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Biology of two-spotted spider mite *Tetranychus urticae* Koch (Acari: Tetranychidae) on okra

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Abstract

The studies on the development and life history traits of *T. urticae* were conducted in the Acarology laboratory following leaf disc method. The life cycle of *T. urticae* Koch consisted of egg, larva, protonymph, deutonymph and adult stages. The immature stages were followed by short quiescent intervals called nymhochrysalis, deutochrysalis and teleiochrysalis. The mite recorded an incubation period of 2.92 days. Larval period of 0.83 and 1.19 days, protonymphal period of 0.36 and 0.58 days and deutonymphal period of 0.67 and 0.29 days were recorded respectively in male and female *T. urticae*. The total developmental period from egg to adult emergence was shorter for male (6.73 days) compared to female (7.52 days). Mating took place immediately after the emergence of the female. *T. urticae* exhibited both sexual and parthenogenetic reproduction. Mated female's progeny consisted of both males and females in the ratio 1:5.8, whereas unmated female produced 100 per cent males. Pre-oviposition, oviposition and post-oviposition periods lasted for 0.58, 9 and 4 days and 0.58, 11 and 4.5 days respectively in mated and unmated female. Mated and unmated females on an average produced 108 and 77 eggs. The adult mite recorded longevity of 12, 12.5 and 17 days for male, mated female and unmated female respectively. The shorter developmental period and minute size of *T. urticae* coupled with high fecundity would help the mite build up population very fast and successfully complete several generations in a crop season attaining the status of major pest.

Key words : biology; *Tetranychus urticae;* sex ratio; viability of eggs

INTRODUCTION

Two spotted spider mite (TSSM), Tetranychus urticae (Tetranychidae: Prostigmata) is a highly polyphagous pest of numerous vegetable crops with a global distribution. It has been reported to feed on more than 900 host plants and is described as a serious pest of at least 150 economically important agricultural and ornamental plants [1,2]. They typically colonize the undersurface of leaves and feed by desapping result in removal of chlorophyll, yellowing and speckling of leaves, webbing, premature leaf fall, stunting of growth, reduction in photosynthetic activity and transpiration and ultimately death of the whole plant [3]. These combinations of effects often reduce the amount of harvestable material. Apart from its polyphagous nature, high reproductive potential and short life cycle, factors such as change in climatic conditions and over-use of plant protection chemicals also have helped to compound the mite problem. Increased concern over adverse effects of the commonly used acaricides warrants the development of alternative management which in turn calls for a thorough understanding regarding the biology of the pest. However, no study on the same has yet been conducted on *T. urticae,* one of the major mite pests of okra in Kerala.

MATERIALS AND METHODS

The studies on the development and life history traits of *T. urticae* were conducted in the Acarology laboratory of the Department of Agricultural Entomology, College of Horticulture Kerala Agricultural University, Thrissur during October-November, 2012 at 30 $\pm$ 3^{0}C and 61.5 $\pm$ 7 % RH, on leaf discs (I cm^2) of okra (variety: *Arka Anamika*) placed on wet cotton bed in Petri plates (120 mm diameter). *T. urticae* was mass cultured in the laboratory on okra leaves placed on plastic trays (23 cm x18 cm x5 cm) lined with well moistened synthetic absorbent sponge and a layer of blotting paper. Leaves were changed every three days to avoid poor nutrition for the mite. Twenty gravid females were collected from mass culture and transferred to individual leaf discs at the rate of one female per disc for oviposition. After 24 hours, eggs were counted and fifty eggs, selected at random were transferred to leaf discs of 2 cm^2 area using a moistened camel hair brush and biology was studied. The development of immature stages of the mite was observed with the help of a stereo binocular microscope at 2 hours interval until they reached maturity. Newly emerged males and females were maintained on separate leaf discs to determine their longevity.

To determine the duration of sexual development of mated female, one female teleiochrysalis was transferred to a leaf disc and four adult males were released onto the disc and allowed to mate after the final moult. The males were removed 24 hours after the emergence of the female. The reproductive biology of unmated female was also studied using teleiochrysalis that moulted to female but not allowed to mate. Observations on mating behaviour, pre-oviposition, oviposition and post-oviposition periods were recorded. The number of eggs laid by the mated as well as unmated females were recorded by replacing the leaf discs carrying eggs with fresh discs till death of the female.

Sex ratio and viability of eggs were studied following the method described by Nagata and Gotch [4]. The eggs laid by each mated as well as unmated female for the first five days were reared and the viability was determined by counting the number of eggs hatched out to larvae. From this the per cent egg viability was worked out. The emerging mites were sexed out after reaching adulthood to determine the sex ratio.

RESULTS

The life cycle of *T. urticae* consisted of five different stages such as the egg, larva, protonymph, deutonymph and the adult. The larva, protonymph and deutonymph stages were followed by short quiescent intervals called nymphochrysalis, deutochrysalis and teleiochrysalis respectively.

Morphology and developmental duration of immature stages of *T. urticae*

Egg

T. urticae preferred to colonize and lay eggs on the underside of the leaves of okra. Gravid female mites laid eggs singly or in groups on the webbings as well as on the leaves, often near the veins and the midrib. Eggs were spherical and transparent when freshly laid, but turned creamy white in colour prior to hatching. During this stage, two dark coloured eye spots, corresponding to the simple eyes of the larvae, were clearly visible. Both males and females of *T. urticae* recorded a mean incubation period of 2.92 days (Table 1).

Larva

The eggs hatched out to hexapod larvae. Newly hatched larva was cream coloured and small in size. On feeding the colour changed from cream to pale green. The simple eyes on the dorso-lateral idiosoma were clearly distinguishable at this stage. The mean larval period recorded was 0.83 days for males and 1.19 days for females (Table 1).

Nymphochrysalis

The larva stopped feeding and moved to a suitable place on the leaf and entered into its first quiescent stage called nymphochrysalis. During this stage, the anterior two pairs of legs were extended straight forward and kept close to each other. The posterior legs were extended backwards and held close to the sides of opisthosoma. At the end of this stage moulting took place. Average nymphochrysalis period was 0.26 days for male and 0.68 days for females as presented in Table 1.

Protonymph

The first nymphal stage the protonymph emerged by splitting open the larval skin along the dorsal midline and was characterized by the presence of four pairs of legs. Protonymph was larger in size and darker in colour as compared to the larva. The mean protonymph period lasted for 0.36 days for males and 0.58 days for females, as can be seen from Table 1.

Deutochrysalis

At the end of protonymphal period, the protonymph entered its second quiescent stage, the deutochrysalis. It remained anchored to the leaf surface in a manner similar to that of nymphochrysalis.This stage, on an average, lasted for 0.67 days in the case of males and 0.29 days in the case of females (Table 1).

Deutonymph

Deutochrysalis moulted to the second nymphal stage, the deutonymph. Sexual characters could be distinguished from this stage onwards. Deutonymph was light reddish in colour. Female deutonymphs were larger and broader than their male counterparts while male deutonymphs were elongate. They were actively moving and feeding. The mean deutonymph period was 0.93 days in for males and 1.05 days for females as presented in Table 1.

Teleiochrysalis

The deutonymph entered the third quiescent stage, the teleiochrysalis. This stage lasted on an average 0.76 days for males and 0.81 days for females (Table 1).

Adult

After the final moult, adult mite emerged from teliochysalis. The mites exhibited sexual dimorphism in the adult stage. Males were reddish green or light red in colour and smaller in size with body tapering posteriorly to a blunt point. Female mites were carmine red in colour, larger and plumper with longer setae over the body and legs. They turned darker after mating. Both males

Table 1. Duration of development stages of *T. urticae* on okra

Stage	Development period (Mean days ± SD)*	
	Male	Female
Egg	2.92 ± 0.003	2.92 ± 0.003
Larva	0.83 ± 0.03	1.19 ± 0.25
Nymphochrysalis	0.26 ± 0.01	0.68 ± 0.04
Protonymph	0.36 ± 0.03	0.58 ± 0.05
Deutochrysalis	0.67 + 0.03	0.29 + 0.04
Deutonymph	0.93 ± 0.04	1.05 ± 0.05
Teleiochrysalis	0.76 ± 0.03	0.81 ± 0.06
Total developmental period	6.73 ± 0.18	7.52 ± 0.50

*Mean value of fifty observations

and females had bright red eye spots on the dorso-lateral idiosoma.

Total development period

The total development period from egg to adult emergence was 6.73 days for males and 7.52 days for females (Table 1).

Adult longevity

Adult males recorded a mean longevity of 12 days while the corresponding figures for mated and unmated females were 12.5 days and 17 days respectively (Table 2).

Reproductive biology of *T. urticae*

Mating behaviour

Newly emerged males were found actively moving in search of females to mate. They rested near or over the quiescent female deutonymphs that they came across, guarding them and even fighting with the rival males for the yet to emerge females, when a couple or more males were present. Mating took place immediately after the emergence of the female. Male pushed and raised the posterior abdominal region of the female and slide underneath with its hysterosoma upturned. Mating lasted for a mean period of 1.78 minutes (Table 3). Male was observed to mate with several females, though a female usually mated only once. However, females which were surrounded by several males were observed occasionally being attempted to mate by these males if the former stood motionless or were slow moving. But it lasted only for few seconds.

Pre-oviposition, oviposition and post-oviposition periods

The life span of adult female mites consisted of pre-

Table 2. Adult longevity of *T. urticae*

Sex		Duration (Days ± SD)*
Male		12 ± 1
Female	Mated	12.5 ± 0.71
	Unmated	17 ± 1

*Mean of ten observations

Table 3. Pre-oviposition, oviposition and post-oviposition periods

Parameters		Duration (Mean + SD)*
Mating period		1.78 + 0.36 minutes
Pre-oviposition period	Mated female	0.58 ± 0.06 days
	Unmated female	0.84 ± 0.04 days
Oviposition period	Mated female	9 ± 1.83 days
	Unmated female	11 ± 1 days
Post-oviposition period	Mated female	4 ± 1 days
	Unmated female	4.5 ± 0.71 days

*Mean of ten observations

Table 4. Fecundity, sex ratio and egg viability of *T. urticae*

	Fecundity (No. of eggs)	Male : Female ratio	Egg viability (%)
Mated female *	108 + 7.0	1: 5.8	92.10 ± 6.85
Unmated female *	77 ± 6.56	1: 0	

*Mean of ten observations

oviposition period, oviposition period and post-oviposition period, which were observed to be of longer duration in unmated females. The mean pre-oviposition period in mated and unmated females lasted for 0.58 days and 0.84 days respectively. Oviposition and post-oviposition periods lasted for 9 days and 4 days in case of mated females and 11 days and 4.5 days in case of unmated females as represented in Table 3.

Fecundity, sex ratio and egg viability of *T. urticae*

Mated females on an average laid 108 eggs whereas unmated females laid only 77 eggs. Mated female produced a progeny consisting of both males and females in the ratio 1:5.8 whereas unmated females produced only males. The viability of eggs of *T. urticae* was 92.10 per cent (Table 4).

DISCUSSION

The development of egg, larva and nymphs of *T. urticae* on okra in the present study was shorter compared to that on jasmine [5] and gerbera [6]. Difference in duration of development could also be influenced by sex. For instance, males of *T. urticae* recorded a shorter developmental period of 6.73 days compared to 7.52 days in females on okra. Several workers had already reported a similar trend in the developmental biology of different species of *Tetranychus* spp. infesting various crops.

Males of *T. urticae* were reported to completed their life cycle in 6.3 days and females in 6.5 days on pear [7], while Rajkumar [8] observed a duration of 10.70 days for male and 12.36 days for female to complete their life cycle in jasmine. The early emergence of male ensures sexual reproduction and sustenance of population as against parthenogenesis which is commonly observed in *T. urticae* in the absence of males and which results in all male population.

The males rested over the quiescent female deutonymphs which they came across to mate immediately after the emergence of the female. This peculiar behaviour prior to mating was common among *T. urticae* and other spider mites [9,10,11]. *T. urticae* preferred to colonize and lay eggs on the underside of leaves and showed a general preference to lay eggs near the veins and midrib of okra. The preference for the under surface of the leaves for oviposition could be due to the better protection from direct sunlight and rainfall.

Mated females produced a progeny consisting of both males and females in the ratio 1: 5.8. Kaimal and Ramani [12] reported a similar sex ratio of 1:5 in *T. ludeni* on velvet bean whereas Manjunatha and Puttaswamy [13] reported a wider sex ratio (1:10) in *T. neocaledonicus* on French beans. As the males are known to be polygamous [14] the chances of females getting fertilized become high which will ensure population build up and sustenance of the species.

Unmated females of *T. urticae* exhibited arrhenotokous reproduction. This is in conformity with earlier reports by several authors in *T. urticae* and in other species of *Tetranychus* mites [15,16,17]. This behaviour of unmated females to produce a progeny of males may be for imparting a natural control over its population when the food source is scarce or space is limited, thereby increasing the chances for survival.

Mated females laid more number of eggs (108 eggs) compared to unmated females (77 eggs). This higher fecundity of mated females is in accordance with the findings of Rajkumar [18] in *T. urticae.* The higher egg viability of 92.10 per cent observed in the current study, is an evidence of the high biotic potential of this species. A higher egg viability of 96.5 per cent in *T. urticae* [19] was also reported on gerbera.

In the present study, the longevity of unmated females was more than that of mated females and males. The negative influence of mating on life expectancy was also reported in other species on tetranychid mites as well [20,21].

CONCLUSION

The shorter developmental period of *T. urticae* averaging 6-8 days and high fecundity of 108 eggs observed in the present study would help them in successfully completing 2-5 generations per month at 30 $\pm$ 3^{0}C and 61.5 $\pm$ 7 % relative humidity. The shortening of life cycle along with significant increase in the rate of reproduction in *T. urticae* with the increase in temperature enables these mites to fast multiply and attain pest status especially during the drier and hotter months of the year in Kerala.

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