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Research Article

Life Cycle of *Tetranychus cinnabarinus* (Boisduval) (Acari: Tetranychidae) on Lablab Bean

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ABSTRACT

Development times of the carmine spider mite, *Tetranychus cinnabarinus* (Boisduval) was evaluated in the laboratory on excised leaf disc of lablab bean, *Dolichos lablab* at 30 ± 2°C and 70 ± 5% relative humidity. Total development times from egg to adult stage were 7.33 ± 0.13 days. The pre-oviposition period, oviposition period and post-oviposition period were 0.5 ± 0, 8.05 ± 0.14 and 0.65 ± 0.07 days respectively. Fecundity averaged 42.5 ± 1.7 eggs and longevity, 9.2 ± 0.13 days.

Key Words: *Tetranychus cinnabarinus*, *Dolichos lablab*, Protonymph, Quiescence, Deutonymph, Oviposition

INTRODUCTION

The carmine spider mite, *T. cinnabarinus* is an extremely polyphagous plant mite and is described as a serious pest attacking vegetables, fruits, pulse crops, cotton, jute, tea and so on (Hazan *et al*., 1973; Gupta, 1985; Dhooria & Sagar, 1989; Rosero *et al.*, 1990; Wu & Jing, 1993; Wang *et al*., 2004 and Cakmak *et al*., 2005). *T. cinnabarinus* in all stages remain often confined to the undersurface of leaves covered with thin webs and dust particles. Feeding of the carmine mite by inserting their stylets into host leaves and sucking the cell contents can damage protective leaf surface, palisade layers and cause yellowing, crinkling, crumpling, curling and twisting of leaves (Jeppson *et al.*, 1975). In addition, they spin heavy webs on leaves which reduce photosynthesis and transpiration rate of plants (Hazan *et al*., 1974 & 1975). Eventually, the leaves dry up and fall off. Further, feeding by this mite severely affects the growth, flowering and fruit formation in crops (Kazak and Kibritci, 2008). The current host plant, *Dolichos lablab* of the family Fabaceae originated in Asia and is a very popular pulse crop grown as an important source of food in the tropics. The plant is easy to grow in poor, acidic to alkaline soils and takes 90-150 days to reach maturity. It is a twining vine with broad leaflets, flowers and flat pods containing beans. Young immature pods are cooked and eaten like green beans. Leaves and flowers are eaten raw in salads or cooked like spinach. The large starchy root tubers and immature /dried seeds are boiled or baked for food. The mature seeds are also used as bean sprouts. The plant is sometimes grown as a cover crop, livestock fodder and green manure (Hendricksen & Minson, 1985 and Murphy *et al.*, 1999). Lablab bean is also known for its capacity to fix atmospheric nitrogen and enhance soil fertility (Schaaffhausen, 1963). *T. cinnabarinus* occurrs in abundance on lablab bean plants depleting the quality and yield of beans. The objective of the current investigation was therefore to obtain a thorough understanding of the life cycle of *T. cinnabarinus* on lablab bean in order to provide a platform to develop an ideal IPM program in future.

MATERIALS AND METHODS

T. cinnabarinus culture

Developmental studies of *T. cinnabarinus* were carried out in an environmental growth chamber at 30 ± 2°C and 70 ± 5% relative humidity. Stock cultures of the mite were maintained on potted bean plants for more about a year in the field at Calicut University campus, Malappuram, Kerala. Individual cultures of all life stages of the mite were maintained on fully expanded leaf discs (16 cm^2) of lablab bean placed abaxial side up in petridishes lined with 110x110x5mm water-saturated cotton pads (Sangeetha and Ramani, 2007). The petridishes were covered by lid leaving a small gap to prevent excessive moisture retention inside the petridish. The different stages of development till adulthood were noted at 6h interval using Stemi DV4 stereozoom microscope. When the leaf showed signs of decay, all the mites were carefully transferred to fresh leaf discs. The cotton pads were wet daily with water in order to maintain leaves' vitality.

Development time of life stages

To determine the duration of sexual development, 5-10 colonies of newly moulted females were introduced along with 2-4 new males and the males were removed soon after the females laid their first set of eggs.

Studies on parthenogenesis were initiated starting from 5-10 quiescent female deutonymphs that moulted to females and laid their first batch of eggs. Beginning with these eggs, the complete life cycle of the individual mites were traced. Adult mites of each colony were transferred to fresh leaf disc every 24hrs. The duration of different developmental stages was recorded for 10 generations. The developmental success in individual stages and total duration of development were calculated and tabulated. Values are expressed as mean ± SEM (Standard Error of Mean). 'n' indicates the number of trials.

RESULTS

The carmine mite, *T. cinnabarinus* passes through four developmental stages with resting (quiescent) and moulting phases at the end of larval and nymphal development. The duration of individual developmental stages of the carmine spider mite on lablab bean in different generations maintained in the laboratory is detailed below.

Incubation period

The eggs were spherical, shiny and yellow coloured when freshly laid. Gradually, the colour changed to bright orange, few hours before hatching into a six legged larva. The period of incubation took shortest duration of 2.69 days for parthenogenetic development and longest duration of 2.73 days for sexual development. However, the period averaged 2.71 ± 0.07days (Table 1).

Larval period

The larva was small, hexapod and yellowish with slight sexual dimorphism especially at the hysterosomal region. The larva remained motionless for a short duration after hatching and then initiated feeding. The newly hatched larval active life averaged 1 ± 0 day (Table 1). Like other tetranychid larvae, the larva of *T. cinnabarinus* also passed through the first quiescent phase, which subsequently moulted into the 1st nymphal stage or the protonymph.

Protonymphal period

The protonymph differed from the larva by its slightly larger size, reddish brown colouration and possession of 4 pairs of legs. The protonymph was more active than the larva. Feeding activity, quiescence and emergence were similar to those of the larva. The protonymphal active phase ranged from 0.68 day to 0.9 day averaging to 0.79 ± 0.07 day (Table 1).

Deutonymphal period

Deutonymphal stage showed marked resemblance with the adult stage, except for the smaller size, paler colour and difference in setation. Sexual dimorphism was quite obvious at this stage. The hysterosoma of the female was markedly robust due to ovarian development while that of the male tapered towards the anal region. Deutonymph exhibited voracious feeding which progressed till quiescence. The duration of deutonymphal period averaged 0.71 ± 0.07 day with the shortest duration of 0.67 day and longest duration of 0.75 day in thirty five generations studied (Table 1)

Adult Stages

Adult male was very active, slightly smaller than the female with a wedge shaped hysterosoma, bearing a black spot on either lateral side. The adult females were larger, reddish and more or less elliptical in shape. The emergence of females after moulting immediately followed copulation and active feeding prior to the initiation of oviposition. Males either wandered actively, searching for females for mating or engaged in feeding activity. The average total duration from egg to adult stage was 7.33 ± 0.13 days.

The females of *T. cinnabarinus* exhibited two types of reproduction – sexual and parthenogenetic. The eggs laid by mated females developed into both males and females while those of virgin females developed only into males. The total duration of development showed variation with respect to the nature of reproduction. However, parthenogenetic development required comparatively shorter duration (6.8 ± 0.17 days) compared to sexual development (7.7 ± 0.16 days) (Table 1).

Quiescence and Moulting

While in quiescence, *T. cinnabarinus* penetrated its stylets into the leaf tissue and remained sedentary preferably near the mid rib or major veins on the leaf surface at the end of active larval and nymphal stages. The durations of Ist, IInd and IIIrd quiescence on lablab bean leaves were 0.5 ± 0, 0.83 ± 0.1 and 0.75 ± 0.1 day respectively (Table 1). As the quiescence approached its final stage, the cuticle turned transparent. A crack appeared at the dorsal region below the propodosoma which widened by the forceful movements of the individual leading to the emergence of the successive instar by the process of moulting. The entire process required about 25 minutes for completion.

Mating

Sperm transfer was made possible by inserting extruded aedeagus of the male into the female genital pore. Males mated frequently with a few minutes interval, taking 17 to 24 seconds with an average of 20 seconds. The females died within hours after egg laying.

Table 1. Duration (in days) of development and longevity of *T. cinnabarinus* on *D. lablab*

Egg	Larva	1st Q	Proto-nymph	2nd Q	Deuto-nymph	3rd Q	Total duration	Longevity
2.71±0.07	1±0	0.5±0	0.79±0.07	0.83±0.1	0.71±0.07	0.75±0.1	7.33±0.13	9.2±0.13
2.73±0.06	1.08±0.03	0.6±0.04	0.9±0.02	0.84±0.1	0.75±0.05	0.80±0.1	7.7±0.16 Sexual	9.3 ± 0.2 Mated
2.69+0.05	0.92+0.02	0.4+0.03	0.68+0.06	0.82+0.1	0.67+0.09	0.7+0.1	6.8±0.17 Parthenogenesis	9.1 ± 0.19 Unmated

n = 35

Table 2. Duration (in days) of pre-oviposition, oviposition and post-oviposition periods of *T. cinnabarinus* on *D. lablab*

Pre-oviposition	Oviposition	Post-oviposition
0.5 ± 0	8.05 ± 0.14	0.65 ± 0.07

n = 35

Table 3. Fecundity and daily mean oviposition of *T. cinnabarinus* on *D. lablab*

Mean number of eggs laid/female/day on different days of oviposition									Total number of eggs laid
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
4.5±0.3	7.1±0.3	13.7±0.2	8.7±0.5	5.6±0.2	3.8±0.1	2.8±0.02	1.1±0.12	0.5±0.16	47.8 ± 1.9 Mated female
2.4±0.2	4.5±0.3	9.2±0.4	10.1±0.4	4.1±0.02	3.3±0.03	2.5±0.1	0.9±0.01	0.2±0.04	37.2 ± 1.5 Unmated female
SEM								Mean ±	42.5 ± 1.7

n = 35

Pre-oviposition, Oviposition and Post- Oviposition periods

Ovipositing females deposited eggs in groups, though the eggs were separate from each other. They were mostly laid on the underside of the leaf surface or attaching to the webbing spun by them extensively, prior to oviposition. The respective durations of pre-oviposition, oviposition and post-oviposition of *T. cinnabarinus* on *D. lablab* were 0.5 ± 0 day, 8.05 ± 0.14 days and 0.65 ± 0.07 days (Table 2). An indication of cannibalistic behaviour by *T. cinnabarinus* males by feeding on post – ovipositing females of the same species was a notable feature observed in the present investigation.

Fecundity and longevity

The eggs laid by a single female and the daily fecundity of *T. cinnabarinus* are presented in Table 3. The maximum number of eggs was laid between the 2nd and 4th days of the oviposition period. This trend was common in both mated and virgin females. However, the average fecundity was found more in the case of mated females. The total number of eggs laid per female in her life time was 42.5 ± 1.7 eggs (Mated - 47.8 ± 1.9 eggs & Virgin - 37.2 ± 1.5 eggs). Longevity of the females on *D. lablab* averaged 9.2 ± 0.13 days (Mated - 9.3 ± 0.2 days & Virgin - 9.1 ± 0.19 days) (Table 1).

Hatching

Hatching was marked by the appearance of a slit, which progressed to either sides of the egg, resulting in the separation of the egg shell into equal upper and lower halves. Formation of the slit required 5 to 6 minutes. It was hastened by the active movement and thrusting action of the emerging larva which favoured protrusion of its legs and mouth parts. Hatching was completed in 12 – 15 minutes.

DISCUSSION

Extensive research had been carried out in the biology of spider mites. Hence, information gathered on the developmental aspects of *T. cinnabarinus* is within the variation pattern for spider mite species. Srivastava and Mathur (1962) observed that *T. cinnabarinus* took 14.3 days to complete its development on castor. This was twice as much longer than our findings. Longer durations ranging from 9 to 9.45 days were recorded by Kazak *et al.* (2003) on the developmental time of *T. cinnabarinus* on 6 cultivars of strawberry. Hotter and dryer weather accelerates the life cycle of spider mites (Haile and Higley, 2003). Therefore, high temperature and low humidity provided in the laboratory could be a reason for the shorter development time of *T. cinnabarinus* as observed in the current investigation. Mean development time of *Tetranychus sp.* as reported by Tanyag and Colting (1996) were 8.95 – 15.83 days. The differences encountered were most probably due to differences in cultivar and experimental conditions. However, similar duration on the development of *T. urticae* from egg to adult was recorded by Sabelis (1981).

Nandagopal and Gedia (1995) studied the biology of *T. cinnabarinus* on groundnut and the durations recorded for larva, protonymph and deutonymph of male and female respectively were 1.09, 1.11 & 3.17 days and 1.12, 1.08 & 5.04 days. The respective durations of the carmine mite were shorter on lablab bean and hence could be inferred that lablab bean was the more susceptible host for *T. cinnabarinus* compared to ground nut. The accumulated mean fecundity of 43 eggs observed in this study was lower than 77 eggs observed by Dhooria and Sagar (1989) on 4 different varieties of Japanese mint. Hazan *et al*. (1973) recorded highest fecundity at 24°C and 38% RH and lowest mortality for the species at 30°C and 38% or 63% RH. The longevity of *T. cinnabarinus* observed in this study was within 8-14 days reported by Srivastava and Mathur (1962) and 3-19days by Dhooria and Sagar (1989). The number of females of *T. cinnabarinus* always outnumbered males in the ratio of 1 male: 10 females. *T. cinnabarinus* performed both sexual and parthenogenetic reproduction. The instance of arrhenotoky in particular has been reported in several spider mite species by Nandagopal and Gedia (1995). The occurrence of dual reproductive means is to enhance the male population which is otherwise very low in field conditions.

Northcraft and Watson (1987) reported that the developmental time, longevity and survival rate of adult females of *T. cinnabarinus* were all significantly decreased with increase in temperature. While conducting biological studies of the same mite on *Solanum melongena* in different seasons, Biswas *et al.*, (2004) observed negative impact of temperature on hatching, duration of development and reproduction though no significant influence of relative humidity was noted. Differential suitability of host plants to the mite is an important factor while exploring IPM solutions for *T. cinnabarinus* and other mite species (Adango *et al.*, 2006). The study revealed shorter developmental cycle for the species at 30 ± 2°C and 70 ± 5% RH that enabled *T. cinnabarinus* to undergo 3-4 generations per month. The high infestation rate of the mite on lablab bean during the summer months of the season as evidenced through field sampling further envisaged the colonization

of the host by the species and its population build-up in alarming rates so as to acquire the status of a major pest.

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