RESEARCH ARTICLE Agricultural Science Digest, Volume 45 Issue 1: 124-130 (February 2025)

Biological Manifestation of Different Temperature Regimes and Certain Insecticides on *Cheilomenes sexmaculata* (Fab.) Preying on Cowpea Aphid, *Aphis craccivora* Koch

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10.18805/ag.D-6135

ABSTRACT

Background: Ladybird beetles are great bio-control agents and campodeiform grubs of these little predators are able to devour aphids in a voracious fashion. They feed on a wide array of aphid species most noticeably on the infamous black aphids or cowpea aphids *Aphis craccivora* (Koch).

Methods: The growth and feeding potential of *C. sexmaculata* were studied in the laboratory of the Department of Entomology, Faculty of Agricultural Sciences (Institute of Agricultural Sciences), SOA Deemed to be University, Bhubaneswar, India at four different temperatures 20°C, 25°C, 30°C and 35°C during 2021-2022.

Result: The life history parameters indicated that the duration of eggs, larvae, pupae, adult males and adult females was longest at 30°C and shortest at 20°C. Such variations were also observed in morphometry and feeding potential. The trend was 30°C> 25°C> 35°C >20°C. In the case of feeding potential the trend was adult female > adult male > 4th instar>3rd instar > 2nd instar > 1st instar across all temperatures. Adult females lived longer than males and thereby consumed more aphids than males. Maximum consumption was seen in case of adult female at 30°C which was 633±5.71 aphids and least feeding was seen at 20°C by 1st instar grub which was 8.9±0.56 aphids. The effect of insecticides in direct spray method indicated that dimethoate 30 EC killed more ladybirds and clothianidin 50% WDG killed the least. This trend was strong across all temperatures and insect growth stages. The feed contamination method indicated that clothianidin 50% WDG, imidacloprid 17.8% SL and thiamethoxam 25% WG produced higher mortality rates than direct contamination method. All insecticides showed increased mortality up to 72 h and the mortality trend was 72 HAT > 48 HAT > 24 HAT. The mortality rate of immature individuals is higher than that of adults.

Key words: Direct application, HAT (Hours After Treatment), Morphometry, Prey feed contamination.

INTRODUCTION

Needless to say, that severe outbreaks of pests have become ubiquitous due to the repeated application of insecticides. Furthermore, according to various reports by international organizations, more than a million farmers die due to pesticide poisoning in a year (Sarkar, 2023). A sustainable approach and reduced dependency on pesticides may help tackle such issues in the long run. As the world's farming society is approaching sustainable management of pests and diseases, the use of ladybird beetles is gaining momentum in managing aphid population below damage boundary (Sanghani *et al.,* 2018). The demand for organic crops and pesticide-free food items is rising globally and to meet this demand ladybirds can be used as a major pest control tool. In semiarid regions of our country cowpea is farmed as a protein rich legume crop (Ghosh, 2024). Both adults and nymphs of bean aphid suck sap from the underside of the leaves and impair the plant physiological system as well as act as a passage for transmitting viral diseases (Pal *et al.,* 2023). According to Chhangani *et al.* (2022) *Cheilomenes sexmaculata* (Fab,) are great predators against bean aphids, *Aphis craccivora* Koch. The greater objective of this research is to help the agricultural communities in managing the predatory ladybird population in the field. Zigzag ladybird beetles resembling a split pea might look winsome to human observation are nightmare for soft-bodied aphids. These are key predators that can be observed near aphid infested plants and are very much capable of limiting their population (Reddy *et al.,* 2001). *Cheilomenes sexmaculata* (Fabricius) is an extensively dispersed ladybird species in South-east Asian countries including India (Aniyaliya *et al.,* 2022). High temperature tolerance in Zigzag ladybird also enables them to feed on aphids effectively in hot and humid climates (Wang *et al.,* 2013).

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How to cite this article: Nanda, S.R., Mishra, B.K., Roy, S., Khamari, B., Pati, P., Dash, S. and Priyadarshini, P. (2025). Biological Manifestation of Different Temperature Regimes and Certain Insecticides on *Cheilomenes sexmaculata* (Fab.) Preying on Cowpea Aphid, *Aphis craccivora* Koch. Agricultural Science Digest. 45(1): 124-130. doi: 10.18805/ag.D-6135.

Submitted: 24-07-2024 **Accepted:** 16-09-2024 **Online:** 07-10-2024

MATERIALS AND METHODS

Cowpea seeds of the variety KSP 178 were sown in disposable glasses and three plantlets per glass were maintained. Adults of *A. craccivora* were collected from various cowpea fields of Instructional Farm- 2, Siksha 'O' Anusandhan (Deemed to be University) Bhubaneswar, India during 2021-2022 and released on cowpea seedlings to raise a stable stockpile of the aphid population. Adults of *C. sexmaculata* were then collected and kept in a rearing cage (30 cm length, 30 cm breadth and 30 cm height) and supplied with nearly ten cowpea plantlets infested heavily by *A. craccivora*. *C. sexmaculata* laid eggs in clusters on the leaves and on the side of the rearing cage. They were removed with the help of a fine camel hair brush and placed in separate Petri dishes of 110 mm diameter layered with blotting paper for further rearing. Upon hatching tender twigs of cowpea infested with aphids were kept in the Petri dishes by covering the cut ends of the twigs with moistened cotton swab to keep them fresh and succulent. After hatching the grubs were raised for one generation from the egg to adult stage before conducting the research. Studies on the growth and predatory potential of *C. sexmaculata* were conducted at different temperatures *i.e.*, 20°C, 25°C, 30°C and 35°C respectively inside a BOD incubator, maintaining ten treatments each.

Growth

The duration of the first instar was measured as the time interval between the date of hatching and the date of first moulting. The subsequent durations were recorded as the time interval between moults. Pupal period was calculated as the time interval between pupal formation and adult emergence. Adult longevity was calculated as the time interval between the adult emergence and death. The methodologies adopted were somewhat similar to Singh *et al.* (2003) with little modifications. Growth stages of *Cheilomenes sexmaculata* was represented in Fig 1.

Feeding potential

To calculate feeding potential ten numbers of 1st, 2nd, 3rd and 4th instar grubs were supplied with counted number of aphids in the morning (9:00 am to 11:00 am). Observations were taken at 24 h intervals by subtracting the remaining number of aphids from the number of aphids supplied in the beginning. Thus, the total number of ten adult males and ten adult females were kept separately in 20 Petri dishes (one in each) maintaining ten replications.

Effect of insecticides on *C. sexmaculata*

Six insecticides *viz.*, clothianidin 50% WDG, abamectin 1.9% EC, thiamethoxam 25% WG, dimethoate 30 EC, acephate 75 SP, imidacloprid 17.8% SL of doses as mentioned in Table 1 were evaluated for their detrimental effect on *C. sexmaculata* maintaining three replications and for control, only water was used. Ten freshly laid eggs of the same duration, laid at the same time were taken for each replication and mortality evaluated in accordance to hatchability percentage *i.e.,* number of eggs hatched was subtracted from the number of eggs taken initially. Similarly, ten grubs of equal age were taken from each instar. For the study on pupae, ten pupae were taken in each replication and pupal mortality was analysed based upon the number of pupae from which adults emerged. The study was conducted on adult beetles irrespective of sex. All experiments were performed using the direct spray method and prey feed contamination method, except for eggs and pupae, which were only conducted under the direct spray method.

Direct spray method

Direct spray method was performed by spraying the insecticide formulations directly on to the aphids and the

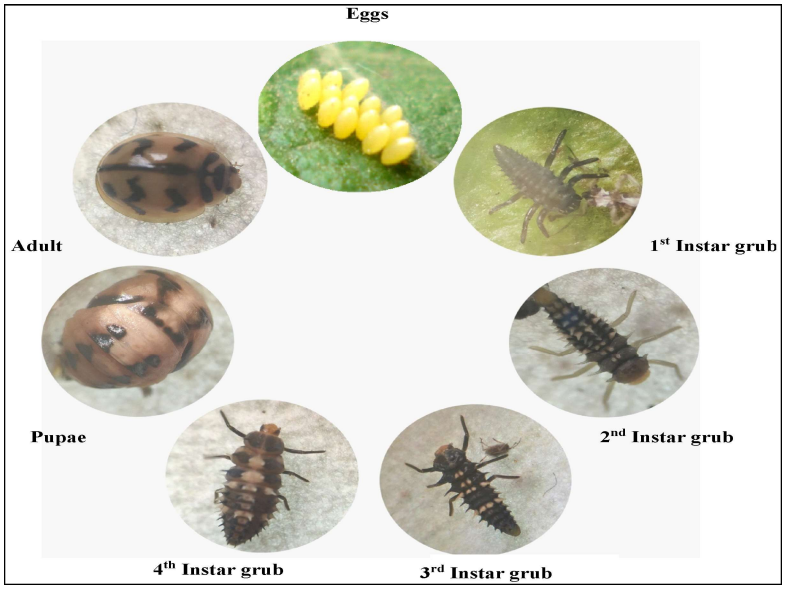


Fig 1: Life Cycle of *C. sexmaculata.*

grubs and beetles were made to eat them. In case of eggs and pupae the insecticides were sprayed directly up on them to take observations. This method was adopted from Shanmugapriya and Muralidharan (2017).

Prey feed contamination method

In case of prey feed contamination, the insecticide formulations were first sprayed on fresh twigs and after releasing aphids they were supplied to the beetles as food. Readings were taken after 24, 48 and 72 hours to assess the mortality percentage.

Statistical analysis

The data obtained from the experiments were statistically analyzed using one factor (ANOVA) in completely randomized design (CRD) as suggested by Gomez and Gomez (1984). The transformed values of mortality for all stages of *C. sexmaculata* were obtained by arc sin transformation.

RESULTS AND DISCUSSION

Duration of developmental stages and morphometry at different temperature

Data on biology of *C. sexmaculata* implied that the growth and developmental period was significantly higher at the temperature range of 25°C to 30°, whereas developmental period at 20°C and 35°C was significantly less indicating unsuitability of the climate. The developmental period at 20°C (1.3±0.07 days, 1.7±0.18 days, 1.7±0.19 days, 2.3±0.05 days, 2.6±0.11 days, 2.2±0.09 days, 12.1±0.12 days and 15.8± 0.02 days) was shorter than that at 25°C (2.3±0.13 days, 2.6±0.08 days, 1.8±0.19 days, 2.5±0.09 days, 2.8±0.07 days, 2.6±0.08 days, 13.4±0.25 days and 16.2±0.03 days) of egg, 1st instar, 2nd instar, 3rd instar, 4th instar, pupa, adult male and adult female respectively. The developmental period increased significantly at 30°C (3.0±0.06 days, 2.9±0.16 days, 2.2±0.25 days, 3.3±0.15 days, 3.6±0.13 days, 3.1±0.18 days, 16.6±0.39 days and 20.2±46 days) but declined thereafter at 35°C (2.7±0.06 days, 2.7±0.12 days, 2.1±0.09 days, 2.8±0.09 days, 3.0±0.04 days, 3.2±0.03 days, 14.9±0.12 days and 17.1±0.34 days) of egg, 1st instar, 2nd instar, 3rd instar, 4th instar, pupa, adult male and adult female respectively, which indicated that 25°C to 30°C was the most suitable temperature for growth and development of *C. sexmaculata* (Table 1). Consequent study indicated that adult females lived longer (15.8±0.02 days, 16.2±0.03 days, 20.2±0.46 days and 17.1±0.34 days) than the males (12.1±0.2 days, 13.4±0.25 days, 16.6±0.39 days and 14.9±0.12 days) at 20°C, 25°C, 30°C and 35°C respectively. Wang *et al.* (2013) reported that *C. sexmaculata* is highly sensitive to temperature variation. Increased temperature resulted in an increase in developmental duration and increased growth at different stages of the ladybird, but only up to 30°C thereafter decreased at 35°C. Aman *et al*. (2023) also recorded a decrease in duration of development at 35°C from 30°C. This research will help the multiplication and release of ladybirds in farmers′ fields to

Table 1: Developmental period, morphometry and feeding potential of *C. sexmaculata* at different temperature.

Developmental stages	Developmental period (Days) (Mean+S.E)				Length (mm) (Mean+S.E)				Breadth (mm) (Mean+S.E)				Feeding potential (Mean+S.E)			
	20°C	25°C	30°C	35°C	20°C	25°C	30°C	35°C	20°C	25°C	30°C	35°C	20°C	25°C	30°C	35°C
Egg	1.3±0.07	2.3±0.13	3.0±0.06	2.7±0.06	0.63±0.07	1.04±0.04	1.2±0.06	1.1±0.04	0.07±0.06	0.29±0.1	0.45±0.03	0.38±0.07				
1st Instar	1.7±0.18	2.6±0.08	2.9±0.16	2.7±0.12	1.1±0.03	1.42±0.06	1.69±0.03	1.49±0.03	0.31±0.09	0.38±0.08	0.65±0.03	0.42±0.2	8.9±0.56	10±0.55	15.9±0.72	12.2±1.07
2nd Instar	1.7±0.19	1.8±0.19	2.2±0.25	2.1±0.09	2.3±0.04	2.9±0.09	4.28±0.06	4.13±0.1	0.38±0.1	0.43±0.19	0.89±0.21	0.68±0.25	23±1.56	29.2±1.01	49.4±1.86	34.61±1.61
3rd Instar	2.3±0.05	2.5±0.09	3.3±0.15	2.8±0.09	3.1±0.1	4.6±0.15	5.95±0.04	5.74±0.13	0.62±0.1	0.71±0.28	1.2±0.42	0.83±0.18	34±1.26	39.7±1.18	68.1±1.36	58.5±1.71
4th Instar	2.6±0.11	2.8±0.07	3.6±0.13	3.0±0.04	4.2±0.09	6.5±0.12	7.7±0.09	7.37±0.32	0.91±0.32	1.1±0.19	1.46±0.09	1.36±0.01	68.3±1.49	73.9±1.72	134.9±1.71	125.1±1.48
Pupa	2.2±0.09	2.6±0.08	3.1±0.18	3.2±0.03	3.7±0.12	3.9±0.13	4.3±0.41	4.1±0.1	2.0±0.04	2.14±0.70	2.7±0.06	2.32±0.01				
Adult male	12.1±0.12	13.4±0.25	16.6±0.39	14.9±0.12	3.6±0.16	4.24±0.09	4.8±0.13	4.36±0.06	3.1±0.09	3.46±0.11	3.9±0.13	3.75±0.07	319.9±5.47	396.2±5.49	588.8±4.35	493.4±4.87
Adult female	15.8±0.02	16.2±0.03	20.2 ±0.46	17.1±0.34	4.1±0.04	4.95±0.01	5.6±0.1	5.35±0.03	3.8±0.43	4.07±0.15	4.33±0.1	4.16±0.21	482±5.63	569.1±5.78	633±5.71	588.7±6.67

check aphid population. The results in Table 1 and also showed that at 20°C the developmental periods were shortened and the physical growth was also the least. Females led an increased life span as well as more significant in size than the males.

The length and breadth of egg, grub and adults indicated that 30°C is the most suitable temperature for the overall growth since every stage showed maximum morphometric parameters at that temperature followed by 25°C. The size diminished 20°C which is the least followed by at 35°C compared to other two temperatures (25°C and 30°C). Temperature sensitivity can be clearly seen in respect of low and high regimes with this ladybird.

Feeding potential

The feeding potential of *C. sexmaculata* grubs and adults was highest at 30°C and lowest at 20°C. Females consumed far more aphids (482±5.63 aphids, 569±5.78 aphids, 633±5.71 aphids and 588.7±6.67 aphids) than the males (319.9±5.47 aphids, 396.2±5.49 aphids, 588.8±4.35 aphids and 493.4±4.87 aphids) at 20°C, 25°C, 30°C and 35°C respectively. Thus, an increased life-span in the range of 25°C to 30°C surely helped. Furthermore, 4th instar grubs ate at the maximum voracity compared to the rest of the grub stages. The feeding potential was observed to be highest at 30°C (15.9±0.72 aphids, 49.4 ± 1.86 aphis, 68.1±1.36 aphids, 134.9±1.71 aphids, 588.8±4.35 aphids and 633±5.71 aphids) followed by 25°C (10±0.55 aphids, 29.2±1.01 aphids, 39.7±1.18 aphids, 73.9±1.72 aphids in case of 1st instar, 2nd instar, 3rd instar, 4th instar, adult male and adult female respectively. As the temperature decreased the amount of apatite decreased (Table 1).

Solangi *et al.* (2007) emphasized that as the insects metamorph into adults, their preying efficiency increases drastically. The consumption of aphids was more significant in 3rd and 4th instar (Aniyaliya *et al*., 2022). Later the feeding potential decreased towards the end of 4th instar just before pupation (Mishra *et al.,* 2012). Adults consumed more aphids than the grubs (Kumar *et al.,* 2013). Furthermore, females consume more aphids than males probably because of their increased life span and vigor (Geethu *et al*., 2020). This research also highlighted an increased consumption of aphids by ladybird with an increase in temperature till 30°C. Beyond that the feeding declined (Wang *et al*., 2013). Similar trend is also seen at 20°C. Table 1 showed that the optimum temperature range for maximum feeding was 25°C to 30°C. Within this range grubs and adults devour significantly more aphids than 20°C and 35°C. The maximum consumption was seen in case of adult female at 30°C which was 633±5.71 and least feeding was seen at 20°C by 1st instar grub which was 8.9±0.56.

Effect of insecticides

Direct application method

The number of eggs treated with dimethoate 30EC showed the highest percentage of failure to hatch (84.01%) after the incubation period. Since mortality of eggs was recorded on the basis of hatching, it was not imperative to assess mortality in the time dimension. Similar trend was also observed for the pupae (73.31%). Grubs of 1st instar, 2nd instar, 3rd instar, 4th instar and adults showed maximum mortality when treated with dimethoate 30EC (77.81%, 70.69%, 67.44%, 67.25% and 59.70%) followed by acephate 75SP (53.66%, 46.09%, 43.97%, 43.85% and 38.92%) and least with clothianidin 50% WDG (4.66%, 4.13%, 3.94%, 3.93% and 3.49%). Mortality also increased with time. The mortality trend was 24 HAT > 48 HAT > 72 HAT. Morality is higher in case of young neonates than in grown-up ones. The results under dimethoate 30 EC were significantly different from those of all other treatments. The result of the poor performer clothianidin 50% WDG was similar to that of thiamethoxam 25% WG. Furthermore, the result under abamectin 1.9% EC was similar to that of imidacloprid 17.8% SL. All the other treatments were significantly different (Table 2)

The results in Table 2 showed that the mortality of eggs was highest when treated with dimethoate 30 EC *i.e.* 73.31%. This was significantly different from that of the other treatments. The lowest mortality rate was recorded when treated with clothianidin 50% WDG. This indicated that organophosphate insecticides were much more detrimental to the bio-control agent and should not be used when the goal is to manage pest populations catering to environmental sustainability. Shanmugapriya and Muralidharan (2017) also found similar trend in their experiment. All other stages were similarly affected by pesticides use. The mortality percentage with thiamethoxam 25% WG was similar to that with clothianidin 50% WDG (Sanghani *et al*., 2018) and Clothianidin 50% WDG showed no significant difference compared to the control treatment (Sanghani *et al*., 2018). Hence clothianidin 50% WDG was the safest insecticide among the insecticides used in the experiment. The effects of insecticides decreased as the ladybird grew but increased across all stages when observed for longer period of time. The mortality trend in time dimension was 72 HAT> 48 HAT> 24 HAT.

Prey feed contamination method

The grubs of were subjected to this method. Mortality rate rose rapidly in the case of clothianidin 50% WDG (17.41%, 16.98%, 16.95%, 14.02% and 13.33%) and imidacloprid 17.8 % SL (43.90%, 40.26%, 38.02%, 32.94% and 31.33%) for 1st instar, 2nd instar, 3rd instar, 4th instar and adults respectively compared to the direct application method. All other treatments also resulted in increased mortality across 24, 48 and 72 HAT.

Analyzing Table 3 provided us with the result that when insecticide-treated aphids were given to ladybirds instead of direct application, overall mortality increased. The increase in mortality rate was higher in case of systemic neonicotinoids, which failed to significantly affect in the direct application method. According to Sheela and Shinde

Table 2: Mean per cent mortality of *C. sexmaculata* in direct application method.

Treatments	Insecticides	Mean per cent mortality																
		Egg	1st Instar			2nd Instar			3rd Instar			4th Instar			Pupae	Adult		
			24 HAT	48 HAT	72 HAT	24 HAT	48 HAT	72 HAT	24 HAT	48 HAT	72 HAT	24 HAT	48 HAT	72 HAT		24 HAT	48 HAT	72 HAT
T_1	Clothianidin	34.41	4.66	7.69	14.41	4.13	6.98	13.89	3.94	6.66	13.72	3.93	6.63	13.69	13.66	3.49	5.90	13.04
	50% WDG	(35.91)	(12.46)	(16.09)	(22.30)	(11.72)	(15.31)	(21.88)	(11.44)	(14.95)	(21.74)	(11.43)	(14.92)	(27.71)	(21.69)	(10.76)	(14.05)	(21.16)
T_2	Abamectin	61.66	33.98	35.50	41.48	30.56	34.22	38.65	29.35	33.98	35.76	29.12	33.75	34.21	33.72	25.62	31.82	32.13
	1.9% EC	(51.74)	(35.65)	(36.57)	(40.09)	(33.56)	(35.80)	(38.43)	(32.80)	(35.65)	(36.72)	(32.65)	(35.51)	(35.79)	(35.49)	(30.40)	(34.33)	(34.52)
T_3	Thiamethoxam	41.46	13.46	28.62	29.17	11.52	27.60	28.12	10.99	25.94	27.78	10.96	24.95	27.72	27.49	9.73	23.22	26.40
	25% WG	(40.08)	(21.52)	(32.34)	(32.68)	(19.84)	(31.69)	(32.02)	(19.36)	(30.61)	(31.80)	(19.33)	(29.96)	(31.76)	(31.62)	(18.17)	(28.80)	(30.91)
T_4	Dimethoate	84.01	77.81	80.53	82.59	70.69	74.81	77.66	67.44	72.99	73.97	67.25	70.20	73.88	73.31	59.70	65.33	70.30
	30EC	(66.42)	(61.89)	(63.81)	(65.33)	(57.22)	(59.87)	(61.79)	(55.20)	(58.68)	(59.32)	(55.09)	(56.91)	(59.26)	(58.89)	(50.59)	(53.92)	(56.97)
T_5	Acephate	69.33	53.66	56.40	56.42	46.09	54.23	54.39	43.97	51.12	53.56	43.85	49.26	53.47	53.33	38.92	45.76	51.90
	75 SP	(56.37)	(47.09)	(48.67)	(48.68)	(42.75)	(47.42)	(47.51)	(41.53)	(45.64)	(47.04)	(41.46)	(44.57)	(46.98)	(46.90)	(38.59)	(42.56)	(46.08)
T_6	Imidacloprid	53.66	26.49	32.34	32.85	22.67	29.82	31.17	21.62	28.45	30.89	21.56	28.32	30.69	30.63	19.14	25.20	29.26
	17.8% SL	(47.09)	(30.97)	(34.65)	(34.97)	(28.43)	(33.09)	(33.93)	(27.70)	(32.23)	(33.76)	(27.66)	(32.15)	(33.64)	(33.60)	(25.94)	(30.13)	(32.74)
T_7	Control	28.76	1.41	2.14	3.98	1.33	1.69	3.65	0.66	0.66	3.33	0.33	0.33	3.21	2.69	0.00	0.00	0.69
		(32.43)	(6.81)	(8.41)	(11.50)	(6.62)	(7.46)	(11.01)	(4.65)	(4.65)	(10.51)	(3.29)	(3.29)	(10.32)	(9.43)	(0.00)	(0.00)	(4.76)
SEM±		2.44	3.19	2.38	2.03	2.89	2.33	2.00	2.54	2.22	1.97	3.06	2.27	2.31	2.13	2.32	2.07	2.21
$CD_{(0.05)}$		7.52	9.84	7.33	6.25	8.90	7.18	6.16	7.83	6.84	6.07	9.43	6.99	7.13	6.56	7.15	6.38	6.81

The values inside the parentheses are arcsine transformed values, whereas those outside are the original values.

HAT = Hours after treatment.

Table 3: Mean per cent mortality of *C. sexmaculata* in prey feed contamination method.

Treatments	Insecticides	Mean per cent mortality														
		1st Instar			2nd Instar			3rd Instar			4th Instar			Adult		
		24 HAT	48 HAT	72 HAT	24 HAT	48 HAT	72 HAT	24 HAT	48 HAT	72 HAT	24 HAT	48 HAT	72 HAT	24 HAT	48 HAT	72 HAT
T_1	Clothianidin	17.41	20.66	25.89	16.98	18.41	25.66	16.95	18.39	25.39	14.02	17.29	24.03	13.33	16.66	23.33
	50% WDG	(24.66)	(27.03)	(30.58)	(24.33)	(25.40)	(30.43)	(24.31)	(25.39)	(30.25)	(21.98)	(24.57)	(29.35)	(24.41)	(24.08)	(28.88)
T_2	Abamectin	47.98	54.17	57.36	46.80	48.27	50.89	46.71	48.22	50.41	38.64	46.71	49.98	36.74	43.69	46.43
	1.9% EC	(43.84)	(47.9)	(49.23)	(43.16)	(44.00)	(45.51)	(43.11)	(43.97)	(45.23)	(38.43)	(43.11)	(44.98)	(37.31)	(41.37)	(42.95)
T_3	Thiamethoxam	21.83	24.81	25.12	21.49	22.14	22.91	21.36	22.03	22.46	17.58	21.56	21.66	16.72	20.00	20.00
	25% WG	(27.85)	(29.87)	(30.07)	(27.61)	(28.06)	(28.59)	(27.52)	(27.99)	(28.28)	(24.78)	(27.66)	(27.73)	(24.13)	(26.56)	(26.56)
T_4	Dimethoate	77.93	87.34	89.99	75.67	77.94	81.69	75.15	77.55	81.44	70.58	74.86	78.86	66.66	70.41	76.69
	30EC	(61.97)	(69.15)	(71.55)	(60.44)	(61.98)	(64.66)	(60.09)	(61.71)	(64.48)	(57.15)	(59.90)	(62.62)	(54.73)	(57.04)	(61.13)
T_5	Acephate	65.81	70.03	74.81	63.79	65.40	70.14	63.39	65.19	70.03	53.00	59.21	64.81	50.41	56.46	60.31
	75 SP	(54.21)	(56.80)	(59.87)	(53.00)	(53.96)	(56.8)	(52.76)	(53.84)	(56.80)	(46.71)	(50.30)	(53.61)	(45.23)	(48.71)	(50.94)
T_6	Imidacloprid	43.90	44.94	49.99	40.26	42.16	48.21	38.02	40.24	47.89	32.94	39.23	44.98	31.33	36.29	43.33
	17.8% SL	(41.49)	(42.09)	(44.99)	(39.38)	(40.48)	(43.97)	(38.06)	(39.37)	(43.79)	(35.02)	(38.78)	(42.11)	(34.03)	(37.04)	(41.16)
T_7	Control	0.83	0.83	2.41	0.69	0.73	1.98	0.41	0.69	1.61	0.33	0.41	1.21	0.00	0.00	0.33
		(5.22)	(5.22)	(8.93)	(4.76)	(4.90)	(8.08)	(3.67)	(4.76)	(7.28)	(3.29)	(3.67)	(6.31)	(0.00)	(0.00)	(3.29)
SEM±		3.20	3.15	3.64	3.14	2.61	3.57	3.12	2.49	3.51	2.85	2.35	3.49	2.96	2.27	3.03
$C.D_{(0.05)}$		9.86	9.71	11.21	9.67	8.04	11.00	9.62	7.66	10.81	8.78	7.24	10.75	9.12	6.94	9.33

The values inside the parentheses are arcsine transformed values, whereas those outside are the original values.

HAT= Hours after treatment.

(2019) this is due to the accumulation of systemic insecticides in the aphid body which were used as feed for *C. sexmaculata* and thus systemic insecticides like imidiacloprid and clothianidin found a get way to enter the body of ladybirds. Although clothianidin 50% WDG showed significantly different mortality from controlled treatment it cannot be considered highly leather and still holds the position of least toxic to ladybirds. dimethoate 30 EC topped the list at 24, 48 and 72 HAT.

Conclusion

These studies indicated that 30°C is the most suitable temperature for the growth, development and feeding of the coccinellid predator whereas the increase or decrease of temperature slowed down the same. Lower temperature of 20°C is more detrimental for the growth, development and feeding capacity as compared to higher temperature of 35°C. Among the insecticides dimethoate was the most toxic one for all life stages and clothianidin was found to be the least toxic.

Acknowledgement

The authors express gratitude to the Professor and Head and advisor during the research period of Department of Entomology Siksha 'O' Anusandhan (Deemed to be University) Bhubaneswar, India for their guidance and support during research and manuscript writing process.

Conflict of interest

I on the behalf of all authors declare that we have no conflicts of interest related to this work.

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