



Effect of temperature on biology of red spider mite (*Oligonychus coffeae*) on three different TV clones

PURNIMA DAS¹, SIMANTA SAIKIA², SURAJIT KALITA³, LAKSHMI KANTA HAZARIKA⁴
and SATYENDRA KUMAR DUTTA⁵

Assam Agricultural University, Jorhat, Asom 785 013

Received: 31 January 2011; Revised accepted: 5 January 2012

ABSTRACT

An experiment to study the effect of temperature and diet on growth and development of the red spider mite (RSM), *Oligonychus coffeae* Nietner (Acarina : Tetranychidae) revealed prolongation of life cycle period up to 18.79 days at 20°C, which, however, was reduced to 8.06 days at 35°C. The longevity of adult male and female were 12.7 and 28.3 days, respectively at 20°C. Amongst the TV (Tocklai Vegetative) clones of tea, TV₁ was found to be the most preferred diet, followed by TV₁₀ and TV₆. Fecundity was 120.7±21.74, 114.7±14.88 and 102.0±24.75 on TV₁, TV₆ and TV₁₀ respectively. The thermal constant needed for egg to adult formation ranged from 149.60 to 185.38 day°C on TV₁ clone.

Key words: Red spider mite, Temperature, Thermal constant, TV clone

The red spider mite (RSM), *Oligonychus coffeae* Nietner (Acarina : Tetranychidae) is one of the most widespread and ancient pest of tea in north-east India having been discovered in 1868 (Harrison, 1938; Hazarika *et al.* 2009). It attacks the maintenance foliage and causes 17 to 43% yield loss. The larvae, nymphs and adults of RSM lacerate on cell chloroplasts of the maintenance foliage (Helle and Sabellis 1985, Walling, 2000) producing minute characteristic reddish brown marks on the upper surface of the mature leaves which turn red in severe cases. Under such situation, Rao (1974) reported up to a loss of 340 to 511 kg of made tea/ha. High temperature and dry condition are conducive for this pest. Das and Das (1967) and Haque (2007) studied the effect of temperature and relative humidity (RH) on its biology and identified 30°C as the critical temperature. They also reported that the mite did not survived beyond 35°C. However, in their natural habitat biology of mite is not only affected by abiotic challenges (temperature, RH, etc.) but also biotic factors (host plant, parasitoids, predators, etc.). In such situation interaction of temperature and host plant on the performance of the RSM is

essential for developing a management strategy. Basic information in this aspect is not available. Hence, an attempt has been made to ascertain the role of temperature on development and reproductive parameters of RSM on three clones, viz TV₁, TV₁₀ and TV₆, which were identified as the susceptible, less susceptible and moderately resistant clones by Hazarika *et al.* (1995). Though studies on interaction between diet and temperature on tea pest are rare to find, effect of temperature and RH on the RSM (Das and Das 1967), temperature and photoperiod of *Adoxophyes honmai* (Nabeta *et al.* 2005) and evaluation of linear and non-linear developmental models on *Xyleborus fornicatus* (Walgama and Zalucki 2006) are common.

MATERIALS AND METHOD

The tea clones used for the experiments, i.e. TV₁ (susceptible), TV₁₀ (less susceptible) and TV₆ (moderately resistant) are being maintained in the Experimental Garden for Plantation Crops, Assam Agricultural University, Jorhat for last 25 years. The 4th leaf from the top of each clones were used for all the experiments. The mites were cultured on the detached leaves in Petri-dishes of 15 cm diameter by modifying Helle and Sabellis (1985) technique (Hazarika *et al.* 1995).

The mite infested leaves from the field were collected in a sterilized polyethene bag and brought to the Physiology Laboratory, Department of Entomology, AAU, Jorhat. These test mite stocks were cultured on detached leaves, the petioles of which were wrapped in a moist cotton plug to keep the tea

¹ Assistant Professor, Department of Entomology;

² Senior Field Officer, Itanagar Development Zone, Spice Board, Government of India, Itanagar, Arunachal Pradesh;

³ Subject Matter Specialist (e mail: surjit_kalita@yahoo.com), Krishi Vigyan Kendra (Chirang), Kajalgaon, Asom 783 385;

⁴ Dean (e mail.lkhazarika@yahoo.com), Faculty of Agriculture;

⁵ Professor and Head (e mail: satyendradutta@yahoo.co.in), Department of Entomology

leaf afresh for longer period and the leaf was placed by keeping the upper surface facing upward on a moist cotton pad in Petri-plates of 15 cm diameter. The cotton pad was kept moistened by adding double sterilized water periodically. A leaf disc of 2.5 cm² instead of the whole leaf was used in the experiment, to which three pairs of quiescent male and female deutonymphs were released. Each replicate was comprised of one Petri-plate with three such leaf discs. Females were allowed to lay eggs for 48 hr, after which adults were removed. Out of the total eggs laid, 20 eggs were allowed to develop per replication. To prevent the movement of the mites to under surface of the leaf disc, proper care was taken so that there will be no space left between edge of the leaf disc and cotton pad. Each such set was replicated 10 times at four different temperatures, viz 20, 25, 30 and 35°C under BOD incubator with at 85% RH and L:D cycle of 14:10 hr. Observations were taken daily at morning, afternoon and evening hours under stereo binocular microscope (10 × magnification) for determining the various biological parameters like fecundity of mated female, incubation period, larval protonymphal, quiescent protonymphal, deutonymphal, quiescent deutonymphal, pre- and post-ovipositional, ovipositional as well as adult longevity (male and female).

The data recorded on different life stages were subjected to two factor analysis of variance for computing their interaction effect and thermal constants were determined (Andrewartha and Birch 1954).

RESULTS AND DISCUSSION

Table 1 revealed that the developmental parameters of the RSM significantly varied with the temperature and types of clones. Amongst the TV₁, TV₁₀ and TV₆, at a particular temperature, time taken from hatch to adult (nymphal period)

Table 1 Effect of temperature on developmental stages of *O. coffeae* on TV clones of tea

Clone	Temperature (°C)	Nymphal period (days)	Life-cycle period (days)	Thermal constant from egg to adult (K) (day°C)
TV ₁	20	7.80±1.89	18.70±0.22	149.60
	25	6.34±1.43	12.19±1.05	156.65
	30	5.02±1.02	9.32±0.41	166.50
	35	4.26±0.83	8.06±1.46	185.38
TV ₁₀	20	7.89±1.53	18.79±1.38	150.32
	25	6.24±1.43	12.09±0.13	157.17
	30	5.00±1.41	9.45±0.69	170.10
	35	4.36±0.83	8.51±0.60	195.73
TV ₆	20	7.96±0.92	18.46±1.52	166.14
	25	6.31±1.42	12.11±0.97	169.54
	30	5.14±0.23	10.99±0.47	208.81
	35	4.57±0.70	9.52±0.94	228.48
CD (P=0.01)				
Clone		1.190	3.726	
Temperature		0.987	3.051	
Clone × temperature		0.463	1.563	

was the lowest on TV₁, whereas it was the highest on TV₆. Similar trend was also observed in cases of the life-cycle period, incubation period and adult longevity (Tables 2, 3). Haque *et al.* (2007) also reported completion of life-cycle of *O. coffeae* within 5.30 days at 30°C as compared to 12.97 days at 18°C. Naher *et al.* (2008) has also reported temperature dependent developmental phases in *Tetranychus urticae*.

Table 2 Effect of temperature and clones on different developmental parameters of *O. coffeae*

Clone	Temperature (°C)	Incubation period (days)	Larval period (days)	Protonymphal period (days)	Deutonymphal period (days)
TV ₁	20	10.90±0.83	1.43±0.08	1.20±0.12	1.75±0.11
	25	5.85±0.32	1.32±1.20	1.06±0.08	1.55±0.19
	30	4.30±0.39	0.94±0.92	0.90±0.10	1.05±0.05
	35	3.80±0.63	0.82±0.19	0.78±0.18	0.92±0.19
TV ₁₀	20	10.90±0.83	1.40±0.07	1.20±0.12	1.78±0.13
	25	5.85±0.32	1.24±0.08	1.09±0.08	1.59±0.12
	30	4.45±1.39	0.90±0.10	0.96±0.12	1.05±0.07
	35	4.15±0.47	0.84±0.20	0.84±0.15	0.92±0.14
TV ₆	20	10.50±0.92	1.40±0.07	1.25±0.07	1.80±0.14
	25	5.80±0.32	1.25±0.07	1.13±0.80	1.58±0.18
	30	5.85±0.32	0.99±0.10	0.96±0.93	1.07±0.07
	35	4.95±0.44	0.85±0.24	0.90±0.21	1.00±0.12
CD (P=0.01)					
Clone		0.404	0.104	0.084	0.087
Temperature		0.350	0.091	0.073	0.075
Clone × temperature		0.202	0.052	0.042	0.044

Developmental phases of mite and insects may be sensitive to plant trait, which is pronounced in our investigation. At 20°C, the developmental parameters did not differ significantly amongst the tea clones. The highest duration of egg stage (10.9±0.83 days), total time from hatch to adult (7.80±1.89 days) and egg to adult (18.70±0.22 days) were recorded at 20°C as compared to the lowest duration of egg stage (3.8±0.63 days), total time from hatch to adult (4.26±0.83 days) and egg to adult (8.06±1.46 days) at 35°C on TV₁ clone. On the resistant clone TV₆, the duration of the life stages were found to be 4.95±0.44 days, 4.57±0.70 days and 9.52±1.75 days, respectively at 35°C (Tables 1, 2). The mean canopy temperature during the winter and summer season were recorded to be 22°C and 33.1°C, respectively during the study period.

Similarly, the highest quiescent larval, protonymphal, quiescent protonymphal, deutonymphal and quiescent deutonymphal periods were recorded at 20°C and lowest at 35°C on TV₁ clone (Table 2). These quiescent stayed for longer periods in less susceptible and moderately resistant clones of TV₆ and TV₁₀, respectively than that of susceptible one, i.e TV₁ at temperature above 30°C, through which they escapes from the adverse effect of temperature. This is in conformity with the results of Ito (2010), who reported that diapause induction of immature stages of *Tetranychus kanzawai* Kishida (Acari: Tetranychidae) was much higher in less preferred or non host plants, but without affecting the adults. It may also be due to presence of some physico-chemical properties on the leaves and also immature stages have less mobility than the adults. At 35°C, the larval,

protonymphal and deutonymphal stages rested for longer duration on resistant clone TV₆ as compared to susceptible TV₁ clone (Table 2). Similar observations on temperature dependent developments were also reported by Das and Das (1967).

It is evident from the Table 2 that an increase in temperature from 20°C to 35°C resulted in gradual decrease in larval, protonymphal and deutonymphal periods. The larval, protonymphal and deutonymphal periods were longest, i.e 1.43±0.08, 1.20±0.12 and 1.75±0.11 days, respectively on TV₁ and 1.40±0.07, 1.25±0.07 and 1.80±0.15 days, respectively on TV₆ clone at 20°C. At 35°C temperature, larval, protonymphal and deutonymphal periods gradually decreased to 0.82±0.19, 0.78±0.18 and 0.92±0.19 days on TV₁ and 0.85±0.24, 0.90±0.21 and 1.00±0.12 days respectively on TV₆ clone. The rates at which mites grow are influenced by the environment; and amongst the various abiotic factors, temperature, relative humidity and diet are most important. Within the limits of temperature which permits growth, development generally proceeds more rapidly at higher temperatures.

Reproductive parameters such as pre-oviposition, oviposition period and post-oviposition period, varied with temperature, and were found to be highest at 20°C recording 2.16±0.12, 25.0±11.69 and 3.2±1.33 days, respectively and lowest of 0.86±0.12, 11.0±3.27 and 0.82±0.21 days respectively at 35°C on TV₁ clone (Table 3). Similar observations were recorded by Das and Das (1967). But fecundity was recorded to be the highest of 120.7±21.74 numbers of eggs per female at 25°C and lowest of 50.5±11.96

Table 3 Effect of temperature on reproductive parameters of *O. coffeae* on TV clones of tea

Clone	Temperature (°C)	Pre-oviposition (days)	Oviposition (days)	Post-oviposition (days)	Life time fecundity (nos.)	Adult longevity (days)			
						Male	Thermal constant (K) (day°C)	Female	Thermal constant (K) (day°C)
TV ₁	20	2.16±0.12	25.00±11.69	3.20±1.33	105.20±15.48	12.70±3.23	63.50	28.30±5.02	283.00
	25	1.46±0.42	23.90±4.70	2.50±1.36	120.70±21.74	11.40±0.58	114.00	27.30±5.24	409.50
	30	0.91±0.17	13.70±3.26	1.80±0.75	66.50±20.94	7.60±1.85	114.00	26.60±2.91	532.00
	35	0.86±0.12	11.00±3.27	0.82±0.21	50.50±11.96	5.90±1.86	118.00	16.10±2.81	402.50
TV ₁₀	20	2.14±0.13	22.00±3.97	2.40±1.28	98.60±17.94	10.40±2.46	166.40	26.90±4.62	403.50
	25	1.24±0.18	19.50±6.53	2.20±0.83	102.00±24.75	8.00±1.95	168.00	22.80±7.60	456.00
	30	0.99±0.18	13.30±3.03	1.50±0.67	56.20±16.70	6.90±2.02	179.40	22.20±1.70	555.00
	35	0.86±0.18	11.90±3.00	0.83±0.21	53.40±17.05	6.20±2.58	192.20	17.40±3.24	522.00
TV ₆	20	2.14±0.10	21.40±4.82	2.40±1.28	95.30±18.28	9.80±2.67	166.60	24.70±4.45	395.60
	25	1.59±0.45	19.50±8.18	2.30±0.78	114.70±14.88	8.30±1.62	182.60	22.10±9.03	464.10
	30	1.04±0.12	12.90±3.24	1.60±0.66	55.00±13.53	6.80±1.72	183.60	22.00±1.32	572.00
	35	0.90±0.14	12.50±4.43	0.88±0.21	45.90±17.39	6.30±1.89	201.60	17.60±4.09	545.60
CD (P=0.01)									
Clone		0.171	3.232	0.646	15.320	1.525		3.578	
Temperature		0.148	2.799	0.561	13.268	1.320		3.098	
Clone × temperature		0.086	1.616	0.323	7.660	0.762		1.789	

numbers at 35°C on TV₁ clone (Table 3), which is well supported by the observations of Das and Das (1967). Moreover, hatching of eggs and all other developmental stages of RSM was greatly reduced to an extent of more than 50% at 35°C. Numbers of egg laid was also greatly reduced as because more than 80% of the adults died at temperature at or above 30°C. The adult longevity of both male and female RSM, which decreased with increase in temperature, were found to be highest, i.e. 12.7±3.23 and 28.3±5.02 days, respectively at 20°C. The female lived longer than the male at all the temperatures irrespective of the clones. A striking sexual dimorphism in adult longevity is the way to maximize female fitness (Rolf 2002). Correlation studies revealed that temperature had significant but negative correlation with developmental and reproductive parameters of RSM (Table 4). Haque *et al.* (2007) also reported accelerated developmental rate at higher temperature with reduced developmental periods.

While calculating the thermal constant required for entire developmental period (egg to adult), it was found that the requirement is lowest (149.60 to 185.38 day°C) on TV₁, while it was more on TV₆ (166.14 to 228.48 day°C) and TV₁₀ (150.0 to 233.22 day°C) (Table 1). Moreover, the total heat requirement during the total life span of male was less than females, which may be because of the fact that female live longer than that of male (Table 3). Again, on TV₁ both male and female consumed least heat (63.50 to 118.00 and 283.00 to 402.50 day°C, respectively) as compared to TV₆ (66.60 to 201.60 and 395.60 to 545.60 day°C, respectively) and TV₁₀ (166.40 to 192.20 and 403.50 to 522.0 day°C, respectively). In cases of temperature fluctuation with heat requirement for growth and development, it was found out that irrespective of clones, the total heat consumption goes on decreasing in females at temperature above 30°C.

While studying the interaction effect of temperature with clone on biology of RSM, it was found out that temperature exerts a significant effect on the biology and

longevity of all the developmental stages. But clones have significant effect on adult male and female longevity, duration of egg stage and protonymphal stage, whereas interaction effect of clone with temperature was pronounced only on egg stage of RSM.

Though temperature is the main abiotic factor that influences biology, ecology and population dynamics of a pest (Andrewartha and Birch 1954), however, from the present investigation it is evident that along with temperature, clone (diet) plays a significant role on growth and development of RSM. A reason for variation in developmental and reproductive parameters between temperatures and clone is implicit in the temperature tolerance *vis-a-vis* host preference of *O. coffeae*. Though its critical temperature is 30°C (Das and Das 1967), an intermediate temperature between 20°C and 25°C was found to be optimal at which RSM showed highest fecundity and adult emergence.

REFERENCES

- Andrewartha H G and Birch L C. 1954. *The Distribution and Abundance of Animals*. Chicago University Press, Chicago.
- Das G M and Das S C. 1967. Effect of temperature and humidity on the development of red spider mite, *Oligonychus coffeae* (Nietner). *Bulletin of Entomological Research* 37: 433–5.
- Haque M, Wahab A, Naher N and Begum A. 2007. Developmental stages of red spider mite, *Oligonychus coffeae* Neitner (Acari: Tetranychidae) infesting rose. *University Journal of Zoology Rajshahi University* 26: 71–2.
- Harrison C J. 1938. *The Occurrence and Treatment of Red Spider on Tea in North-East India*. Memorandum of Toklai Experimental Station, No. 2, pp: 26. Indian Tea Association, Calcutta.
- Hazarika L K, Bhuyan M and Hazarika B N. 2009. Insect pests of tea and their management. *Annual Review of Entomology* 54: 267–84
- Hazarika L K, Sharma M, Saikia M K and Borthakur M. 1995. Biochemical basis of mite resistance in tea. (in) *National Conference on Insect Biochemistry and Molecular Biology* held on October 19, 1995 at Trivandrum, Kerala.
- Helle W and Sabellis M W. 1985. *Spider mites—Their Biology, Natural Enemies and Control*. Vol. 1A, pp 331–5. Elsevier Science Publishing Company Inc. 52, Vanderbilt Avenue, New York, NY-10017.
- Ito K. 2010. Effect of host plants on diapause induction in immature and adult *Tetranychus kanzawai* (Acari: Tetranychidae). *Experimental and Applied Acarology* 52: 11–7.
- Nabata F H, Nakai M and Kunmi Y. 2005. Effect of temperature and photoperiod on the development and reproduction of *Adoxophyes honmai* (Lepidoptera: Tortricidae). *Applied Entomology and Zoology*. 40: 231–8.
- Naher N, Islam W, Khalequzzaman M and Haque M. 2008. Study on developmental stages of spider mite (*Tetranychus urticae* Koch) infesting country bean. *Journal of Biological Sciences* 16: 109–14.
- Rao G N. 1974. Control of tea mites in south India. (in) *Handbook of Tea Culture*. United Planters' Association of Southern India, Bangalore.

Table 4 Correlation (r value) of temperature with growth parameters of *O. coffeae* on different TV clones

Parameter**	TV ₁	TV ₁₀	TV ₆
Egg	-0.8928	-0.9092	-0.8513
Larval	-0.9694	-0.9724	-0.9928
Protonymphal	-0.9995	-0.9986	-0.9857
Deutonymphal	-0.9707	-0.9745	-0.9639
Male longevity	-0.9617	-0.9818	-0.9798
Female longevity	-0.7175	-0.8488	-0.6938
Fecundity	-0.8894	-0.8612	-0.7737
Pre-ovipositional period	-0.9152	-0.9479	-0.9734
Ovipositional period	-0.9719	-0.9510	-0.9461
Post-ovipositional period	-0.9771	-0.9962	-0.9615

** Significant at $P > 0.01$

Rolf J. 2002. Batemans principles and immunity. *Proceeding of Royal Society of London* **B 269**: 867–72.

Walgama R S and Zalucki M P. 2006. Evaluation of different models to describe egg and pupal development of *Xyleborus*

formicatus Eichh. (Coleoptera: Scolytidae), the shoot hole borer of tea in Sri Lanka. *Insect Science* **13**: 109–18.

Walling L.L. 2000. The myriad plant responses to herbivores. *Journal of Plant Growth Regulators* **19**: 195–216.