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Research Article

Biology of *Tetranychus ludeni* Zacher (Acari: Tetranychidae) – A Pest of Velvet Bean

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ABSTRACT

Post embryonic development of the spider mite, *Tetranychus ludeni* Zacher infesting *Mucuna deeringiana* was studied in the laboratory at 30 ± 2°C and 70 ± 5% relative humidity. Rearing of the life stages of the mite was carried out following leaf flotation technique. The durations of pre-oviposition period, oviposition period and post-oviposition period were recorded to be 0.5 ± 0, 11.5 ± 0.38 and 0.5 ± 0 days respectively. Fecundity recorded was 83.6 ± 3.4 eggs and longevity, 12.6 ± 0.37 days. The total duration of sexual and parthenogenetic reproduction respectively were 10.04 ± 0.13 days and 9.04 ± 0.13 days. The parthenogenetic development required comparatively shorter duration than sexual ones. Sex ratio (male: female) was 2: 10.

Key Words: *Mucuna deeringiana*, oviposition, quiescence, sexual and parthenogenetic reproduction

INTRODUCTION

The spider mite species, *Tetranychus ludeni* is a serious pest of a wide variety of economically important plants. The mites often infest the upper surface of the leaves causes yellowing of leaves followed by formation of necrotic patches and drying up. It is one of the important mite pests of vegetable crops in India reported to attack French bean, brinjal, potato, water melon and many other vegetable and fruit crops limiting the production of these crops (Jeppson *et al.*, 1975; Puttaswamy and ChannaBasavanna, 1980b). As a highly polyphagous mite, *T. ludeni* occurs in the field almost throughout the year. Moreover, this is the only spider mite in India known to be a vector of the plant viral disease, *viz.* Dolichos Enation Mosaic Virus (DEMV) (Rajagopalan, 1974). The current host plant of *T. ludeni*, *Mucuna deeringiana* (Bort.) Merr. (velvet bean) is grown mainly as livestock fodder and for soil improvement. The plants are highly palatable to the livestock. Velvet bean has also shown to exhibit nematicidal property and is planted as either a rotational crop or an inter-planted crop in diverse geographical areas. Planting of velvet bean is significant in lowering fungal populations at the end of the season and bacterial populations in the following season, compared to cowpea (Kloepper, *et al*., 1999). Velvet bean also influences bacterial diversity, generally increasing frequency of bacilli, *Arthrobacter* spp. and *Burkholderia cepacia*, while reducing fluorescent pseudomonads (Vargas-Ayala *et al.*, 2000). Hence, it marks its importance in the field of agriculture and livestock management. Moreover, all parts of the plant are nutritious and the long hairy pods are used for preparation of curries. *T. ludeni* emerged as a prominent faunal element on velvet bean. The high intensity of *T. ludeni* infestation on them and the extensive degree of visible damage caused due to mite attack led to the selection of this plant for the study. The present paper gives an account of the developmental strategies of *T. ludeni* infesting *M. deeringiana,* a so far unrecorded host plant for the species.

MATERIALS AND METHODS

Biological studies of *T. ludeni* were conducted in an environmental growth chamber at 30 ± 2°C and 70 ± 5% relative humidity. Stock cultures of the mite were maintained on *M. deeringiana* plants in the field at Calicut University campus, Malappuram, Kerala. Experimental and control plots (3m x 3m) were set up 100m apart from each other. Seeds of *M. deeringiana* were sown separately in enriched soils of the plots prepared for the study. The plots were irrigated regularly and the seedlings were grown with utmost care. The plots were covered separately with fine nets to ensure protection from pest attack. Artificial infestation of *T. ludeni* adults was done by stapling mite-infested leaf bits on experimental plants when they reached 2 months of age. Individual cultures of all life stages of the mite were maintained on leaf discs (16 cm^2) of velvet bean placed in petridishes lined with water-saturated cotton pads (Sangeetha and Ramani, 2007). To determine the duration of sexual development, 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. Regular observations at 6h interval was done using Stemi DV4 stereozoom microscope to gather information on mating, oviposition, incubation and hatching, larval and nymphal stages, quiescence and moulting and total duration of F_1 generations. Values are expressed as mean ± SEM (Standard Error of Mean). 'n' indicates the number of trials.

RESULTS

Oviposition

Adult females exhibited a general preference to the upper surface of the leaves though no specific selection of site for depositing eggs was noticed. Ovipositing females constructed silken webs prior to the deposition of the eggs. On several occasions, females were found depositing eggs at random on the webbing. The eggs were spherical and transparent when freshly laid. On the following day, they turned pale yellow in colour and finally to orange on the third day. Prior to hatching, part of gnathosoma, eye spots and legs of the larva could be seen through the egg case. The pre-oviposition and post-oviposition periods of *T. ludeni* were recorded to be 0.5 ± 0 days. The oviposition period was 11.5 ± 0.38 days (Table 1).

Fecundity and Longevity

Fecundity was recorded minimum on the 1st and 2nd days of oviposition under laboratory conditions. On the 6th day of oviposition, the fecundity attained the maximum level and it showed a gradual decline from the 7th day onwards, reaching the minimum on the final day of oviposition. The daily egg production reached a peak of 14.7 ± 0.87 eggs on day 6 and declined to a minimum of 3.1 ± 0.31 eggs on day 10. The total number of eggs per female of *T. ludeni* recorded on *M. deeringiana* averaged 83.6 ± 3.4 eggs. The number of eggs per mated female per day was higher than in the virgin females (Table 2). Longevity of *T. ludeni* averaged 12.6 ± 0.37 days on velvet bean. A comparison of the life span of mated and virgin females revealed 12.0 ± 0.35 days and 13.2 ± 0.58 days respectively (Table 3).

Hatching

The beginning of the process was marked by an increase in the size of the egg at the equatorial region. The sequences of events were similar as in other tetranychid representatives. The whole process was completed within a period of 10 to 12 minutes. Hatchability of eggs ranged from 90 to 95%.

Duration of developmental stages (Table 3)

Incubation period: The incubation period of *T. ludeni* on *M. deeringiana* was observed to be 2.64 ± 0.06 days.

Larval period:The newly hatched larva could be easily distinguished by its small size and the presence of 3 pairs of legs. It was the smallest among the life stages. The larva just after hatching was creamy white in colour except for the distinctly visible reddish eye spots. After emergence, the larva remained inactive for 5 to 10 minutes and then initiated feeding. Feeding characteristics resembled that of the larva of other tetranychid representatives. As feeding proceeded, the colour of the larva turned into greenish yellow. The active larval period lasted for 1.06 ± 0.03 days. At the end of the active period, the larva entered into an inactive stage called the first quiescence which was followed by moulting and emergence of the protonymph.

Protonymphal period: Protonymph or the first stage nymph was an active instar characterized by the presence of 4 pairs of legs. It was larger in size, pale yellow in colour with greenish spots on its dorsolateral region. Feeding started at about 5 to 10 minutes after moulting from the quiescent stage. The active protonymphal period extended for 1.08 ± 0.06 days at the end of which the protonymph entered into the second quiescent phase, followed by the process of moulting into the deutonymph.

Deutonymphal period: The deutonymph or the second stage nymph was slightly larger in size than the protonymph. The feeding activity of deutonymph started 10 minutes after moulting and continued till it attained third quiescence. The deutonymphal period on *M. deeringiana* was completed in 1.87 ± 0.04 days. This followed quiescence and moulting into the adult stage.

Adult Stages: Freshly moulted adult can be distinguished to their sexes with ease. The adult male was much smaller in size, pale yellow in colour and spindle shaped. Males moved faster than females and were found in less number compared to female. The adult female was much larger than the male, reddish in colour with cylindrically shaped abdomen.

Quiescent Periods: *T. ludeni* entered into an inactive stage called quiescent phase at the end of active period of each developing stage. During this period, the third pair of legs was found folded beneath the hysterosoma while the first two pairs were directed forwards. An interesting feature noted in this species was the tendency

Table 1: Duration (in days) of pre-oviposition, oviposition and post-oviposition periods of *T. ludeni* on *M. deeringiana*

Pre-oviposition	Oviposition	Post-oviposition
0.5 ± 0	11.5 ± 0.38	0.5 ± 0

n = 35

Table 2: Fecundity and rate of daily egg production of *T. ludeni* on *M. deeringiana*

Number of eggs laid on different days of oviposition										Total number of eggs laid
1	2	3	4	5	6	7	8	9	10	
5.1±0.27	7.2±0.36	8.8±0.38	12.8±0.5	13.6±0.6	16.4±0.87	11.3±0.6	7.7±0.47	5.2±0.54	3.1±0.31	91.2 ± 3.6 Mated female
3.7±0.24	5.8±0.35	7.3±0.45	10.1±0.4	12.7±0.9	14.8±0.34	9.8±0.2	5.6±0.27	3.2±0.23	2.0±0.21	75.0 ± 2.6 Unmated female
								Mean ± SEM		83.6 ± 3.4

n = 35

Table 3: Duration (in days) of development and longevity of *T. ludeni* on *M. deeringiana*

Egg	Larva	1st Q	Proto-nymph	2nd Q	Deuto-nymph	3rd Q	Total duration	Longevity
2.64±0.06	1.06±0.03	0.87±0.06	1.08±0.06	1±0	1.87±0.04	1±0	9.54±0.18	12.6 ± 0.37
3.06±0.06	1.08±0.03	0.91±0.04	1.10±0.02	1±0	1.89±0.05	1±0	10.04±0.13 Sexual	12.0 ± 0.35 Mated
2.23+0.05	1.04+0.02	0.86+0.03	1.06+0.06	1+0	1.85+0.02	1+0	9.04+0.13 Parthenogenesis	13.2 + 0.58 Unmated

n = 35

of aggregation during the larval and nymphal quiescent periods. The larva entering quiescence selected a suitable site under the webbing and moved in close proximity and gradually became stationary close to each other. Subsequently, other larvae and nymphs were found moving to seek positions close to their precedes. The colony of quiescent individuals was found acquiring more or less a circular form due to participation of individuals from all directions and this structure remained intact until the completion of moulting. The respective durations of the three quiescent phases of *T. ludeni* were 0.87 ± 0.06, 1.00 ± 0 and 1.00 ± 0 day.

Moulting: The process of moulting of individuals to the successive nymphal or adult stage marked the termination of aggregation. In *T. ludeni*, it was a gradual process completed within 20 to 25 minutes.

Mating: Copulation in this species occurred immediately after the final moult of the female deutonymph. The males emerged earlier than the females and were found guarding the quiescent female deutonymphs and copulating with the female immediately after the emergence of the latter.

Total duration of development: *T. ludeni* performed both sexual and parthenogenetic reproduction. However, the series of events involved was similar in both types of reproduction. Also, all the progeny were found to be males in the case of parthenogenetic development while in the sexual reproduction both males and females were produced with a sex ratio of 2:10. The total duration of development was found to average at 9.54 ± 0.18 days. The duration of sexual development was 10.04 ± 0.13 days while that of parthenogenetic development was 9.04 ± 0.13 days. The parthenogenetic development required comparatively shorter duration than sexual ones.

DISCUSSION

Information gathered on the developmental aspects of *T. ludeni* depicted a common pattern of developmental processes involving a larval and two nymphal instars as in other tetranychid mite species described by earlier authors (Puttaswamy and ChannaBasavanna, 1980b; Gotoh *et al.*, 2003; Haque *et al.*, 2007). Majority of the tetranychid species were found depositing eggs adjacent to the midrib of the leaves of the host plant (Banu and ChannaBasavanna, 1972; Puttaswamy and ChannaBasavanna, 1980b; Sangeetha and Ramani, 2007). However, *T. ludeni* showed no specific preference during oviposition. The silken web in *T. ludeni* (Puttaswamy and ChannaBasavanna, 1980b) served adequate protection to the eggs and the subsequent instars, which may be the possible reason for the randomised deposition of eggs.

The pre-oviposition and oviposition periods of *T. ludeni* recorded by Puttaswamy and ChannaBasavanna (1981) on brinjal leaves were 0.98 day and 10.85 days. This is almost in agreement with the current findings although the post-oviposition periods recorded by the authors were three folds higher up to 2.4 days. However, at 19.3 ^{o}C - 28.4 ^{o}C and 53% - 88% RH, the pre-oviposition, oviposition and post-oviposition periods were 1.54 days, 12.75 days and 3.61 days respectively (Puttaswamy and ChannaBasavanna, 1980b). The oviposition rate of *T. ludeni* reached the peak on the 6th day as evidenced in the current study. On the contrary, oviposition rate attained peak levels on 4th day in *T. evansi* (Qureshi *et al.*, 1969), 7th day in *T. urticae* (Shih *et al.*, 1976) and 9th day in *T. ludeni* (Puttaswamy and ChannaBasavanna, 1980b). Longevity of the mites was influenced by several factors of which mating appeared to be vital. The longevity of mated females was lower than that of virgin females. This indicated negative influence of mating on the longevity of *T. ludeni*. Rate of daily egg production was yet another factor that influenced the longevity of these individuals (Puttaswamy and ChannaBasavanna, 1980a). High frequency of oviposition reduced the life expectancy of the females as observed in the present study.

The hatching characteristics of the species followed a more or less similar trend as in other spider mites involving the formation of an equatorial slit on the egg case and culminating in the separation of the case into two halves ((Puttaswamy and ChannaBasavanna, 1980b; Sangeetha and Ramani, 2007). However, fluid discharge from the egg of *T. ludeni* was a notable feature during hatching. The pattern of moulting is in support with earlier reports on tetranychid mites (Siddig and Elbadry, 1971; Banu and ChannaBasavanna, 1972; Gupta, 1985; Sangeetha and Ramani, 2007). The process of mating appeared to be common among different genera of tetranychid mites (Penman and Cone, 1972; Qureshi *et al.*, 1969; Beavers and Hampton, 1971;

Banu and ChannaBasavanna, 1972). Males preferred virgin females who were more gregarious and remained on the leaves for longer time than the mated ones so as to increase the mating opportunities (Cone *et al.*, 1971; Hazan *et al.*, 1973; Penman and Cone, 1974; Oku *et al.* 2005). Generally, a single copulation was reported in the case of tetranychid females, while males were known to copulate many times (Banu and ChannaBasavanna, 1972, Nandagopal and Gedia, 1995; Sangeetha and Ramani, 2007; Haque *et al.*, 2007).

A deviation from this behaviour was noted in *T. ludeni*. The same female was found engaged in multiple mating with different males.

T. ludeni 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. However, the series of events involved was similar in both types of reproduction. All the progeny were found to be males in the case of parthenogenetic development while in the sexual reproduction both males and females were produced with a sex ratio of 2 males:10 females. The total durations of development of *T. ludeni* averaging 222 days (Mallik and ChannaBasavanna, 1983) and 10.16 days (Singh *et al.,* 1989) seemed to coincide with the current duration of the mite on velvet bean.

The biological phenomenon of aggregation as observed in many groups of organisms, serving various life activities of the species in question, was a feature noted in *T. ludeni*. Repeated occurrence of the process at the time of each quiescent period has indicated the significance of the phenomenon in the ontogeny of the species. Hence, further studies on the aggregation behaviour of this species particularly, of the larval and nymphal instars are warranted. More studies on the mediation of pheromones in this behaviour will help in unveiling the exact nature of the relationship among the members of the species. An interesting and cognitive aspect that emerged from the study was the incidence of *T. ludeni* on *M. deeringiana* which is a new record of host plant, so far unreported from India. This clearly indicate the possibility of new host arenas yet to be explored thereby necessitating further attention to be focused on this aspect.

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