



EFFECT OF TEMPERATURE ON BIOLOGY OF *BREVICORYNE BRASSICAE* L. AND *MYZUS PERSICAE* SULZER OF CABBAGE

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ABSTRACT

Knowing the effect of temperatures on growth and development of crop pests is essential. In this study, effect of six temperature regimes on the cabbage aphids *Brevicoryne brassicae* L., and *Myzus persicae* Sulzer was studied in Manipur, India. For both the species, 25°C was found to be the optimal in relation to the most of the parameters studied; *B. brassicae* could not tolerate the extreme temperatures and died in its 2nd nymphal stage. A decrease in reproductive periods with increase in temperature may accommodate 1-2 additional brood(s) a year, consequently will lead to increased damage to cabbage, more particularly, under staggered transplanting.

Key words: *Brevicoryne brassicae*, *Myzus persicae*, temperature, aphid, cabbage, Allen's rule, Bergmann's rule, morphometrics, thermotolerance, global warming, Manipur

Cabbage aphid *Brevicoryne brassicae* L. and green peach aphid *Myzus persicae* Sulzer are the most damaging pests on cabbage (Theunissen, 1989). Temperature greatly affects the development, reproduction, survival and other behaviour of insect pests (Bursell, 1974; Summers et al., 1984; Bale et al., 2007). Temperature related studies have been used extensively to predict population dynamics and developmental rate of aphids (De Loach, 1974; Hayakawa et al., 1990; Soh et al., 2018); however, geographically separated populations of aphids may differ in their response to temperature (Campbell et al., 1974). Studies on the effect of temperatures on the life parameters of *B. brassicae* and *M. persicae* have not been done in the northeast region of India. A basic understanding of the insect's development in relation to temperature variation is essential for planning IPM strategies. This is particularly required for the temperature regimes predicted to occur in a place due to changing climate. The temperature in the state of Manipur fluctuates within 21.5-29.4°C in summer and within 4.3-21.7°C during winter (<https://www.weather-ind.com/en/india/imphal-climate#temperature>). If no measures are taken average temperatures in India are predicted to increase by 1.5 to 3°C (Mani et al., 2018). Thus, Manipur may experience the highest maximum temperature of 24.7°C during winter and 32.4°C in summer. No comparative study has been done on biology of aphids under different temperatures

in the northeast. Hence, this study to know the effect of temperatures on the biology of *B. brassicae* and *M. persicae*.

MATERIALS AND METHODS

The study was conducted in the Entomology Laboratory of the College of Agriculture, Central Agricultural University Imphal, Manipur (24°48'52.4"N, 93°53'25.2"E). *Brevicoryne brassicae* and *M. persicae* were subjected to six constant temperature regimes viz, 10°, 15°, 18°, 20°, 25°, and 30°C, with a 12 hr. photoperiod and a RH of 70± 10%. Rearing methodology was adopted as described by Ramalho et al. (2015). Colonies of *B. brassicae* and *M. persicae* were raised separately from the field populations collected from the experimental farm of the University. Colonies were maintained on cabbage seedlings raised in plastic pots of 10 cm dia containing sterile potting mix and covered with glass chimney (10 cm dia and 170 cm in height). The upper portions of the chimney were covered with muslin cloth held tight by the rubber band. Fifty pots were maintained in the laboratory in order to get sufficient number of newly laid nymph every day. Randomly selected apterous females from the stock culture were transferred in sufficient numbers to the excised cabbage leaf disc placed upside down in petridishes. Offspring born within 24 hr were confined individually on cabbage leaf discs in petri dishes. Such individuals of both *B. brassicae* and *M. persicae* under observations

were transferred separately everyday to fresh leaf disc. Immature stages and adults were observed and their survivorship recorded. Developmental periods were recorded separately. Differences in parameters were tested using ANOVA, with significant differences ones compared using LSD tests. Error graphs and trend lines are also drawn.

RESULTS AND DISCUSSION

Period of life stages: *B. brassicae* could not tolerate the extreme temperatures (10°C and 30°C) and died in the 2nd nymphal stage. Similar to the present result, the highest mortality of *B. brassicae* was also recorded at 30°C by Pal et al. (2008); likewise, 10, 30, and 35°C have been reported to be more lethal to *B. brassicae* than 15, 20, and 25°C (Soh et al., 2018). Except for few occasions, the pre-reproductive, reproductive, and post-reproductive periods of both the aphid species decreased significantly with the increase of temperature (Table 1). Such a decrease in reproductive periods may accommodate 1-2 additional brood(s) in a crop season which may lead to potential increase in population size of aphid and more damage to cabbage crop. If it happens, the additional brood is likely to cause more damage, since the transplanting of cabbage is staggered on account of small land-holdings of poor/ marginal farmers of Manipur and their inadequate knowledge on resource allocation in relation to pest management. Such an increase in brood number has also been reported from other countries too, e.g., in the UK, an increase in temperature of only 2°C would allow the number of generations/ years to increase from 18 to 23°C with a potentially huge increase in population size (Harrington et al., 1999). The pre-reproductive, reproductive and post-reproductive periods of both *B. brassicae* and *M. persicae* were the shortest at 25°C; similar results were reported by Campbell and Mackauer (1977) in pea aphid *Acyrtosiphon pisum*.

The adult longevity varied at different temperature regimes (Table 1); longevity of *M. persicae* was more than *B. brassicae* at each temperature regime by about 4-6 days. Adult longevity differed significantly in temperature regimes in *B. brassicae* also; however, it was at par at 18 and 30°C in case of *M. persicae* (Table 1). It was the longest at 15°C for *B. brassicae* and at 10°C for *M. persicae*. Under the predicted elevated temperature on account of global warming, *M. persicae* is likely to pose more threat to cabbage in the state of Manipur. Higher surviving ability with the longest adult longevity of *M. persicae* at low temperature of

10°C might help it establish and intensify the damage on cabbage in hilly tracts that usually experience lower minimum temperature than in plains. One study carried out by Zhou et al. (1995) reveals that temperature, especially the winter temperature, is the dominant factor affecting phenology for five species of aphids, including *M. persicae*, and for 1°C increase in average winter temperature advanced the migration phenology by 4-19 days depending on species. Temperature has also been reported to be one of most influential weather factors on mustard aphid in some recent studies under Indian condition (Baviasa et al. 2018; Das et. al., 2019).

Morphometrics: The nymphal body length, body width, antennal length and cornicle length of both the aphid species were positively related with temperature (Table 2-5) up to 25°C. At 30°C, these parameters showed an abrupt decline in *M. persicae*. Even though 30°C is not lethal to *M. persicae*, as in case of *B. brassicae*, it may affect the vigour of former species. The maximum body length, width, antennal and cornicle length of both the aphid species were observed at 25°C; however, minimum lengths of these parameters were observed for *B. brassicae* at 15°C and for *M. persicae* at 10°C. At 30°C, the tested morphometric parameters declined abruptly in *M. persicae*. The morphological data are in general agreement with the Allen's rule that "protruding body parts" are relatively shorter in cooler temperatures. The data are also in agreement to a great extent with Bergmann's Rule which states that individual body size tends to be less in the warmer parts of a species' range. Bergmann's Rule came in to effect in the present study in five out of six temperatures studied.

Temperature affects the size of aphids and they develop smaller at higher temperature (Wool, 1977; Nealls et al., 1984; Rao et al., 2016; Tiwari and Singh, 2018). The adult weight of aphids, *Acyrtosiphon pisum* on peas (Lamb et al., 1987); and *Macrosiphum euphorbiae* on *Solanum dulcamara* decrease with increase in temperatures (Flynn et al., 2006). In Taiwan, global warming is likely to affect life history traits and demographic parameters of *Aphis craccivora*-Chen et al. (2013). Murdie (1969) also indicated a relative shortening of legs and antennae of pea aphid at higher temperatures. One might also expect to be smaller below the optimum temperature (Blackman and Spence, 1994). In the present study, 25°C has emerged as the optimum temperature for both the aphid species; however, further investigation with due consideration of sets with narrower temperature range within 20-30°C would find the optimum temperature

Table 1. Reproductive periods and adult duration of *B. brassicae* and *M. persicae* at different temperatures regimes

Temperature (°C)	Duration in days (Mean± S.D.)			
	<i>B. brassicae</i>		<i>M. persicae</i>	
	Pre-reproductive period	Reproductive period	Pre-reproductive period	Reproductive period
10	(-)	(-)	2.97±0.02 ^a	31.8±0.65 ^a
15	1.95±0.01 ^a	21.0±0.5 ^a	1.94±0.03 ^b	27.2±0.41 ^c
18	1.86±0.02 ^b	18.0±0.35 ^b	1.83±0.02 ^c	24.8±0.41 ^c
20	1.34±0.02 ^c	14.8±0.65 ^c	1.73±0.01 ^d	21±0.50 ^d
25	0.97±0.01 ^d	13.6±0.6 ^c	1.04±0.03 ^e	17.6±0.44 ^e
30	(-)	(-)	1.92±0.01 ^b	25.4±0.56 ^c
SE (d)	0.22	0.55	0.02	0.66
CD (P=0.05)	0.04*	1.2*	0.05*	1.39*
				0.06
				0.13*
				0.66
				1.38*
				36.80±0.64 ^a
				31.02±0.44 ^b
				28.42±0.43 ^c
				24.42±0.48 ^d
				19.71±0.41 ^e
				29.19±0.56 ^c

Table 2. Nymphal body length (in mm; Mean± S.D.) of instars of *B. brassicae* and *Myzus persicae* at different temperature regimes

Temperature (°C)	<i>B. brassicae</i>							
	Instar I	Instar II	Instar III	Instar IV	Instar I	Instar II	Instar III	Instar IV
10	0.62±0.001 ^{de}	(-)	(-)	(-)	0.629±0.003 ^c	0.66±0.009 ^f	0.69±0.005 ^e	0.74±0.016 ^e
15	0.63±0.004 ^{cd}	0.74±0.005 ^c	0.86±0.004 ^c	1.02±0.001 ^c	0.64±0.002 ^d	0.75±0.009 ^d	0.86±0.01 ^c	1.1±0.003 ^d
18	0.64±0.01 ^c	0.76±0.01 ^c	0.87±0.001 ^c	1.03±0.001 ^c	0.66±0.01 ^{bc}	0.78±0.003 ^c	0.89±0.006 ^c	1.07±0.007 ^c
20	0.67±0.005 ^b	0.83±0.04 ^b	1.14±0.03 ^{ab}	1.34±0.01 ^b	0.67±0.004 ^b	0.88±0.006 ^b	1.12±0.002 ^b	1.37±0.007 ^b
25	0.71±0.01 ^a	0.94±0.005 ^a	1.15±0.02 ^a	1.41±0.02 ^a	0.73±0.01 ^a	0.96±0.007 ^a	1.22±0.016 ^a	1.53±0.01 ^a
30	0.63±0.001 ^{cde}	(-)	(-)	(-)	0.63±0.003 ^{de}	0.68±0.004 ^e	0.73±0.01 ^d	1.04±0.01 ^d
SE (d)	0.007	0.02	0.02	0.01	0.008	0.009	0.01	0.01
CD (P=0.05)	0.01*	0.05*	0.04*	0.03*	0.01*	0.01*	0.03*	0.02*

Each of the tabulated data in Table 1 & 2 is mean value of 5 replications. (-) Life cycle not completed. Mean values in columns superscripted by the same letter are statistically *at par*.

Table 3. Nymphal body width in mm (Mean± S.D.) of *B. brassicae* and *M. persicae* at different instars at different temperature regimes

Temperature (°C)	<i>B. brassicae</i>							
	Instar I	Instar II	Instar III	Instar IV	Instar I	Instar II	Instar III	Instar IV
10	0.26±0.05 ^{de}	(-)	(-)	(-)	0.25±0.01 ^e	0.28±0.007 ^e	0.31±0.006 ^a	0.4±0.013 ^e
15	0.27±0.001 ^{cd}	0.36±0.005 ^c	0.48±0.02 ^c	0.60±0.005 ^c	0.27±0.003 ^{cde}	0.36±0.004 ^c	0.5±0.006 ^c	0.6±0.005 ^c
18	0.29±0.01 ^{abc}	0.37±0.01 ^c	0.52±0.03 ^{bc}	0.61±0.01 ^c	0.29±0.01 ^{bc}	0.37±0.008 ^c	0.53±0.01 ^b	0.62±0.007 ^c
20	0.30±0.004 ^{ab}	0.40±0.01 ^{ab}	0.54±0.01 ^b	0.66±0.01 ^b	0.3±0.01 ^{ab}	0.39±0.01 ^b	0.55±0.008 ^b	0.65±0.008 ^b
25	0.31±0.01 ^a	0.42±0.001 ^a	0.62±0.01 ^a	0.88±0.01 ^a	0.32±0.01 ^a	0.41±0.004 ^a	0.63±0.01 ^a	0.88±0.007 ^a
30	0.27±0.01 ^{cde}	(-)	(-)	(-)	0.28±0.01 ^{bed}	0.3±0.005 ^d	0.33±0.008 ^{de}	0.46±0.006 ^d
SE (d)	0.012	0.008	0.024	0.008	0.011	0.008	0.013	0.011
CD (P=0.05)	0.025*	0.017*	0.054*	0.017*	0.024*	0.017*	0.028*	0.023*

Table 4. Nymphal antennal length in mm (Mean± S.D.) of *B. brassicae* and *M. persicae* at different instars at different temperature regimes

Temperature (°C)	<i>B. brassicae</i>				<i>M. persicae</i>			
	Instar I	Instar II	Instar III	Instar IV	Instar I	Instar II	Instar III	Instar IV
10	0.22±0.03 ^{de}	(-)	(-)	(-)	0.23±0.01 ^{de}	0.27±0.008 ^c	0.31±0.006 ^c	0.51±0.004 ^b
15	0.24±0.005 ^{cd}	0.34±0.01 ^c	0.54±0.02 ^{bc}	0.61±0.005 ^d	0.25±0.005 ^{cd}	0.36±0.007 ^c	0.4±0.006 ^d	0.61±0.004 ^d
18	0.25±0.004 ^e	0.36±0.007 ^b	0.58±0.06 ^{bc}	0.63±0.07 ^c	0.28±0.007 ^b	0.38±0.006 ^b	0.56±0.05 ^c	0.63±0.005 ^c
20	0.29±0.006 ^{ab}	0.37±0.001 ^{ab}	0.60±0.005 ^b	0.87±0.001 ^b	0.31±0.005 ^a	0.39±0.003 ^a	0.63±0.02 ^b	0.87±0.005 ^b
25	0.30±0.006 ^a	0.38±0.002 ^a	0.80±0.01 ^a	1.06±0.006 ^a	0.32±0.009 ^a	0.4±0.006 ^c	0.74±0.009 ^a	1.07±0.006 ^a
30	0.23±0.007 ^{cde}	(-)	(-)	(-)	0.24±0.009 ^{de}	0.3±0.004 ^d	0.38±0.009 ^{de}	0.55±0.007 ^e
SE (d)	0.01	0.009	0.041	0.007	0.01	0.007	0.033	0.007
CD (P=0.05)	0.021*	0.019*	0.089*	0.015*	0.022*	0.016*	0.070*	0.016*

Table 5. Nymphal cornicle length in mm (Mean± S.D.) of *B. brassicae* and *M. persicae* at different temperature regimes.

Temperature (°C)	<i>B. brassicae</i>				<i>M. persicae</i>			
	Instar I	Instar II	Instar III	Instar IV	Instar I	Instar II	Instar III	Instar IV
10	0.021±0.001 ^e	(-)	(-)	(-)	0.024±0.001 ^{de}	0.036±0.0008 ^{de}	0.04±0.006 ^{de}	0.047±0.0007 ^{de}
15	0.04±0.001 ^{cd}	0.04±0.001 ^c	0.05±0.04 ^c	0.05±0.001 ^c	0.049±0.001 ^{cd}	0.05±0.0005 ^{cd}	0.053±0.01 ^d	0.056±0.001 ^{cd}
18	0.06±0.001 ^c	0.06±0.001 ^c	0.07±0.001 ^c	0.07±0.001 ^c	0.064±0.001 ^c	0.064±0.01 ^c	0.075±0.0008 ^c	0.077±0.0009 ^c
20	0.087±0.001 ^b	0.16±0.03 ^b	0.22±0.011 ^b	0.28±0.01 ^b	0.09±0.0007 ^b	0.17±0.02 ^b	0.23±0.01 ^b	0.308±0.006 ^b
25	0.11±0.02 ^a	0.24±0.02 ^a	0.31±0.02 ^a	0.39±0.01 ^a	0.13±0.02 ^a	0.26±0.01 ^a	0.33±0.01 ^a	0.45±0.01 ^a
30	0.03±0.0005 ^{de}	(-)	(-)	(-)	0.032±0.01 ^{de}	0.044±0.002 ^{cde}	0.045±0.0008 ^{de}	0.051±0.001 ^{cde}
SE (d)	0.01	0.02	0.02	0.12	0.014	0.013	0.0086	0.01
CD (P=0.05)	0.02*	0.06*	0.06*	0.027*	0.029*	0.027*	0.018*	0.022*

Each of the tabulated data in Table 3, 4 & 5 is mean value of 5 replications. * Life cycle not completed. Mean values in columns superscripted by the same letter are statistically *at par*.

more precisely; *M. persicae* could thrive well in all the temperature regimes studied, but, *B. brassicae* died in both the extreme temperatures. Thus, *M. persicae* has shown thermotolerance capacity which may magnify its damage to cabbage under changing climatic conditions.

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