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BIOLOGY OF TWO SPOTTED SPIDER MITE, *TETRANYCHUS URTICAE* (ACARI: TETRANYCHIDAE) ON TARO

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Abstract

The biology of twospotted spider mite, *Tetranychus urticae* Koch was studied at the Integrated Pest Management Lab of Entomology division, Bangladesh Agricultural Research Institute (BARI) Gazipur following leaf disc method during March-May, 2022 at 25±2^0 C and 55±5% RH. It was revealed that biology of *T. urticae* consisted of egg, larva, protonymph, deutonymph and adult stages and brief quiescent period called nymphochrysalis, deutochrysalis and teliochrysalis. Egg incubation period 2.90±0.29, larval 1.3±0.2 and 2.7±0.54, protonymphal 2.8±0.25 and 3.0±0.35 and deutonymphal period of 2.4±0.43 and 2.9±0.51 days were recorded in its male and female, respectively. Males took less time to develop overall 6.45±0.30 days than females 8.25±0.28 days from egg to adult emergence. Males were smaller than females, according to morphometric measurements. Both parthenogenetic and bisexual reproduction were noted. The offspring of mated females were 1:2.32 males to females, while unmated females produced only males. An average of 62.0 ± 8.98 eggs were produced by mated females and 38.2 ± 6.36 by unmated females. Correspondingly mated females laid 7.0 to 10.0 (mean 8.6±0.68) and unmated females laid 2.0 to 5.0 (mean 4.0±0.55) eggs per day. The observed adult longevity was 9.30± 0.83 days for males, 12.2±0.80 days for mated females, and 10.0±1.3 days for unmated females, respectively.

Keywords: Spider mite, taro, arrhenotoky, sex ratio, lifer cycle.

Introduction

Twospotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) is one of the most important pests in many crop plants particularly vegetables including taro, and their feeding activity is based on sucking leaf cell contents (Parmagnani *et al*., 2023).The outbreak of this pest becomes secondary pest in agricultural systems that is assumed to be the consequences of frequent and indiscriminate use of toxic chemicals, especially pyrethroid insecticides by the vegetable growers (Dobson *et al*., 2002). Moreover, warm and dry weather is favorable for the multiplication and spread of this pest (Jeppson *et al.*, 1975). It is reported as one of the important pests of vegetable and ornamental crops and the outbreak of this pest in different vegetables in Bangladesh has become a serious problem for the growers. Twospotted red spider mite has been an alarming pest on bean, brinjal, taro, cucurbits and okra etc. which build up from February and decline during July under north Indian conditions (Singh and Singh, 1993).

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Phytophagous spider mites cause damage by piercing leaf cells and ingesting chlorophyll (Croft *et al*., 1998; Seymour, 1982). In high numbers these mites cause leaf discoloration and drying, thus reducing photosynthetic activity and lowering yield and crop quality (Flaherty *et al*., 1992; Hanna *et al*., 1996,). Outbreaks are often caused by the use of broad-spectrum insecticides which interfere with numerous natural enemies that help to manage the mite populations. Spider mites often become secondary pests in agricultural systems and the most common method of control of *T. urticae* is by using chemicals insecticide. A major problem in the control of *T. urticae* using chemical insecticides causes the ability to develop resistance rapidly after a few applications (Rauch & Nauen 2002). The frequent application of acaricides, combined with the short life cycle and high reproductive potential of spider mite, results in the rapid development of resistance (Tirello *et al*., 2012; Van Leeuwen 2010). In addition, intense and continuous use of chemicals causes environmental pollution and disruption of ecological balance. For developing effective and sustainable management approach of this pest, thorough knowledge about their biology is a prime requisite. Taro being the important host crop of twospotted spider mite, only very limited information is available on the biology of this pest on taro leaf and hence, the present study was conducted.

Material and Methods

The study on the development and life history of *T. urticae* was conducted in the IPM Laboratory of Entomology Division, Bangladesh Agricultural Research Institute during March-May, 2022 at 25±2^0 C and 55±5% RH.

Maintenance of the host plant (Taro) in net house

The taro plant was transplanted in 12-inch diameter plastic pot in the net house. Recommended dosages of Farm Yard Manure (FYM) and fertilizers were applied to these plants and the plants were watered as and when required to maintain optimum moisture in the pots. The taro plants were allowed to grow and artificially infested with *T. urticae* and the leaves from these plants were used for biology and life table study. Taro plants were transplanted every 15 days in order to ensure continuous availability of taro leaves for biology and life table studies in the laboratory.

The duration of developmental stages of *T. urticae* was studied on excised leaf disc of taro leaves. Leaf discs were made with fresh taro leaf without mite infestation. Each leaf disc was circular in appearance with 2cm diameter. Twelve leaf discs were prepared. The leaf discs were placed on cotton bed in petri dish (5 cm × 1 cm) facing under surface upward. The cotton bed was kept wet by adding with water with the help of dropper so that the discs remained fresh. The adult female mites were collected from the mass cultural of *T. urticae* on taro plants in the pots at the IPM net house and were transferred to each leaf disc for laying eggs. The

discs containing adult females were checked after 24 hours of mite transfer. The mites were removed at least one egg was found. In this way 15 eggs were collected on leaf discs. Keeping only one egg on each disc the others were destroyed. The discs were checked after every 24 hours and the stages of mite development were noted and the duration of hatching, larval, protonymph and deutonymph period was recorded till the appearance of their adulthood. The leaf discs were changed after 3 to 4 days to ensure their freshness. The immature nymphs were transferred to new disc very carefully with the help of camel hair brush. Deutonymphs of *T. urticae* were collected from the potted taro plants of laboratory culture. Five deutonymphs were transferred on each leaf disc. The disc containing deutonymphs were observed twice daily at 9:00 AM and 5:00 PM. The time of adulthood of the deutonymphs was recorded after moulting. All the mites were removed keeping one male and one female on each disc after moulting. The males were also removed after laying the first egg by the female. In this way more than 5 discs with ovipositing females were maintained for this experiment. The discs were checked after every 24 hours interval with the aid of a stereo binocular microscope. The leaf discs were also changed after every three days in the same way as described earlier. All the discs were checked and the number of eggs laid was counted till the death of the adult. The eggs were hatched into larvae and the larva undergoes moulting to become protonymph and deutonymph. The developmental duration of each stage such as egg, larva, nymph and quiescent stages were recorded. The morphometric measurement of different stages was recorded with the help of a standardized occular micrometer fitted to a camera equipped stereo binocular microscope (Olypus SZ61).

Results and discussion

The life cycle of *T. urticae* consisted of egg, larva, nymph (protonymph, deutonymph) and the adult. Developmental period of various stages and reproductive attributes are presented in Table 1 to Table 3.

Incubation period (Egg): *T. urticae* preferred to colonize and generally lay eggs on the underside of the leaves. Gravid female laid eggs singly or in groups ventral side of the leaves, often near the veins and the midrib of host leaf. Eggs were spherical and transparent when freshly laid, but turned creamy white prior to hatching. During this stage, two dark colored eye spots, corresponding to the simple eyes of the larvae, were clearly visible. Eggs of *T. urticae* measured 136.44±11.68 µm in diameter (Table1). The incubation period ranged from 2.0 to 3.50 days with an average of 2.90±0.29 days (Table 2).

Larval period: Newly hatched larva was creamy coloured, hexapod and small in size. On feeding the color changed from creamy to pale green. The simple eyes on the dorso-lateral idiosoma were clearly distinguishable at this stage. The larvae possessed only three pairs of legs. The larval period ranged from 1.00 to 2.00 days with average of 1.3±0.2 days for male and in case of female 2.7±0.54 days with a

range of 1.0 to 4.0 days was observed (Table 2). The larva measured 154.58±3.95 µm in length and 118.87±4.11 µm in breadth (Table 1). Initially the larva crawled around for some time and anchored at a place to feed on the cell sap.

Nymphochrysalis period: The dark green matured larva stopped feeding and moved to a suitable place on the leaf and entered into the quiescent stage (called nymphochrysalis) by anchoring itself to the leaf surface. During this stage, the anterior 2 pairs of legs were extending straight forward and kept close to each other and posterior legs were extended backwards and held close to the sides of opisthosoma. This stage lasted for 0.25 to 1.30with average of 0.66±0.21 days for male and 0.25 to 1.50 with average of 0.70±0.24 days for female (Table 2). Nymphochrysalis measured 178.58 ± 4.96 µm in length and 129.76 ± 4.11 µm in breadth (Table 1).

Protonymph: At the end of this nymphochrysalis stage, moulting took place. Protonymph is the first nymphal stage emerged by splitting open the larval skin along the dorsal midline and was characterized by the presence of four pairs of legs. The newly emerged protonymph was oval shaped and dark green in color at the beginning, which later turned into amber color. It was larger and darker as compared to the larva. This stage lasted for 2.0 to 3.5 with average of 2.8±0.25 days for male and 2.0 to 4.0 with average of 3.0±0.35 days for female (table 2). Protonymph measured 195.48±8.21 µm in length and 131.72±1.80 µm in width (Table 1).

Deutochrysalis: At the end of protonymphal period, the protonymph entered its second quiescent stage called the deutochrysalis. It remained anchored to the leaf +in a manner similar to that of nymphochrysalis. Its body measured 229.19±7.98µm in length and 141.02±1.11µm in width (Table 1). This period lasted for 0.89±0.24 days for male and 0.95±0.20 days for female.

Table 1. Morphometric measurement of various stages of the twospotted spider mite, *T. urticae*

Stages	Length (µm)		Width(µm)	
	Range	Mean±SE	Range	Mean±SE
Egg (Diameter)	113.6-167.8	136.44 ±11.68	113.6-167.8	136.44±11.68
Larvae	144.7-168.4	154.58±3.95	111.5-129.1	118.87±4.11
Nymphocrysalis	168.3-195.9	178.58±4.96	123.92-134.4	129.76±4.11
Protonymph	225.13-179.52	195.48±8.21	127.77-134.11	131.72±1.80
Deutocrysalis	199.78-245.13	229.19±7.98	129.93-149.31	141.02±1.11
Deutonymph	275.0-353.5	315.34±14.96	147.7-167.1	160.76±3.47
Teliocrysalis	320.7-393.61	371.37±13.23	183.11-197.03	190.04±5.10
Adult male	358.2-451.01	398.65±15.56	160.13-227.05	197.61±2.30
Adult female	428.9-478.1	452.72±13.41	214.3-233.9	224.02±9.31

Deutonymph: Deutonymph is the second nymphal stage. Sexual characters could be distinguished from this stage onwards, and it was pale reddish, female being larger and broader and male elongated. They were actively moving and feeding. Deutonymphal stage lasted for 1.0 to 3.5 with average of 2.4±0.43 days for male and 1.0 to 4.0 with average of 2.9±0.51 days for female (Table 2). Deutonymph measured 315.34±14.96 µm in length and 160.76±3.47 µm in width (Table 1).

The developmental stages of *T. urticae* on taro consists of egg, larva, protonymph, deutonymph and adult and quiescent period such as protochrysalis, deutochrysalis and tiliochrysalis recorded in the present study have also been reported by Krishna and Bhaskar (2014) in *T. urticae* infesting on okra plant.

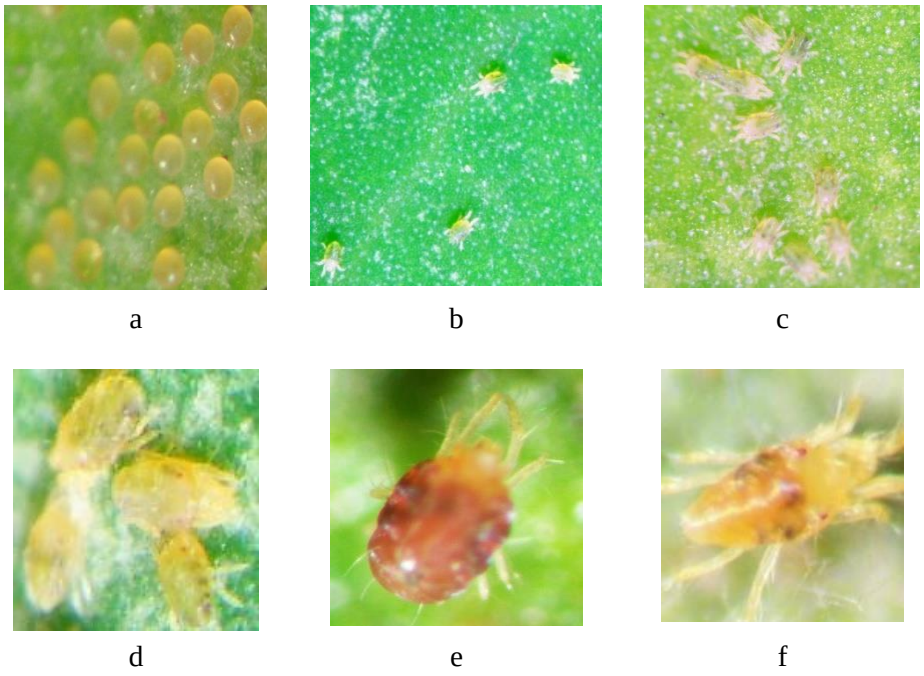

Fig. 1. Stereo micrograph of different developmental stages of *T. urticae*: a) egg, b) larva, c) protonymph, d) deutonymph, e) adult female & f) adult male.

Teliochrysalis: The deutonymph stage was preceded by the quiescent stage before it moulted into an adult stage. It remained inactive by anchoring itself to leaf. The moulting of quiescent deutonymph resulted in the emergence of adult. This stage was only found in female *T. urticae* whereas in case of male it was absent. It is measured 371.37±13.23 µm in length and 190.04±5.10µm in width (Table 1), and lasted for 1.0 to 1.50 with average of 1.0±0.16 days (Table 2).

Total Development period: The total development period from egg to adult emergence was 7.45±0.34 days for males and 8.25±0.25 days for females. The total developmental period for male was less compared to female. Males had been

observed to complete their life cycle in 6.73 days and females in 7.52 days on okra (Aswathi and Bhaskar, 2014); Veerendra *et al.* (2014) observed duration of 12.55± 0.82 days on grapevine. The early emergence of male ensures sexual reproduction against parthenogenesis which is common in *T. urticae*. Several workers had already reported a similar trend in the development biology of different species of *Tetranychus* infesting various crops. Rajkumar *et al.* (2005) recorded a shorter development time for male (10.7 days) compared to female (12.36 days) in *T. urticae* on jasmine.

Table 2. Developmental periods of life stages of *T. urticae* on taro under laboratory condition

Stages	Sex	No. of observation	Range	Duration in days (Mean±SE)
Incubation (egg)		30	2.0-3.5	2.9±0.29
Larval	Male	15	1.0-2.0	1.3±0.20
Larval	Female	20	1.0-4.0	2.7±0.54
Nymphocrysalis	Male	15	0.25-1.3	0.66±0.21
Nymphocry	Female	20	0.25-1.5	0.7±0.24
Protonymph	Male	15	2.0-3.5	2.8±0.25
Protonymph	Female	20	2.0-4.0	3.0±0.35
Deutocrysalis	Male	15	0.2-1.5	0.89±0.24
Deutocrysalis	Female	20	0.5-1.5	0.95±0.20
Deutonymph	Male	15	1.0-3.5	2.4±0.43
Deutonymph	Female	20	1.0-4	2.9±0.51
Teliocrysalis	Female	20	1.0-1.5	1.0±0.16
Adult	Male	15	7.00-8.5	7.45±0.34
	Female	15	7.5-9.00	8.25±0.25
	Male	15	7.0-12.0	9.3±0.83
Adult longevity	Unmated Female	20	6.0-14.0	10.0±1.3
	Mated female	20	11.0-15.0	12.2±0.80
	Male	15	12.0-19.0	14.3±1.30
Total life cycle	Female	20	20.0-26.0	23.1±0.98

Adult: The adult female measured 452.72±13.41 µm in length and 224.02±9.31 µm in width whereas male measured 398.65±15.56 µm in length and 197.61±2.30 µm in width (Table 1).

The mites exhibited sexual dimorphism. Males were reddish green or pale red and smaller with body tapering posteriorly to a blunt point; the body of the adult male was narrow elongated, oval with a distinct abdomen (Picture 1f). They also have numerous long hairs on their legs, and long but sparse hairs on their body. The females were bigger than males with rounded or oval abdomen. Females were

bright red and later turned to deep red or brick red in colour, larger than male with longer setae over the body and legs (Picture 1e). Both males and females had bright red eye spots on the dorsolateral idiosoma.The deutonymph and adult females of *T. urticae* developed on taro were larger in size compared to males as already reported by Krishna and Bhaskar (2014) in *T. urticae* on Okra plant.

Longevity: Adult males recorded a mean longevity of 9.30±0.83 days, while the mated and unmatedfemales showed 12.2±0.80 and 10.0±1.3 days, respectively (Table 2).

Reproductive biology of *T. urticae*: Reproductive biology of *T. urticae* consists of mating behavior, preoviposition, oviposition and postoviposition periods and fecundity etc.

Mating behavior: It was found that, males always emerged earlier than the females and were found actively moving in search for females to mate. After finding the quiescent female deutonymph (teliochrysalis) they rested near or over the quiescent female deutonymphs. It placed the anterior pair of legs on female deutonymphs and waited for its emergence in order to mate immediately after the emergence. Mating took place immediately after the emergence of the female. Sometimes there was competition between two or more males. In some cases, males helped the females for emerging out of deutonymphal skin by pulling the ecdysial skin. Mating

lasted for 2-3 min, and was observed to mate with several females. This peculiar behaviour prior to mating was common among *T. urticae* and other spider mites (Aswathi and Bhaskar, 2014; Veerendra *et al.*, 2014).

Pre oviposition period

The females laid eggs after a gap of certain period. The mean pre oviposition period in unmated and mated females lasted for 2.9±0.75 and 2.2±0.51 days, respectively (Table 3).

Oviposition and post oviposition periods: Oviposition and post oviposition periods lasted for 8.8± 0.80 and 3.0± 0.65 days in case of mated females and 4.2±0.58 and 2.10±0.33 days in case of unmated females as presented in Table 3.

Fecundity, sex ratio and egg viability of *T. urticae*: Fecundity data revealed that mated females laid more eggs than unmated females. The total fecundity of mated female was 49-97 eggs (mean- 62.0±8.98), and that of unmated being 16-50 eggs (mean-38.2±6.36). Correspondingly mated females laid 7.0 to 10.0 (mean 8.6±0.68) eggs per day and unmated females laid 2.0 to 5.0 (mean-4.0±0.55) eggs per day. Mated females laid a greater number of eggs (62.0±8.98) compared to unmated females (38.2±6.36); and this observation is in accordance with Prasad and Singh (2011) in *T. urticae.* High fecundity of mated females of *T. urticae* was reported by Rajkumar (2003). Mated female produced both male and female's progeny in the ratio of 1:2.32, while unmated female produces only male (1:0.0).

Female biased sex ratio was also reported by Krishna and Bhaskar (2014) in *T. urticae* on Okra. Arrhemotoky is also reported by Banato and Gutierrez (1999) in other species of *Tetranychus*. The viability of eggs of mated female was 96.88% and 82.02% of unmated female (Table 3). The higher egg viability (96.88%) observed in this study is evidence of the high biotic potential. A higher egg viability of 96.5% in *T. urticae* was reported on rose (Kaur *et al.*, 2012). The egg viability of 92.1% and 96.5% in *T. urticae* was recorded on Okra and gerbera plants by Krishna and Bhaskar (2014) and Silva *et al*. (2009), respectively.

Table 3. Ovipositional period, fecundity and egg viability of *T. urticae* on taro under laboratory condition

Particulars	Sex	No. of observation	Range	Duration in days (Mean±SE)
Pre oviposition period	Unmated female	12	1.0-5.0	2.9±0.75
	Mated female	15	1.0-4.0	2.2±0.51
Oviposition period	Unmated female	10	3.0-6.0	4.2±0.58
	Mated female	12	7.0-11.0	8.8±0.80
Post oviposition period	Unmated female	10	1.0-3.0	2.1±0.33
	Mated Female	12	2.0-5.5	3.0±0.65
Rate of egg laying	Unmated female	10	2.0-5.0	4.0±0.55
	Mated female	12	7.0-10.0	8.6±0.68
Fecundity	Unmated female	10	16.0-50.0	38.2±6.36
	Mated female	12	49.0-97.0	62.0±8.98
Sex ratio (Male: Female)	Unmated female	157	1:0.00-1:0.00	1:0.00
	Mated female	310	1:1.94 -1:2.88	1:2.32
Egg viability (%)	Unmated female	191	56.25-96.88	82.02
	Mated female	320	94.0-98.98	96.88

Total life cycle

Males completed their life cycle in 14.3±1.30 days whereas; females took 23.1±0.98 days to complete their life cycle. It was clear from the results that males took less time than females to complete their life cycle (Table 2).

The observations on the development of egg, larva and nymphs of *T. urticae* on taro in the present study are more or less similar to the earlier findings of Prasad and Singh (2011), Kaur *et al.* (2012) and Aswathi and Bhaskar (2014). Difference in duration of development could also be influenced by sex; host plants, temperature etc.

The shorter developmental period and high fecundity was observed in the present study. The shortening of life cycle along with significant increase in the rate of reproduction 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 (Siddhapara and Virani, 2018).

Conclusion

Due to climate change and over use of synthetic chemical insecticides to control insect pests, spider mite infestation in different crops is on the rise at present. For developing sustainable mite management technology, proper documentation of its biology could play a vital role. In Bangladesh, along with different crops, spider mite is a serious pest of taro. Since the biology of spider mites was studied on taro crops. The findings of the study would be of particular help for developing sustainable mite management options, thereby increasing the productivity of this crop in Bangladesh.

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