JARQ 38 (3), 161 – 166 (2004) http://www.jircas.affrc.go.jp

REVIEW

Population Dynamics of Tomato Russet Mite, *Aculops lycopersici* (Massee) and Its Natural Enemy, *Homeopronematus anconai* (Baker)

Akira KAWAI[1]* and Mohd. Mainul HAQUE[2]

Department of Fruit Vegetables, National Institute of Vegetables and Tea Science
(Ano, Mie 514–2392, Japan)

Abstract

Developmental rates of *Aculops lycopersici* increased linearly as rearing temperature increased. A total of 81.2 degree-days above a developmental zero of 10.5°C were required to complete development from egg to adult emergence. Adult longevity decreased with increasing temperature. The highest intrinsic rate of natural increase was observed at 25°C as 0.253 per day. The population increased exponentially on greenhouse tomato plants and the intrinsic rate of natural increase was estimated to be 0.175 per day. *A. lycopersici* first reproduced on the released leaves then moved upward. The infestation caused great injury to the plants, with a large number of leaves turning brown and then drying up. The number of leaves, the plant height and the diameter of the main stem of the plants all decreased. *Homeopronematus anconai* naturally occurred on tomato plants. After the rapid population increase of *H. anconai,* the *A. lycopersici* population decreased sharply. An adult *H. anconai* consumed an average of 69.3 *A. lycopersici* deutonymphs per day in the laboratory. *H. anconai* was thought to be a prospective natural enemy of *A. lycopersici.*

Discipline: Insect pest
Additional key words: population growth, injury, developmental zero, thermal constant, biological control

Introduction

The tomato russet mite, *Aculops lycopersici* (Massee) is an important pest of tomato first described by Massee[14] in Australia. It is now cosmopolitan and it has become a serious pest[3,19]. It was first found in Japan in 1986[16] where it has since become an influential pest[17]. Several chemicals are effective to control it, but control methods other than chemicals are not developed. Some natural enemies already have been found but none is effective. Various fragmented studies on its biology have already been conducted and were reviewed by Perring and Farrar[19]. Ecological studies on *A. lycopersici* have continued in Japan with the purpose of analyzing population dynamics of this pest and establishing an integrated pest management (IPM) system for tomato. This paper presents results of the studies on the population dynamics of *A. lycopersici*, its damage to tomato plant and its prospective natural enemy.

Development and Reproduction

A few fragmented studies on the life history of *A. lycopersici* have been published[1,20] and recently detailed studies were conducted[7]. Developmental period is very short at high temperatures. Duration from egg to adult is only 5 days at 30 to 25°C and 9 days at 20°C while that at 15°C is 17 days (Table 1). Developmental rates increased linearly as rearing temperature increased from 15 to 27.5°C. The developmental zero from egg to adult is estimated as 10.5°C with thermal constants of 81.2 degree-days. Survival rate of the nymphal stage is high between 15 and 27.5°C, but decreased at 30°C. Female rate is 70

Present address:
[1] Department of Research Planning and Coordination, National Institute of Vegetables and Tea Science (Ano, Mie 514–2392, Japan)
[2] Department of Zoology, Rajshahi University (Rajshahi 6205, Bangladesh)
* Corresponding author: fax +81–59–268–3213; e-mail tpest@affrc.go.jp
Received 19 November 2003; accepted 25 February 2004.

to 80% regardless of temperature. At 25°C, longevity of female adults is 26 days and fecundity per female is a maximum of 51.7 eggs (Table 2). The intrinsic rate of natural increase increased with temperature to a peak of 0.286 at 25°C (Table 3). This rate was much higher than that of other eriophyoid mites[2,15] and is nearly equal to that of *Tetranychus ulticae* (0.292) or *T. kanzawai* (0.268)[13].

These experiments were conducted at 30–33% relative humidity. High humidity retarded development and decreased the number of eggs of *A. lycopersici* at high temperatures and 30–60% humidity was suitable for reproduction[20]. Population growth in the field at high humidity conditions would be slower than the data in Table 3.

Population growth on tomato plant

Population growth of *A. lycopersici* on tomato plant was examined in a glasshouse[6]. A hundred adults of *A. lycopersici* were released on the fourth and fifth leaves from the base of the plant. The population increased exponentially and peaked (187,286 per plant) at 6 weeks after infestation (Fig. 1). The change in population density during the 6 weeks after infestation fitted well to the equation $Nt = 0.175t + 0.495$ ($r = 0.964$, $P<0.01$) (t: days after release, Nt: population density at day t). Population increased exponentially and the intrinsic rate of natural increase per day was estimated as 0.175. This rate is much higher than the intrinsic rate of natural increases of *Trialeurodes vaporariorum* or of *Thrips palmi* obtained

Table 1. Developmental duration and survival rate of *A. lycopersici* at different temperatures[7]

Temp.	Duration in days a)			Survival (%)		
(°C)	Egg	Nymph	Egg to adult	Egg	Nymph	Egg to adult
15	8.26 ± 0.18 (38)	8.78 ± 0.31 (27)	17.07 ± 0.18 (27)	93.8	82.1	77
17.5	5.85 ± 0.14 (39)	6.05 ± 0.14 (38)	11.76 ± 0.19 (38)	97.9	95.8	93.8
20	4.59 ± 0.12 (32)	4.06 ± 0.11 (32)	8.66 ± 0.18 (32)	96.7	72.2	69.8
22.5	3.57 ± 0.08 (47)	3.62 ± 0.10 (45)	7.16 ± 0.11 (45)	97.9	89.9	88
25	3.14 ± 0.14 (29)	2.40 ± 0.10 (25)	5.48 ± 0.14 (25)	94.1	88.5	83.2
27.5	2.57 ± 0.07 (47)	2.21 ± 0.07 (47)	4.79 ± 0.09 (47)	97.5	92.7	90.3
30	2.23 ± 0.09 (30)	2.36 ± 0.09 (28)	4.57 ± 0.09 (28)	95	55.7	52.9

a): $\bar{x}$ ± SE. Numbers in parenthesis indicate sample size.

Table 2. Fecundity and longevity of ovipositing female *A. lycopersici* on tomato leaves at constant temperatures[7]

Temp. (°C)	Longevity of ovipositing female a)	% of ovipositing females b)	Fecundity (total eggs / ovipositing female)
15	32.2 ± 0.6 (26)	77.1	21.9 ± 4.1
20	29.7 ± 0.7 (31)	75.6	31.9 ± 4.4
25	25.7 ± 0.8 (27)	69.2	51.7 ± 9.8
30	17.3 ± 0.6 (23)	74.2	42.7 ± 6.7

a): $\bar{x}$ ± SE. Numbers in parenthesis of the longevity column show sample size.
b): No. of ovipositing females / No. of mites.

Table 3. Parameters of *A. lycopersici* population growth on tomato leaves at constant temperatures[7]

Temp. (°C)	Mean generation time (T_0)	Net reproductive rate (R_0)	Intrinsic rate of natural increase (r_m)
15	20.7	17.5	0.138
20	20.2	24.4	0.158
25	12.8	38.7	0.286
30	13	27.1	0.253

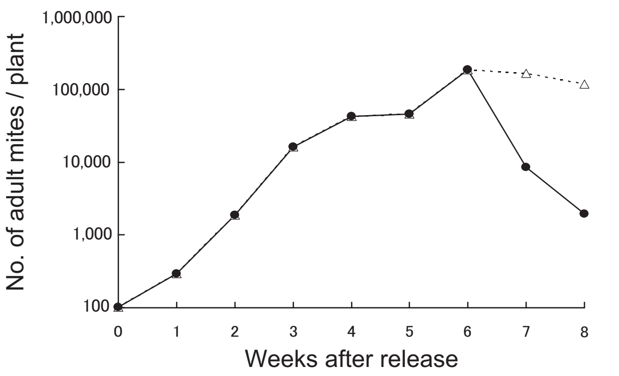

Fig. 1. Population fluctuations of adult *A. lycopersici* on tomato plants[6]

—●— : with predator, *H. anconai*.

···△··· : without predator.

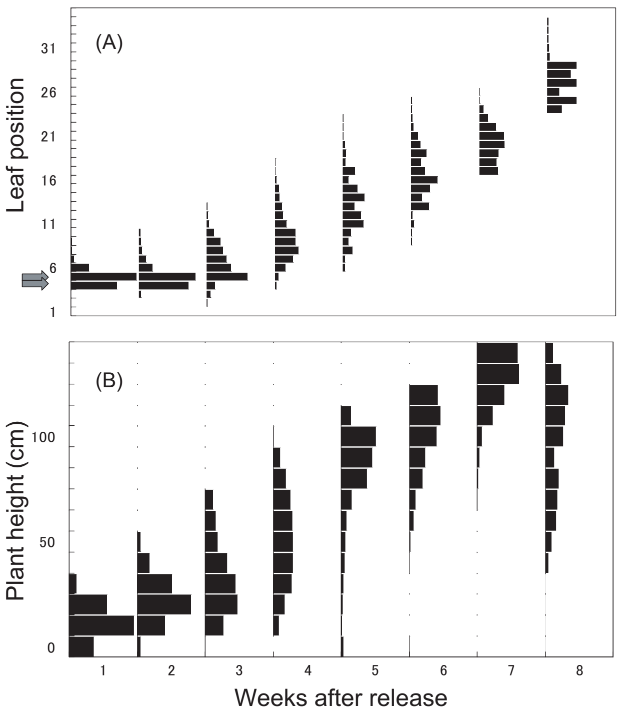

Fig. 2. Vertical distribution of adult *A. lycopersici* on infested leaves (A) and stems (B)[6]

Arrows indicate the leaves of initial release.

in the greenhouse. From this rate, it is estimated that the population of *A. lycopersici* can increase 1,914 times in 30 days and 36,316 times in 60 days. The population of *A. lycopersici* on the plants decreased gradually from 7 weeks after infestation because of the damage to the host plant caused by the attack.

On tomato plant, more than 70% of the *A. lycopersici* population infested the leaves and most of the rest infested the stems. The vertical distribution of adults on leaves and stems is shown in Fig. 2. On leaves (Fig. 2A), until 2 weeks after infestation, more than 80% of the population was found on the fourth and fifth leaves, where the mites were released. However, a few mites were found on the ninth and eleventh leaves at 1 and 2 weeks after infestation, respectively. At 3 weeks after infestation, the percentage was highest on the fifth leaf, but that on the fourth and fifth leaves was only 36%. The part with the highest percentage then moved up the plant. *A. lycopersici* first reproduced on the infested leaf and then moved upward. The leaves with the highest density were in the middle part of the plant and the leaves in the apical parts had a low density population. On the stem (Fig. 2B), at 1 week after infestation, about half of the population was found 10 to 20 cm from the base and this position was near where the mites were released. Until 4 weeks after infestation, the position with the largest population moved upward and the distribution tended to be uniform. From 5 to 7 weeks after infestation, the population on the apical part of the stem increased.

Damage to tomato plant

Thirty-two species were listed as host plants of *A. lycopersici* and 29 of these species were in the family Solanaceae[19]. The injury by *A. lycopersici* is essentially restricted to the family Solanaceae. Tomato is the most susceptible species and severe injury is frequently observed. Injury is seldom observed on other Solanaceous species, i.e. potato, eggplant and petunia. Significant differences in susceptibility to *A. lycopersici* were found between tomato varieties[10] and highly resistant allied species of the same genus as tomato were found (Kitamura & Kawai, unpublished). Breeding of resistant varieties is expected.

Injury by *A. lycopersici* on tomato plant was quantitatively examined by releasing them in a glasshouse[6]. A hundred adults were released at the lower leaves and the physical characters of an infested plant were compared with those of an uninfested one (Fig. 3). From 1 week after infestation, the plant height was significantly shorter than that of an uninfested one and the difference became larger as the *A. lycopersici* population increased. The total number of leaves and the thickness of the main stem on infested plants were significantly smaller at 1 to 3 weeks after release and again at 6 to 8 weeks after release. Browning and drying of leaves were observed from 4 and 5 weeks after release, respectively (Fig. 4). At 7 and 8 weeks after release, 58 and 79% of the leaves were dried up in infested plants, respectively. However in the uninfested plants, only 3 and 4% of leaves turned brown and dried up due to aging in the same time frame. At 8 weeks after release, infested plants had only 4.8

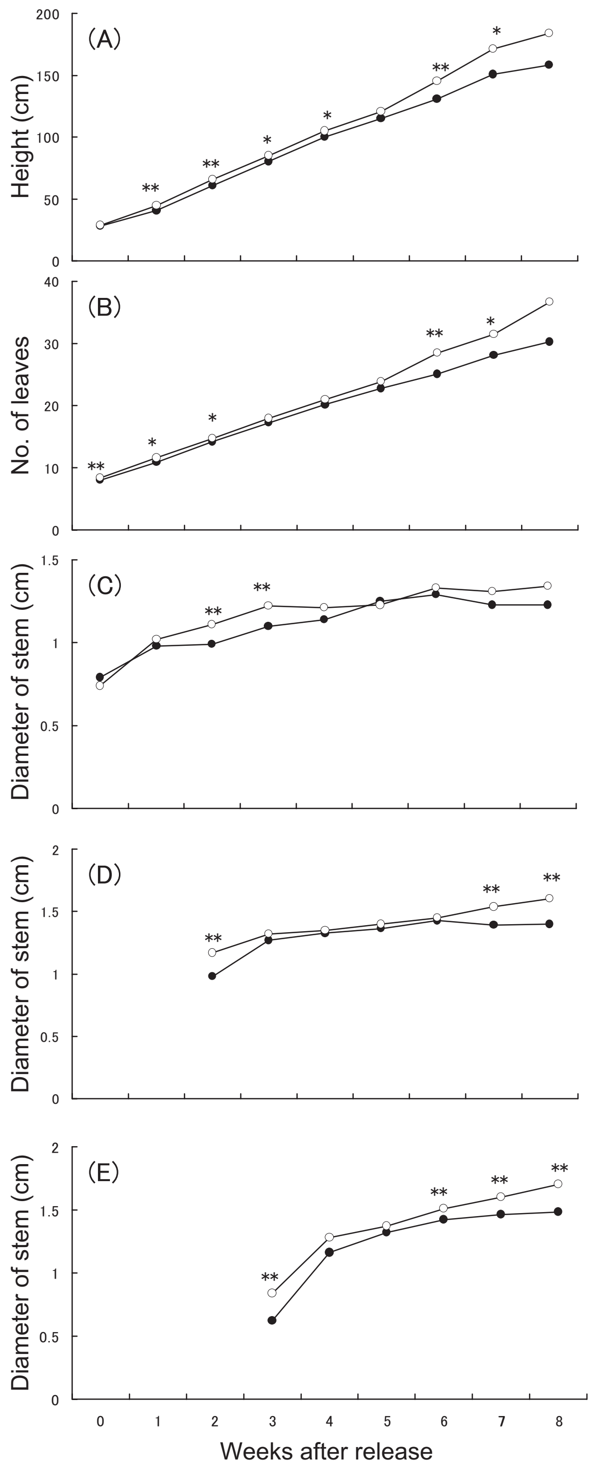

Fig. 3. Comparison of physical characteristics between infested and uninfested plants[6]

● : infested plants, ○ : uninfested plants.
(A) plant height, (B) total number of leaves, and diameter of the main stem at the (C) fifth inter-node, (D) tenth inter-node, (E) 15th inter-node.
*: significant difference at the 5% level by *t* test.
**: significant difference at the 1% level by *t* test.

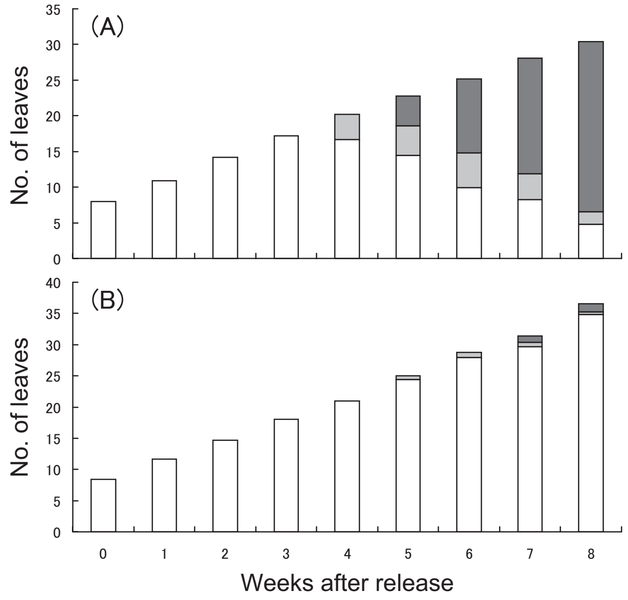

Fig. 4. Number of dried, brown and healthy leaves on infested (A) and uninfested (B) plants[6]

■: dried leaves, ■: brown leaves,
□: healthy leaves.

healthy leaves, while uninfested ones had 34.8 healthy leaves.

A heavy infestation just after transplanting severely affects plant growth of small plants. As tomato plants grow, the effect of infestation on plant growth becomes smaller. From 6 weeks after infestation, since *A. lycopersici* reproduces on upper leaves and the number of healthy leaves becomes fewer, the growth of the plant is again suppressed by the injury.

Natural enemy

Several species were already reported as natural enemies of *A. lycopersici* (Table 4), but the control effect of these natural enemies is not clear.

In an experiment on population growth of *A. lycopersici* on tomato (Fig. 1), the predator, *Homeopronematus anconai* (Baker) naturally appeared on several plants from 7 weeks after the release of *A. lycopersici*[11]. *H. anconai* rarely moved between plants and it reproduced on the plant where it first appeared. More than 2,000 individuals were found on the leaf with the highest number in the eighth week. The population of *A. lycopersici* decreased rapidly in the plants where predators appeared. At 1 and 2 weeks after the appearance of the predator, the densities of *A. lycopersici* were 5.3% and 1.7% of that without predators, respectively. *H. anconai* was thought to regulate the population of *A. lycopersici.*

Table 4. Natural enemies of *Aculops lycopersici*

Order	Family	Scientific name	Reference
Acarina	Phytoseiidae	*Euseius concordis*	5
		Amblyseius victoriensis	9
	Stigmaeidae	*Agistemus exsertus*	18
	Tydeidae	*Homeopronematus anconcai*	8
		Pronematus ubiquitus	1
Thysanoptera	Phaleothripidae	*Leptothrips mali*	3
	Thripidae	*Scolothrips sexmaculatus*	1

The population density of *A. lycopersici* on potted tomato plants was depressed by the release of *H. anconai*[8]. On the contrary, Brodeur et al.[4] stated that *H. anconai* consumed 3–4 individuals of *A. lycopersici* per day and failed to develop to the adult stage when solely present with this prey. However, an adult *H. anconai* consumed an average of 69.3 *A. lycopersici* deutonymphs during a 24 h experimental period in the laboratory[11]. Adults and nymphs of *H. anconai* predated all stages of *A. lycopersici*, and when a small number of *H. anconai* were released on tomato plants in a greenhouse with a high density of *A. lycopersici*, the population of *A. lycopersici* was suppressed to a low density (Kawai et al., unpublished). *H. anconai* would be an effective control agent of *A. lycopersici.*

Prospect for IPM

Rapid reproduction of *A. lycopersici* and severe injury of tomato plant were quantitatively revealed. Several chemicals are effective to control *A. lycopersici.* However, in considering an IPM system for tomato, control methods other than chemicals are required.

Breeding of resistant varieties would be one of the effective methods. *H. anconai* is thought to be the other prospective control agent. In order to use this biological control agent, a mass production system should be established. Since Knop and Hoy[12] showed that *H. anconai* can be reared on pollen, a mass production system for *H. anconai* using pollen as food should be established. Moreover, packing and transportation methods for *H. anconai* and a simple forecasting method for *A. lycopersici* should be also established.

References

1. Abou-Awad, B. A. (1979) The tomato russet mite, *Aculops lycopersici* (Massee) (Acari: Eriophyidae) in Egypt. *Anz. Schadlingskd. Pflanzens. Umweltschutz.*, **52**, 153–156 [In German with English summary].
2. Allen, J. C., Yang, Y. & Knap, L. (1995) Temperature effects on the development and fecundity of the citrus rust mite (Acari: Eriophyidae). *Environ. Entomol.*, **24**, 996–1004.
3. Bailey, S. F. & Keifer, H. H. (1943) The tomato russet mite, *Phylocoptes destructor* Keifer: Its present status. *J. Econ. Entomol.*, **36**, 706–712.
4. Brodeur, J., Bouchard, A. & Turcotte, G. (1997) Potential of four species of predatory mites as biological control agents of the tomato russet mite, *Aculops lycopersici* (Massee) (Acari: Eriophyidae). *Can. Entomol.*, **129**, 1–6.
5. De Moraes, G. J. & Lima, H. C. (1983) Biology of *Euseius concordis* (Chant), a predator of the tomato russet mite. *Acarologia*, **24**, 251–255.
6. Haque, M. M. & Kawai, A. (2002) Population growth of tomato russet mite, *Aculops lycopersici* (Acari: Eriophyidae) and its injury effect on the growth of tomato plants. *J. Acarol. Soc. Jpn.*, **11**, 1–10.
7. Haque, M. M. & Kawai, A. (2003) Effect of temperature on development and reproduction of the tomato russet mite, *Aculops lycopersici* (Massee) (Acari: Eriophyidae). *Appl. Entomol. Zool.*, **38**, 97–101.
8. Hessein, N. A. & Perring, T. M. (1986) Feeding habits of the Tydeidae with evidence of *Homeopronematus anconai* (Acari: Tydeidae) predation on *Aculops lycopersici* (Acari: Eriophyidae). *Int. J. Acarol.*, **12**, 215–222.
9. James, D. G. (1989) Influence of diet on development, survival and oviposition in an Australian phytoseiid, *Amblyseius victoriensis* (Acari: Phytoseiidae). *Exp. Appl. Acarol.*, **6**, 1–10.
10. Kamau, A. W., Mueke, J. M. & Khaemba, B. M. (1992) Resistance of tomato varieties to the tomato russet mite, *Aculops lycopersici* (Massee) (Acarina: Eriophyidae). *Insect Sci. Applic.*, **13**, 351–356.
11. Kawai, A. et al. (2001) First record of *Homeopronematus anconai* (Baker) in Japan and predation on *Aculops lyco-*

persici (Massee). *Nihon Dani Gakkaishi* (*J. Acarol. Soc. Jpn*.), **10**, 43–46 [In Japanese with English summary].

12. Knop, N. F. & Hoy, M. A. (1983) Biology of a tydeie mite, *Homeopronematus anconai* (n. comb.) (Acari: Tydeidae), important in San Joaquin valley vineyards. *Hilgardia*, **51**, 1–30.
13. Kondo, A. & Takafuji, A. (1985) Resource utilization pattern of two species of tetranychid mites. *Res. Popul. Ecol.*, **27**, 145–157.
14. Massee, A. M. (1937) An eriophyid mite injurious to tomato. *Bull. Entomol. Res.*, **28**, 403.
15. Mizuta, T. (2000) Effect of temperature on developmental period and oviposition of tea rust mite, *Acaphylla theavagran* Kadono. *Nihon Ouyou Doubutsu Konchu Gakkaishi* (*Jpn. J. Appl. Entomol. Zool.)*, **44**, 95–99 [In Japanese with English summary].
16. Nemoto, H. (1991) Ecological and morphological studies on the eriophyid and tarsonemid mites injurious to horticultural plants and their control. *Saitama-ken Engei Shikenjo Tokubetsu Hokoku* (*Spec. Bull. Saitama Hort. Exp. Sta.)*, **3**, 1–85 [In Japanese with English summary].
17. Nemoto, H. (2000) Recent topics on pests; eriophyid mites. *Nougyou oyobi Engei* (*Agric. Hort.)*, **75**, 181–187 [In Japanese].
18. Osman, A. A. & Zaki, A. M. (1986): Studies on the predation efficiency of *Agistemus exsertus* Gonzalez (Acarina, Stigmaeidae) on the eriophyid mite *Aculops lycopersici* (Massee). *Anz. Schadlingskd. Pflanzens. Umweltschutz*., **59**, 135–136 [In German with English summary].
19. Perring, T. M. & Farrar, C. A. (1986) Historical perspective and current world status of the tomato russet mite (Acari: Eriophyidae). *Entomol. Am. Misc. Publ.,* **63**, 1–19.
20. Rice, R. E. & Strong, F. E. (1962) Bionomics of the tomato russet mite, *Vasates lycopersici* (Massee). *Ann. Entomol. Soc. Am*., **55**, 431–435.