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Effect on Temperature Influences of the Life Table Studies for Aphid, *Aphis craccivora* Koch. in Cowpea under Laboratory Condition

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To study the life table aphid, Aphis craccivora in cowpea at different temperature.
Study Design: Simple random sampling design with two treatments and 12 replications.
Place and Duration Study: Agricultural College and Research Institute, Madurai and 2019-2020.

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Methodology: We used a simple random sampling design, which included two temperature variables (30 and 35°C) and 12 repetitions for A. craccivora. The female adult aphids were placed in dishes with leaf dishes and 12 hours light appropriate temperature. Female adult aphids were placed in dishes containing leaf discs and incubated at the appropriate temperature, with a 12-hour light phase. They were transferred to new dishes as needed. We evaluated the pre-reproductive and reproductive periods under a stereomicroscope every 24 hours, and we determined the number of nymphs produced and their longevities at each temperature.
Results: Aphid, Aphis craccivora Koch. is most important pest in Pulses ecosystem and life table studies on cowpea, the net reproductive rate (22.53 individuals / female at 30^0 C; 14.23 individuals / female at 35^0 C, mean generation time 11.41days at 30^0C; 10.39 at 35^0C, population doubling time (2.710 days at 30^0C, 2.539 at 35^0C in Cowpea. The age specific survivorship curve revealed that the population followed Type III curve and 50 per cent mortality of A. craccivora 9 days at 30^0C and 7.5 days at 35^0C in cowpea.
Conclusion: The life table aphids insects parameters of net reproductive rate, population doubling time, mean generation time and age specific curve was maximum in 30^0C than 35^0C in Cowpea.

Keywords: Life table parameters; cowpea; black aphid; temperature growth champers.

1. INTRODUCTION

"Climate change has been globally recognized as the most imminent and critical issue affecting humanity and our survival in the 21st century. According to the last assessment report from the Intergovernmental Panel on Climate Change, the mean temperature is predicted to increase by 1.10 – 6.40 °C by the year 2100 AD" [1,2] "The global atmospheric concentration of greenhouse gases (GHGs) - carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) - has increased significantly as a result of human activities since the pre-industrial era" [3,4,5,6]. "The increasing concentration of these gases is expected to have a great effect on global climate change, which in turn may affect agriculture" [7]. "Pulses are the major source of protein in the vegetarian diet in our country. In addition to being a rich source of protein, they maintain soil fertility through biological nitrogen fixation and thus play a vital role in promoting sustainable agriculture" [8]. "The main victims of global climate change are the insect pests that affect crop plants. Rising the interactions between crop plants and insect pests can be significantly impacted by temperatures and increased CO2 levels" [9,10,11]. It has been reported that global climate warming may lead to the expansion of the geographic range of insect pests with altitude, increased abundance of tropical insect species, decrease in the relative proportion of temperature-sensitive insect populations, and more incidences of insect-transmitted plant diseases. With this background, the proposed study focuses on the effects of climate change on estimating life table parameters for key pests under controlled and varied temperature regimes in different cropping systems in Tamil Nadu under two environmental regions.

2. MATERIALS AND METHODS

2.1 Life Table Studies of Cowpea Aphid, *Aphis craccivora* Koch

The *A. craccivora* colonies were initially collected from the field and then established and maintained on cowpea seedlings (VBN 2) planted in mud pots at the Department of Agricultural Entomology, Agricultural College and Research Institute, Madurai, Tamil Nadu. A single cowpea plant of the VBN 2 variety was sown in a polythene plastic pot (9 cm in diameter, 8 cm deep) containing a soil mixture of clay-loam, sand, and coir pith. These pots were kept in BOD chamber conditions at two temperature regimes of 30°C and 35°C with a relative humidity of 60% throughout the life cycle study. First-instar nymphs of aphids were placed in Petri dishes (15 cm diameter) containing black gram and cowpea leaf discs (14 cm diameter) along with 1% agar solution. The leaf discs came from plants grown in soil without pesticides. "Before the experiment, the leaf material was disinfected with a 1% sodium hypochlorite solution for 5 minutes, washed with tap water, and finally rinsed with distilled water for 10 minutes to maintain moisture. The Petri dishes were then placed in a BOD incubator set to 30°C and 35°C. The experiment followed a complete randomized block design with 12 replications. Using a camel hair brush, groups of 12 first-instar nymphs were placed on individual cowpea plants. The cowpea leaf disc was

replaced daily and observations on moulting, number of progeny, and mortality were recorded daily" [12].

2.2 Reproductive Parameters on Aphid, *Aphis craccivora* Koch

"To generate pre-adapted adult female aphids, individual females of each aphid species were transferred to separate Petri dishes (10 cm diameter) containing a cowpea leaf disc and 1% agar solution. The dishes were kept at temperatures of 30°C and 35°C, with a relative humidity of 70% ± 10% for 6 hours. After this period, all females and nymphs, except for one per dish, were removed. The dishes were then placed in BOD chambers at temperatures of 30°C and 35°C, with a relative humidity of 70% ± 10% and a 12-hour photophase until the aphids developed into adult females. These females were then used in the fertility study" [12].

2.3 Temperature trials

The experiment utilized a simple random sampling design, involving two temperature variables (30°C and 35°C) with 12 repetitions for *A. craccivora*. Female adult aphids were placed in dishes containing leaf discs and incubated at the appropriate temperature under a 12-hour photoperiod. They were transferred to new dishes as needed. The pre-reproductive and reproductive periods were monitored under a stereomicroscope every 24 hours, and the number of nymphs produced and their longevities were recorded at each temperature.

2.4 Survivorship curve

The survivorship curve is created by plotting lx on the y-axis and age on the x-axis in a life table. Typically, the y-axis is logarithmic, represented as log10 (lx), to facilitate comparisons among different studies and species. In other words, log transformations standardize the survivorship curve [13].

2.5 Statistical Analysis

The population growth was estimated using the fertility life table, utilizing parameters such as net reproductive rate (R0), intrinsic rate of increase (rm), mean generation (T), doubling time (DT), and finite rate of increase (λ). The field data was analyzed using a simple Randomized Block Design and the significance was tested using the 'F' test, as described by Panse and Sukhatme [14].

3. RESULTS AND DISCUSSION

3.1 Age Specific Life Table of Aphid, *A. craccivora* Koch. In Cowpea at two Temperatures (30^0C and 35^0C)

"Constructing a life table is a simple method for keeping track of natality, mortality, and reproductive output in a population of interest. A life table describes the mortality and survival patterns of a population. These tables provide information on parameters such as the number of survivors, the number of deaths, and life expectancy based on mortality ratios for each age or age group" [15]. "It has been observed that global warming, leading to increased temperatures, may accelerate the life cycles of certain plant species" [16,17], which in turn may significantly affect feeding and reproduction patterns in associated insect pests such as aphids, jassids, mealybugs, etc. "Such increases can greatly exacerbate negative ecological and economic consequences" [18].

3.2 Cowpea

In cowpea, the highest net reproductive rate (22.53 individuals/female), intrinsic rate of increase (0.273 days), finite rate of increase (1.314 days), and mean generation time (11.41 days) were recorded at 30°C, while the values were lower at 35°C (14.23, 0.256, 1.291, and 10.39 respectively). The doubling time was maximum at 35°C (2.710 days) and minimum at 30°C (2.539 days). These findings are in contrast with those reported by Messenger [19] and Graham [20], who found that the maximal intrinsic rate of increase (rm) of 0.41 was recorded at a fluctuating temperature averaging 29.40°C, or a maximal intrinsic rate of increase (rm) of 0.35 at a constant temperature of 25°C for laboratory populations of brown citrus aphid, *Therioaphis maculata*. They also observed that when the populations were exposed to extreme temperatures of 33°C, they ceased to grow. Similarly, for *Toxopetera citricida* reared on citrus, Komazaki [21] reported higher net reproductive rates of 33.13, 44.32, and 41.08 at 15°C, 20°C, and 25°C, respectively, compared to 44.3, 38.84, and 36.79 at 15.2°C, 19.9°C, and 24.90°C.

The mean generation times at 15.2°C, 19.9°C, and 24.90°C temperatures are shorter than those reported by Komazaki [21]. Auad and Moraes [22] also reported that the reproductive period of

Table 1. Age-specific life table of *Aphis craccivora* Koch on cowpea (cv. VBN 2) at two temperature regimes

Age (Days) (x)	Survival number.		Survivorship l_x		dn_x		mn_x		Number of off springs m_x		l_xm_x		xl_xm_x		e^ -rcx	
	30ºC	35ºC	30ºC	35ºC	30ºC	35ºC	30ºC	35ºC	30ºC	35ºC	30ºC	35ºC	30ºC	35ºC	30ºC	35ºC
0	30	30	1.00	1.00	0	4	0	0	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00
1	30	26	1.00	0.87	2	5	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.71
2	28	21	0.93	0.70	4	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.50
3	24	21	0.80	0.70	6	2	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.36
4	18	19	0.60	0.63	2	1	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.25
5	16	18	0.53	0.60	2	7	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.18
6	14	11	0.47	0.37	1	3	0	124	0.00	11.27	0.00	4.13	0.00	24.80	0.11	0.13
7	13	8	0.43	0.27	2	3	210	98	16.15	12.25	7.00	3.27	49.00	22.87	0.07	0.09
8	11	5	0.37	0.17	6	2	189	76	17.18	15.20	6.30	2.53	50.40	20.27	0.05	0.06
9	5	3	0.17	0.10	1	1	132	54	26.40	18.00	4.40	1.80	39.60	16.20	0.04	0.05
10	4	2	0.13	0.07	1	0	80	43	20.00	21.50	2.67	1.43	26.67	14.33	0.02	0.03
11	3	2	0.10	0.07	3	2	65	32	21.67	16.00	2.17	1.07	23.83	11.73	0.02	0.02
Total	0	0	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02
							676	**427**	**101.40**	**94.22**	**22.53**	**14.23**	**189.50**	**110.20**		

x = Age of the insects in days; lx = Number surviving at the beginning of each interval, out of 30; dnx = Number dying during the age interval, out of 30; qx = Mortality rate at the age interval x; mx = eggs produced per surviving individual at each stage; lxmx = eggs produced per original individual at each stage

Table 2. Life history parameters of *A. craccivora* Koch. On Cowpea (cv. VBN 2) at two temperature regimes

Parameters	Cowpea	
	30^0 C	**35^0 C**
Age of first oviposition (days)	7.00	6.00
Age of 50% mortality (days)	9.00	7.50
Age of last oviposition (days)	11.00	11.00
Length of oviposition (days)	3.00	3.50
Net Reproductive Rate(R_0) (No. of individuals/female)	22.53	14.23
Intrinsic rate of natural increase(r_m) (day^{-1})	0.273	0.256
Finite rate of increase(λ) (day^{-1})	1.314	1.291
Mean generation time(T) (days)	11.41	10.39
Doubling time(t) (days)	2.539	2.71

Table 3. Logistic relationship between age and the probabilities of survival of *Aphis craccivora* Koch on cowpea (cv. VBN 2) at two temperature regimes

Sl. No.	Temperature ºC	'a' (50% mortality/days)	'b' (Intercept)	R^2 value
1	30	9	1.247	0.882
2	35	7.5	1.159	0.905

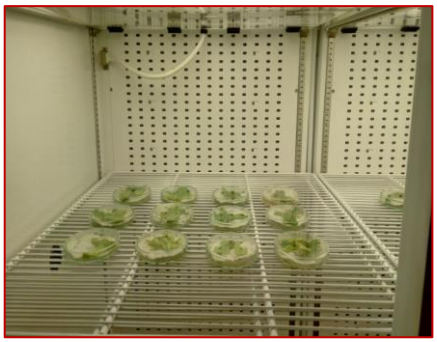
the aphid Uroleucon ambrosiae lasted 15.57 days at 15ºC, 12.23 days at 20ºC, and 8.47 days at 25ºC. Jalalipour et al. [23] recorded survivorship, fecundity, and longevity of the *Aphis craccivora* under both laboratory and natural conditions. They found that under natural conditions, *Aphis craccivora* had a significantly shorter nymphal developmental time, adult longevity, and life span than those reared under laboratory conditions. However, the intrinsic rate of increase (rm), net reproductive rate (R0), the finite rate of increase (λ), and gross reproductive rate (GRR) in the laboratory were higher than those obtained in the field, except for a higher mean generation time (T) resulting from field experiments [24,25].

3.3 Survivorship (l_x)

The survival of *A. craccivora* indicates that it follows a type III survivorship curve. The survivorship pattern of *A. craccivora* on cowpea is observed at two temperatures (30°C and 35°C) [26,27]. Using the Doesn't Use Derivative (DUD) method, survivorship curves of *A. craccivora* reared on cowpea leaves were smoothed. The parameters (a and b) of the smoothed curves of *A. craccivora* on cowpea leaves were estimated at 30°C (1.253) and 35°C (1.232) respectively. Fifty percent mortality of *A. craccivora* was recorded after 6 days at 30°C and 7 days at 35°C. The parameters (a and b) of the smoothed curves of cowpea leaves on *A. craccivora* were estimated at 30°C (1.247) and 35°C (1.159) respectively. Fifty percent mortality of *A. craccivora* was also recorded after 9 days at 30°C and 7.5 days at 35°C on cowpea. These Type III curves indicate high mortality in early life, followed by a period of much lower and relatively constant losses, which is evident in the present studies. Additionally, 50 percent mortality was observed in first instar nymphs, whereas in later instars, the mortality rates were on a declining trend [28-31].

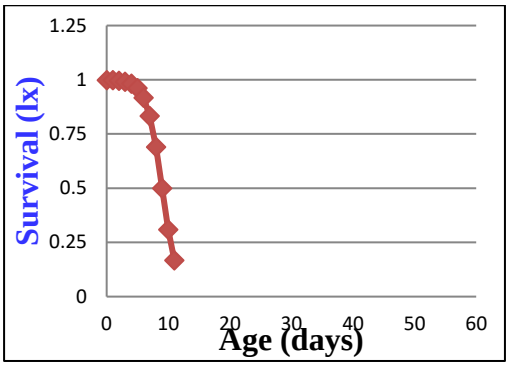
Insect Growth Chamber

View on cowpea potted plants inside growth chamber

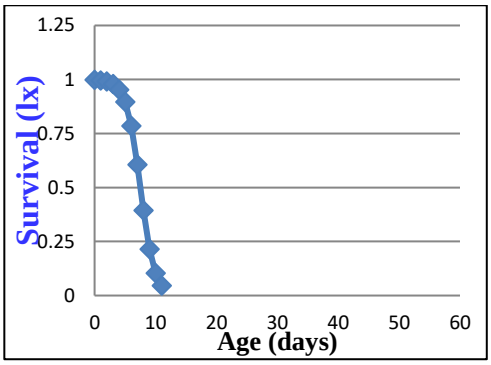


View of petri dishes with leaf discs and aphids inside growth chamber

Fig. 1. Studies on life table of *Aphis craccivora* Koch. in Cowpea at 30^0 C and 35^0 C



***Aphis craccivora* on cowpea (30ºC)**



***Aphis craccivora* on cowpea (35ºC)**

Fig. 2. Age specific life table of *A. craccivora* Koch. on Cowpea (cv.VBN 2) at two temperature condition

4. CONCLUSION

In life table studies on cowpea, the net reproductive rate of *Aphis craccivora* was 22.53 individuals per female at 30°C and 14.23 individuals per female at 35°C. The mean generation time was 11.41 and 10.39 days, respectively at 30°C and 35°C to complete one generation. Population doubling time was 2.710 and 2.539 days, respectively at 30°C and 35°C. The age-specific survivorship curve revealed that the population followed a Type III curve and 50 percent mortality of *A. craccivora* occurred at 9 days at 30°C and 7.5 days at 35°C in cowpea.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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