potatoes at 26.7 degrees C and reared on flowering croton at the same temperature. Thus, host plants have a great influence on potential fleahopper population size.

Cotton fleahopper populations migrate from host to host throughout the summer (Reinhard 1926, Thomas 1936, Almand 1974). However, Eddy (1927) reported that fleahoppers could be found on croton throughout the growing season. He concluded that populations on croton might be a source of fleahoppers for continual infestations in cotton. Results of the

TABLE 9. LIFE AND AGE SPECIFIC FECUNDITY TABLE FOR COTTON FLEAHOPPERS REARED ON BEANS AND POTATOES AT 23.9°C

Pivotal age in weeks (X)	Proportion alive from 100 eggs (1x)	$\overline{X}$ no. female eggs/ female/week (mx)	1xmx
2.5	.659	-----	-----
3.5	.597	-----	-----
4.5	.529	.76	.4020
5.5	.447	11.10	4.9617
6.5	.381	2.14	0.8153
7.5	.226	1.05	0.2373
8.5	.154	0	0
9.5	.105	0	0
10.5	.090	0	0
11.5	.030	0	0
			R_o = 6.4164

R_o = Net reproductive rate per generation = Σ1xmx

T_c = generation time in days = Σ1xmxX/Σ1xmx = 5.6383

r_c = Capacity for increase = $\log_e R_o/T_c$ = 0.3297

λ = Finite rate of increase per day = antilog r_c = 1.3905

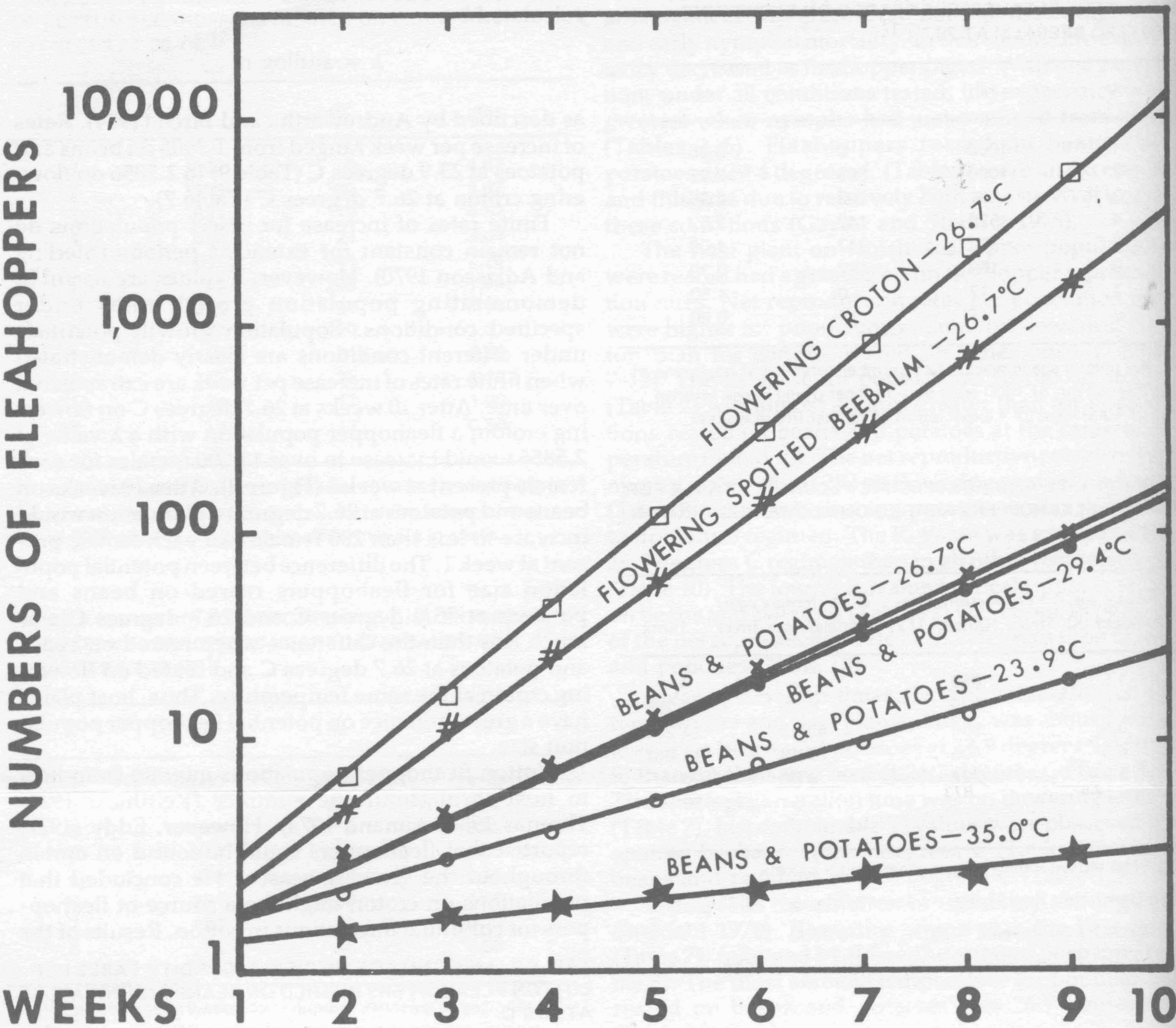

Figure 2.

Exponential rates of increase for cotton fleahopper populations reared under different temperature and host plant conditions.

present study tend to support this conclusion, since flowering croton is a suitable host plant. However, populations also may increase to high levels on other native host plants such as spotted beebalm. Results of the present study and earlier studies (Gaylor and Sterling 1975) indicate that fleahopper populations would not increase to high levels on cotton. Damaging infestations probably result from migration into cotton from native hosts.

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TABLE 10. LIFE AND AGE-SPECIFIC FECUNDITY TABLE FOR COTTON FLEAHOPPERS REARED ON BEANS AND POTATOES AT 26.7°C

Pivotal age in weeks (X)	Proportion alive from 100 eggs (1x)	$\overline{X}$ no. female eggs/ female/week (mx)	1xmx
1.5	.679	-----	-----
2.5	.622	-----	-----
3.5	.601	1.93	1.1599
4.5	.569	11.34	6.4525
5.5	.448	5.36	2.4013
6.5	.327	0	0
7.5	.200	0	0
8.5	.082	0	0
9.5	.024	0	0
10.5	.024	0	0
11.5	.012	0	0
			R_o = 10.0137

R_o = Net reproductive rate per generation = Σ1xmx

T_c = Generation time in days = Σ1xmxX/Σ1xmx = 4.6240

r_c = Capacity for increase = $\log_e R_o / T_c$ = 0.4983

λ = Finite rate of increase per day = antilog r_c = 1.6459

TABLE 11. LIFE AND AGE-SPECIFIC FECUNDITY TABLE FOR COTTON FLEAHOPPERS REARED ON BEANS AND POTATOES AT 29.4°C

Pivotal age in weeks (X)	Proportion alive from 100 eggs (1x)	$\overline{X}$ no. female eggs/ female/week (mx)	1xmx
1.5	.901	-----	-----
2.5	.873	-----	-----
3.5	.873	5.43	4.7404
4.5	.515	3.28	1.6892
5.5	.179	0	0
6.5	.054	0	0
7.5	.036	0	0
			R_o = 6.4296

R_o = Net reproductive rate per generation = Σ1xmx

T_c = Generation time in days = Σ1xmxX/Σ1xmx = 3.7627

r_c = Capacity for increase = $\log_e R_o / T_c$ = 0.4946

λ = Finite rate of increase per day = antilog r_c = 1.6398

TABLE 12. LIFE AND AGE SPECIFIC FECUNDITY TABLE FOR COTTON FLEAHOPPERS REARED ON BEANS AND POTATOES AT 35.0°C

Pivotal age in weeks (X)	Proportion alive from 100 eggs (1x)	$\overline{X}$ no. female eggs/ female/week (mx)	1xmx
1.5	.471	-----	-----
2.5	.403	-----	-----
3.5	.331	2.6100	.8639
4.5	.116	5.2400	.6078
5.5	.025	5.4000	.1350
6.5	.008	0	0
			R_o = 1.6068

R_o = net reproductive rate per generation = Σ1xmx

T_c = Generation time in days = Σ1xmxX/Σ1xmx = 4.0461

r_c = Capacity for increase = $\log_e R_o / T_c$ = 0.1172

λ = Finite rate of increase per day = antilog r_c = 1.1244

REFERENCES CITED

Almand, L. K. 1974. Seasonal abundance, dispersal and control of the cotton fleahopper in certain host plants. Ph.D. Dissertation. Texas A&M University.

Andrewartha, H. G. and L. C. Birch. 1954. The distribution and abundance of animals. The University of Chicago Press. Chicago and London. 782 p.

Birch, L. C. 1953. The influence of temperature, moisture and food on the innate capacity for increase of three grain beetles. Ecol. 34:698-711.

Brazzel, J. R. and D. F. Martin. 1957. Oviposition sites of the pink bollworm on the cotton plant. J. Econ. Entomol. 50:122-4.

Deevey, E. S., Jr. 1947. Life tables for natural populations of animals. Quart. Rev. Biol. 22:283-314.

Drooz, A. T. 1971. The elm spanworm (Lepidoptera: Geometridae): natural diets and their effects on the F_2 generation. Ann. Entomol. Soc. Amer. 64(2):331-3.

Eddy, C. O. 1927. The cotton fleahopper. S. C. Agric. Exp. Stn. Bull. 235. 21 p.

Gaylor, M. J. 1975. Effects of temperature, host plants, photoperiod and rainfall on population dynamics of the cotton fleahopper, *Pseudatomoscelis seriatus* (Reuter). Ph.D. Dissertation. Texas A&M University.

Gaylor, M. J. and W. L. Sterling. 1975. Effects of temperature on the development, egg production, and survival of the cotton fleahopper, *Pseudatomoscelis seriatus*. J. Environ. Entomol. 4(3):487-90.

Laughlin, R. 1965. Capacity for increase: a useful population statistic. J. Anim. Ecol. 34:77-91.

Philipp, J. C. and T. F. Watson. 1971. Influence of temperature on population growth of the pink bollworm, *Pectinophora gossypiella* (Lepidoptera: Gelechiidae). Ann. Entomol. Soc. Amer. 64:334-40.

Reinhard, H. J. 1926. Control of the cotton fleahopper in Texas. Tex. Agric. Exp. Stn. Circ. 40. 8p.

Siddiqui, W. H. and C. A. Barlow. 1972. Population growth of *Drosophila melanogaster* (Diptera: Drosophilidae) at constant and alternating temperatures. Ann. Entomol. Soc. Amer. 65:993-1001.

Southwood, T. R. E. 1966. Ecological methods. Methuen, London. 391p.

Sterling, W. L. and P. L. Adkisson. 1970. Seasonal rates of increase for a population of the boll weevil, *Anthonomus grandis*, in the high and rolling plains of Texas. Ann. Entomol. Soc. Amer. 63:1696-1700.

Strong, F. E. and J. A. Sheldahl. 1970. The influence of temperature on longevity and fecundity in the bug *Lygus hesperus* (Hemiptera: Miridae). Ann. Entomol. Soc. Amer. 63:1509-15.

Thomas, F. L. 1936. Control of the cotton fleahopper. Tex. Agric. Exp. Stn. Circ. 77. 8p.

Van Emden, H. F. and M. J. Way. 1971. Host plants in the population dynamics of insects. p. 181-91. *In* H. F. Van Emden (Ed.). Insect and plant relationships. John Wiley and Sons. New York. 215 p.