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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, eg., in the UK, an increase in temperature of only 2ºC would allow the number of generations/ years to increase from 18 to 23ºC 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 25ºC; similar results were reported by Campbell and Mackauer (1977) in pea aphid *Acyrthosiphon 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 30ºC in case of *M. persicae* (Table 1). It was the longest at 15ºC for *B. brassicae* and at 10ºC 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 10ºC 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 1ºC 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 25ºC. At 30⁰C, these parameters showed an abrupt decline in *M. persicae.* Even though 30ºC 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 25ºC; however, minimum lengths of these parameters were observed for *B. brassicae* at 15ºC and for *M. persicae* at 10ºC. At 30ºC, 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, *Acyrthosiphon 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, 25ºC has emerged as the optimum temperature for both the aphid species; however, further investigation with due consideration of sets with narrower temperature range within 20-30ºC would find the optimum temperature

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

Temperature (⁰C)	Duration in days (Mean± S.D.)							
	B. brassicae				*M. persicae*			
	Pre- reproductive period	Reproductive period	Post- reproductive period	Adult longevity	Pre-reproductive period	Reproductive period	Post- reproductive period	Adult longevity
10	(-)	(-)	(-)	(-)	2.97± 0.02^{a}	31.8± 0.65^{a}	2.03± 0.03^{a}	36.80± 0.64^{a}
15	1.95± 0.01^{a}	21.0± 0.5^{a}	2.99± 0.01^{a}	25.95± 0.48^{a}	1.94± 0.03^{b}	27.2± 0.41^{c}	1.87± 0.01^{bc}	31.02± 0.44^{b}
18	1.86± 0.02^{b}	18.0± 0.35^{b}	1.87± 0.01^{b}	21.73± 0.35^{b}	1.83± 0.02^{c}	24.8± 0.41^{c}	1.92± 0.05^{ab}	28.42± 0.43^{c}
20	1.34± 0.02^{c}	14.8± 0.65^{c}	1.62± 0.02^{c}	17.76± 0.64^{c}	1.73± 0.01^{d}	21± 0.50^{d}	1.78± 0.09^{cd}	24.42± 0.48^{d}
25	0.97± 0.01^{d}	13.6± 0.6^{c}	0.99± 0.01^{d}	15.56± 0.56^{d}	1.04± 0.03^{e}	17.6± 0.44^{e}	1.06± 0.02^{e}	19.71± 0.41^{e}
30	(-)	(-)	(-)	(-)	1.92± 0.01^{b}	25.4± 0.56^{c}	1.85± 0.01^{bed}	29.19± 0.56^{c}
SE (d)	0.22	0.55	0.02	0.54	0.02	0.66	0.06	0.66
CD (P=0.05)	0.04*	1.2*	0.04*	1.19*	0.05*	1.39*	0.13*	1.38*

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

Temperature (⁰C)	*B. brassicae*				*M. persicae*			
	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^{e}	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 (⁰C)	*B. brassicae*				*M. persicae*			
	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 ^{bcd}	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 (^{0}C)	*B. brassicae*				*M. persicae*			
	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^{e}	0.31± 0.006^{e}	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^{c}	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^{a}	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 (^{0}C)	*B. brassicae*				*M. persicae*			
	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.

REFERENCES

Bale J S, Ponder K L, Pritchard J. 2007. Coping with stress. In: Emden HF van, Harrington R (eds.), Aphids as crop pests. CAB International, Wallingford.

Bavisa, R, Parmar, G M, Hirapara, M M and Acharya, M F. 2018. Population dynamics of mustard aphid, *Lipaphis erysimi* (Kaltenbach) on mustard in relation to different weather parameters. Journal of Pharmacognosy and Phytochemistry 7(4): 394-396.

Blackman R L, Spence J M. 1994. The effects of temperature on aphid morphology, using multivariate approach. European Journal of Entomology 91: 7-22.

Bursell E. 1974. Environmental aspects- temperature. M Rockstain (ed). The physiology of Insecta, 2nd ed., vol. 2 Academic Press, New York and London.

Campbell A, Mackauer M. 1977. Reproduction and population growth of the pea aphid (Homoptera: Aphididae) under laboratory and field conditions. Canadian Entomologist 109(2): 277-284.

Campbell A B, Frazer D, Gilbert N, Gutierrez A P, Mackauer M. 1974. Temperature requirements of some aphids and their parasites. Journal of Applied Ecology, 11: 431-438.

Chen C Y, Chui M C, Kuo M H. 2013. Effect of warming with temperature oscillations on low-latitude aphid, *Aphis craccivora.* Bulletin of Entomological Research 103(4): 406-413.

DeLoach C J. 1974. Rate of increase of populations of cabbage, green peach, and turnip aphids at constant temperatures. Annals of the Entomological Society of America, 67(3): 332-340.

Flynn D F B, Sudderth E A, Bazzaz F A. 2006. Effects of aphid herbivory on biomass and leaf level physiology of *Solanum dulcamara* under elevated temperature and CO_2. Environmental and Experimental Botany 56: 10-18.

Harrington R, Woiwod I, Sparks T. 1999. Climate change and trophic interactions. Trends in Ecology and Evolution 14: 146-150.

Hayakawa D L, Grafius E, Stehr F W. 1990. Effects of temperature on longevity, reproduction, and development of the Asparagus aphid (Homoptera: Aphididae) and the parasitoid, *Diaeretiella rapae* (Hymenoptera: Braconidae). Environmental Entomology 19(4): 890-897.

Lamb R J, MacKay P A, Gerber, G H. 1987. Are development and growth of pea aphids, *Acyrthosiphon pisum*, in North America adapted to local temperatures? Oecologia 72(2): 170-177.

Mani Muthukumara, Sushenjit Bandyopadhyay, Shun Chonabayashi, Anil Markandya, Thomas Mosier. 2018. South Asia's hotspots: The impact of temperature and precipitation changes on living standards. South Asia Development Matters. Washington, DC, World Bank. doi:10.1596/978-1-4648-1155-5.

Murdie G. 1969. Some causes of size variation in the pea aphid, *Acyrthosiphon pisum* Harris. Transactions of the Royal Entomological Society of London 121: 423-442.

Nealls V G, Jones R E, Wellington W G. 1984. Temperature and development in host-parasitic relationships. Oecologia 61: 224-229.

Pal M, Singh R, Srivastava P N. 2008. Thermal influence on the life-table statistics of the cabbage aphid, *Brevicoryne brassicae* (Linn). Journal of Aphidology 22(1&2): 73-80.

Ramalho F S, Malaquias J B, Lira A C S, Oliveira F Q, Zanuncio, J C, Fernandes F S. 2015. Temperature-Dependent Fecundity and Life Table of the Fennel Aphid, *Hyadaphis foeniculi* (Passerini) (Hemiptera: Aphididae). PLoSONE. 10(4): e0122490. doi: 10.1371/journal.pone.0122490.

Rao Srinivasa M, Shaila O, Abdul Khadar B, Manimanjari D, Vennilal S, Vanaja M, Rama Rao CA, Srinivas K, Maheswari M, Srinivasa Rao Ch. 2016. Impact of elevated CO_2 and temperature on aphids. Bulletin No. 01/2016, Central Research Institute for Dryland Agriculture, Santoshnagar, Hyderabad, India.

Sevak Das, Tejani D N, Patel J C, Desai A G, Desai A I, Gangwar G P. 2019. Effect of weather parameters on population dynamics of mustard aphid. International Journal of Current Microbiology and Applied Science 8(04): 1648-1653.

Soh B S B, Kekeunou S, Nanga N S, Dongmo M, Hannah R. 2018. Effect of temperature on the biological parameters of the cabbage aphid *Brevicoryne brassicae*. Ecology and Evolution 8: 11819-11832.

Summers C G, Coviello R L, Gutierrez A P. 1984. Influence of constant temperatures on the development and reproduction of *Acyrthosiphon kondoi* (Homoptera: Aphididae). Environmental Entomology 13:236-242.

Theunissen N. 1989. Integrated control of aphids on field grown vegetables. In: Aphids-their biology, natural enemies and control. Vol C. A K Minks, P Harreeijin (eds).

Tiwari A K, Singh R. 2018. Effect of temperature on the morphology of green peach aphid, *Myzus persicae* (Sulzer) (Homoptera: Aphididae). Research Journal of Life Science, Bioinformatics, Pharmaceutical and Chemical Science. doi:10.26479/2018.0405.05.

Wool D. 1977. Genetic and environmental components of morphological variation in gall-forming aphids (Homoptera: Aphididae: Fordinae) in relation to climate. Journal of Animal Ecology 46(3): 875-889.

Zhou X, Harrington R, Woieood I P, Perry J N, Bale J S, Clark, S J. 1995. Effect of temperature on aphid phenology. Global Change Biology 1(4): 303-313.

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