SOME BIOLOGICAL ASPECTS OF THE COWPEA APHID, *APHIS CRACCIVORA* KOCH (HOMOPTERA:APHIDIDAE) ON FABA BEAN

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Abstract: The developmental rates and some life table parameters of the cowpea aphid, *Aphis craccivora* Koch were studied under three constant temperatures (18, 22 and 26°C). The experiment was carried out in electrical incubators provided with a photoperiod of 16:8 (L:D) and 60-70% R.H. Results revealed that the cowpea aphid passed through four instars to reach maturity. Development of nymphal stage is completed in about 7.10, 6.04 and 4.5 days at 18, 22 and 26°C, respectively. Temperature threshold of this stage is found to be 10°C. The thermal units needed to developing one generation were 72 day-degrees. The number of generations of *A. craccivora* which could develop in one season on faba bean plants under Assiut conditions was calculated and found to be about 13 generations. Net reproductive rate (R_0), mean generation time (GT), intrinsic (rm) and finite rate (λ) of increase for *A. craccivora* were also determined. The results indicated clearly that temperatures of 22 and 26°C were seemed to fall in the favourable range for development and multiplication of this pest.

Introduction

Faba bean, *Vicia faba* L. is among the most important crops that supply Egyptian people with protein. Moreover, it is essential for the feeding of livestock (Mannaa *et al.*, 1999). One of the reasons had been given to explain the decreased yield in the crop is the cowpea aphid, *Aphis craccivora* Koch. The pest cause economic damage by direct feeding and also as virus disease vector and disseminator of about 30 plant virus diseases (Gutierrez *et al.*, 1971; Basky and Nasser, 1989 and Nasser *et al.*, 1993). Recently, up to 85% yield loss was recorded in the commonly cultivated cultivar , Giza 2 (El-Defrawi *et al.*, 1994). Way, 1967 concluded that the loss of *V. faba* yield caused by aphids ranged from 53-100%.

Temperature is probably the most important physical environmental factor influencing rates of development and reproduction. Although, the biology of *A. craccivora* as affected by temperature had been extensively studied by several authors (Berg,

1984; Hijan and Singh, 1989; Ven and Chen, 1990 and Nasser and Abdel-Rahman, 1999), few work had been done on the thermal units needed and/or the temperature thresholds of *A. craccivora*.

Therefore, present work was aimed to investigate the effect of temperature on the development of nymphal stage as well as adult longevity and fecundity of the aphid, and also to determine the thermal units needed to complete its life, temperature threshold as well as life table parameters.

Materials and Methods

Adults of *A. craccivora* were collected from faba bean fields grown in the Faculty of Agriculture Farm, Assiut University. The culture of *A. craccivora* was maintained under laboratory conditions on the seedling of faba bean plants for about 10 generations. Seeds of brood bean variety Giza 40 were planted in a plastic pots (7.5 cm in diameter 10 cm high) and after emergence thinned to 1-2 seedlings/pot. Seedlings were artificially infested with nymphs (<8 hrs old) and covered with glass cages. Twenty-five nymphs were individually placed in each of the forementioned temperatures. Nymphs in each temperature regime were observed daily to determine the moulting, duration and survival until the appearance of the aptera. Aptera were allowed to complete their development at the same previously conditions. Apterous females were also inspected daily to observed the number of progeny.

Data obtained were statistically analyzed using analysis of variance and means were compared according to Duncan's Multiple Range test.

Indices of efficiency for development of the different stages of *A. craccivora* were calculated according to the formula of Khattat and Stewart (1977).

Obtained results of the nymphal stage were used to calculate the development threshold (t_0) and the thermal units (TU) required to complete development of the nymphal stage according to the method described by Mangat (1977). The selected life table parameters, namely generation time (GT), population doubling time (DT), net reproductive rate (Ro), intrinsic (rm) and finite (λ) rates increase were estimated as indicated by Birch (1948).

The number of generations was determined according to the method published by Kozchanchikov (1961).

Results and Discussion

1. Nymphal stage:

Data in Table 1 show that the cowpea aphid passed through four instars to reach maturity. The duration of nymphal instars

decreased gradually as temperature increased from 18 to 26°C. The longest nymphal stage was 7.10 days at 18°C, while the shortest one was 4.5 days at 26°C. At a given temperature, the duration of the second instar was found to be the longest. It lasted 2.27, 2.00 and 1.06 days at 18, 22 and 26°C, respectively. Statistical analysis of the data showed significant differences between the total nymphal periods at all tested temperatures. These results are in general agreement with the findings of Ali *et al.* (1993); Abou-Elhagag (1995) and Abdel-Rahman (1997). Hijam and Singh (1989) reported that the duration of the nymphal stage of the cowpea aphid lasted 4.15 days at 28°C. Nasser and Abdel-Rahman (1999) found that the duration of the second instar lasted the longest period when the aphid reared at either 20 or 25°C.

Table (1) :Developmental periods (in days) of immature stages of *A. craccivora* reared at different constant temperatures.

Temp °C	Developmental periods (in days) ± SD				
	Nymphal instars				Total nymph
	1st	2nd	3rd	4th	
18	1.63±0.61a	2.27±0.65a	1.63±0.49a	1.62±0.56a	7.10±1.11a
22	1.44±0.50a	2.00±0.59a	1.44±0.51a	1.22±0.42b	6.04±0.44b
26	1.45±0.51a	1.06±0.24b	1.06±0.24b	1.00±0.00b	4.50±0.52c

As shown from table 2, the highest percentage of survival during the total nymphal stage period was 92.00% at 22°C, followed by 88.00% at 26°C, while the lowest one was 64% at 18°C. It is clear that the highest value of index of efficiency (19.56) was recorded at 26°C, whereas, the lowest index (9.01) was achieved at 18°C. The foregoing results concerning the duration, survival and index of efficiency in relation to temperatures indicated clearly that 22 to 26°C were the most favourable temperatures for the development of the pest (Table 2).

Table(2): Survival and indices of efficiency (IE) of different nymphal instars of *A. craccivora* reared at different constant temperatures.

Temp (°C)	Nymphal instars								Nymphal stage	
	1st		2nd		3rd		4th			
	Survival	IE	Survival	IE	Survival	IE	Survival	IE	Survival	IE
18	84.00	51.53	85.71	37.76	94.44	57.94	94.12	58.10	64.00	9.01
22	96.00	66.67	95.83	47.92	100.00	69.44	100.00	81.97	92.00	15.23
26	92.00	63.45	95.65	90.24	100.00	94.34	100.00	100.00	88.00	19.56

Data in Table 1 were used to calculate the development threshold (t_0) the thermal units (TU) needed for the development of the cowpea aphid nymphs. A temperature developmental threshold for the nymphal stage was found to be 10°C. Consequently the thermal units needed to complete its development were about 72 day-degrees (Table 3 and Figure 1). The results of the present investigation are in full agreement with those of Berg (1984) who found that temperature threshold for the development of the nymphal stage of the pest was 8.1°C. Also, Nasser and Abdel-Rahman, 1999 determined the temperature threshold for the development of the nymphal stage of this kind of aphids and it was nearly the same (9.8°C). Meanwhile, the results concerning temperature threshold (2.6°C) reported by Wen and Chen, (1990) disagree with the results of the present study. The difference in the values of development threshold may be attributed to the host plant effect, aphid biotype and etc.. Moreover, aphids in the colder countries seemed to be better adapted to lower temperature, consequently have had lower temperature developmental threshold.

The mean effective temperature from 15 December to 15 April, the period that the insect was harbouraged to faba bean plants (Salem, 1998 and Mannaa *et al.*, 1999), for the years from 1997 to 2001 was calculated from mean monthly temperature prevailed at Assiut district (Table 4). By using Kozchanchikov formula (1961), the number of generations of *A. craccivora* which could developed during one season on faba bean fields under Assiut conditions was about 13 generations. Many authors (Ali and Rizk, 1980; Ali and Morsy

Table(3): Hypocritical temperature thresholds of *A. craccivora* reared at different constant temperatures.

Developmental threshold (t_0)	Thermal units (DD) = T ($t-t_0$)	
	22°C (T= 6.04)	26°C (T= 4.5)
5	102.70	94.50
6	96.64	90.00
7	90.60	85.50
8	84.56	81.00
9	78.52	76.50
10	72.48	72.00
11	66.44	67.50
12	60.40	63.00
13	54.32	58.50
14	48.32	54.00
15	42.28	49.50

Table(4): Mean monthly temperatures and mean effective temperatures during the periods from 15 December to 15 April for the years of 1997, 1998, 1999, 2000 and 20001 at Assiut district.

ear	Mean monthly temperatures					Mean monthly effective temperatures					
	From 15 to 31 Dec.	Jan.	Feb.	March	From 1 to 15 April	From 15 to 31 Dec.	Jan.	Feb.	March	From 1 to 15 April	Total
97	11.99	10.52	11.33	15.96	19.89	88.23	115.32	126.84	283.96	196.35	810.70
98	14.10	10.85	12.08	16.07	22.11	124.10	125.55	153.12	287.37	229.65	919.79
99	11.78	12.99	13.01	16.31	22.71	84.66	191.89	173.83	294.81	238.65	983.84
00	12.10	13.01	11.89	15.56	20.40	90.10	192.51	147.61	271.56	204.00	905.78
01	11.90	12.61	14.01	17.61	20.79	86.70	180.11	201.88	335.11	209.85	1013.65
tal	61.87	59.98	62.32	81.51	105.90	473.79	805.37	803.28	1472.81	1078.5	4633.76
an	12.37	11.99	12.464	16.302	21.18	94.758	161.076	160.656	294.562	215.70	926.752

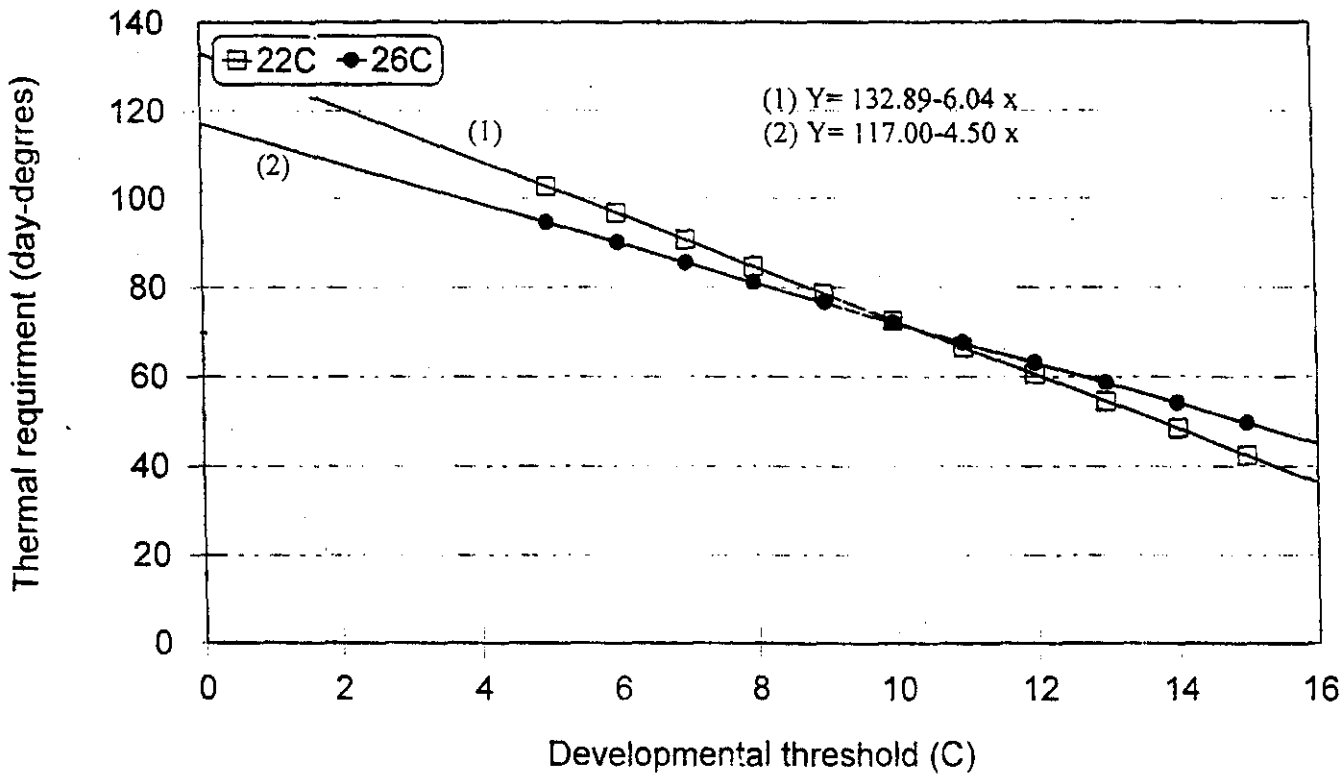

Fig. 1: Thermal units needed for the developement of the nymphal stage of *A.craccivora*.

1982; Mohammad and Mahmoud, 1986; Selim *et al.*, 1987; Mowafy, 1988; Metwally, 1989; Hannou, 1992; Abdel-Alim, 1994; Hassanein, 1994; Salem, 1998; Mannaa *et al.*, 1999 and Abou-Elhagag and Salman, 2001), came to similar results.

2. Adult stage:

Data in Table 5 show that the longevity of females was divided into pre-reproductive, reproductive and post-reproductive periods. The results indicated that there was a gradual decrease in these periods with the increase in temperature. The pre-reproductive periods were 0.27, 0.12 and 0.33 days at 18, 22 and 26°C, respectively. The reproductive periods ranged from 11.29 to 4.29 days when the temperature ranged from 18 to 26°C, respectively. The post-reproductive periods decreased from 1.83 days at 18°C to 1.29 days at 26°C. The longest longevity was 13.37 days at 18°C and the shortest one was (5.91) at 26°C.

The highest average number of offsprings/female as shown in Table 5 was 65.48 offsprings at 22°C. This value was followed by 60.2 and 48.36 offsprings at 18 and 26°C, respectively. Although the longest reproductive period (11.21 days) was achieved at 18°C, the highest number of offsprings was 65.48 offsprings occurred at 22°C. These results are in harmony with the results of (Abdel-Rahman, 1997 and Nasser and Abdel-Rahman, 1999). Abdel-Rahman (1997) found that the mean number of progeny per female of greenbug was varied inversely with the temperature up to 24°C. Nasser and Abdel-Rahman (1999) recorded that the pre-reproductive needed the shortest time from the whole longevity of the adult stage (4%) and the reproductive period needed the longest time (78%), whereas the post-reproductive needed (18%) of the total adult life span. They also found that the number of progeny/female was 56.85 offsprings at 20°C.

Table(5): Adult longevity and fecundity of *A. craccivora* reared at different constant temperatures.

Temp. °C	Adult longevity and fecundity				
	Pre-reproductive	Reproductive	Post-reproductive	Longevity	No. offspring/ female
18	0.27±0.53a	11.21±3.02a	1.83±3.38a	13.37±3.89a	60.21±17.27ab
22	0.12±0.44a	9.69±2.86a	3.16±4.04a	13.01±4.18a	65.48±14.96a
26	0.33±0.62a	4.29±2.73b	1.29±1.86a	5.96±1.97b	48.36±36.92b

3. Life table parameters:

3.1- Net reproduction rate (R_0)

Data in Table 6 clearly show that R_0 decreased as temperatures increased from 18 to 26°C. The calculated data indicate that the cowpea aphid can increase 57.26, 54.65 and 29.05 times after a single generation at 18, 22 and 26°C, respectively. The data also revealed that at 22°C, the population of this pest could increase about 2 times in the course of one generation as compared to that reared at 26°C.

3.2- Generation time (GT):

As shown in Table 6 the shortest generation time (in days) was obtained at the highest tested temperature. The decrease of temperature from 26 to 18°C led to length the generation time from 7.72 to 13.22 days.

Table(6) :Selected life table parameters of *A. craccivora* reared at different constant temperatures.

Parameters	Temperature (°C)		
	18°	22°	26°
Net reproductive rate (R_0)	57.26	54.65	29.05
Generation time (GT)	13.22	11.03	7.72
Doubling time (DT)	2.26	1.91	1.59
Intrinsic rate of increase (rm)	0.3062	0.3627	0.4364
Finite rate of increase (λ)	1.3258	1.4372	1.5471

3.3-Population doubling time (DT):

The population of *A. craccivora* had the capacity to double every 2.26, 1.91 and 1.59 days at 18, 22 and 26°C, respectively (Table 6). This means that population doubling time markedly decreased as temperature increased with the shortest doubling time at 26°C.

3.4- Intrinsic (rm) and finite (λ) rates of increase:

The statistic (rm) expresses the relationship between fecundity, generation time and survival (Birch, 1948). As shown in Table 6, the values of (rm) increased markedly by temperature increase. The value of (rm) at 26°C was approximately 1.4 times higher than that of the pest at 18°C, 1.2 times of that at 22°C. If

(rm) is a measure of the suitability of the environment, then the maximal (rm) reveals the most appropriate reproductive potential under those conditions.

The data indicate that a constant temperature of 26°C is nearly the optimal temperature among those tested, as it had the maximal (rm) value. The intrinsic rate of increase had been used in a comparative manner to estimate the degree of fitness of various genotype to their environment (Ohba, 1967 and Ayala, 1968). On the other hand, when the values of the intrinsic rate of increase (rm) were converted to the finite rate of increase (λ) according to Birch, 1948, it was found that the population of *A. craccivora* had the capacity to multiply about 1.3258, 1.4372 and 1.5471 times per female per day at 18, 22 and 26°C, respectively. It means that population of 10 females could increase in a week to become 70, 120 and 210 individuals at 18, 22 and 26°C, respectively.

In general, the calculated biological parameters (R_0, GT, DT, rm and λ) indicate that temperatures of 22 and 26°C seem to fall in the favourable range for development and multiplication of *A. craccivora*.

The results obtained from the present work are very important for prediction purposes used in an integrated control programme for managing this pest in upper Egypt. When the thermal requirements for different stages of any insect are known, the accumulation of heat units (day-degrees) becomes a useful tool for predicting the appearance of various insect species in the field (Salman, 1988; Ibrahim, 1995 and Nasser and Abdel-Rahman, 1999). Heat summation also have important value in monitoring population of any insect in the early season. Thus, according to these findings, the preparations must be taken for controlling those pests using the ability to predict development of their early season populations which allows optimal focus of control measures aimed at those pests. Such predictive tools facilitate monitoring pests activity and reduce unnecessary insecticide applications.

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بعض الخصائص البيولوجية لمّن البقوليات على الفول البلدى

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تم دراسة تأثير ثلاث درجات حرارة ثابتة وهى ١٨ ، ٢٢ و ٢٦ درجة مئوية على بعض الخصائص البيولوجية لمّن البقوليات . وقد تم اجراء هذه التجارب فى حضانات تعمل بالكهرباء ومتوفر فيها درجة اضاءة ٨:١٦ (ليل:نهار) ورطوبة نسبية ٦٠-٧٠% . أوضحت النتائج أن طور الحورية يتم اكتماله فى حدود ٧,١ و ٦,٠٤ و ٤,٥ يوم على درجات حرارة ١٨ و ٢٢ و ٢٦ على التوالى . وقد وجد أن صفر (عتبة) النمو لطور الحورية هو ١٠°م وأن الوحدات الحرارية اللازمة لإكتمال دورة حياة جيل واحد هو ٧٢ وحدة حرارية . كذلك فإنه قد تم حساب عدد الأجيال من هذه الحشرة والتى تتواجد على نبات الفول البلدى تحت ظروف أسيوط وقد وجد أنها حوالى ١٣ جيل . وقد دلت النتائج بوضوح أن درجتى حرارة ٢٢ ، ٢٦°م يبدو أنهما يقعان فى المدى الحرارى المفضل لنمو وتكاثر هذه الآفة .