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Demographic Evaluation of Red Mite, *Tetranychus bioculatus* (Wood-Mason) on Different Ornamental Hosts

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ABSTRACT

The demographic characteristics of red mite, Tetranychus bioculatus were studied through life table construction based on life history data using leaves of three ornamental host plants viz., marigold (Tagetes sp.), rose (Rosa sp.) and cosmos (Cosmos bipinnatus) in the laboratory at temperature of 20.3±0.66°C and relative humidity of 75.25±3.30%. The life cycle duration of red mite from egg to adult was shortened when feeding on marigold leaves with no significant differences in duration of life stages consuming three different hosts. The fecundity ranged from 70.6 to 109.8 eggs per female and it significantly differed among the mites live on different host plants. The host plants influenced the life table parameters of T. bioculatus showing highest innate capacity of increase (r_m) of 0.24 on marigold. The marigold and cosmos favors increase mite population by 2.2 and 1.5 times, respectively, which higher than those fed on rose in the generation times (GT) of 18.22 and 19.18 days.

Key words: Red mite, ornamental host plants, life history, life table.

INTRODUCTION

There are a wide range of host plants of tetranychid mites throughout the world such as hibiscus, juniper, jute, corn, soybean, cotton, mashkalai, citrus, black olive, apple, various vegetable crops, and rose and camellia (Nucifora and Vacante, 1985; Das, 1987). Tetranychid mites are regarded as serious pests of vegetables and fruit corps. Red mite (*T. bioculatus*) occurs in food and fiber crops of economic importance in Bangladesh and causes considerable losses (Kabir, 1975; Sardar and Sarker, 1987).

Tetranychus bioculatus was found to attack marigold plants for the first time in Bangladesh and is one of the major problems in successful production of many ornamental and field crops (Nucifora and Vacante, 1985). Like other mites, *T. bioculatus* sucks cell sap by penetrating needle-like piercing sucking mouth parts into host tissues and also removes mesophyll tissues. The infested leaves of attacked marigold plants become green to yellow and then white. They spin fine webs which cover the leaves or top of whole plant partially or completely. The young infested plants become stunted and fail to bear flowers and finally die. The yield may be reduced to zero per cent in the severe infestation (Bessin and Willson, 1999).

Ornamental plants or many other agricultural crops grown in Bangladesh are reported to be attacked by one or more species of mites (Sardar and Sarker, 1987) and any grower or producer is

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naturally interested in protecting his crops. It is important to know the life table of mite for effective management of the pest to ensure economic crops yield. A detailed knowledge on the relationship of host plant and the mites and the surrounding environment is essential to prescribe an effective management program. The types of host plants are known to play an important role on the polyphagous mites in building up the population (Sardar and Sarker, 1987). *T. bioculatus* is reported as a polyphagous in agroecosystem (Sardar and Sarker, 1987), But no information have yet been known as to how this mite adapts to different environmental situations. Evaluation of the effects of different host plants on the life table parameters of *T. bioculatus* is very important for designing management program. The knowledge of the biology of *T. bioculatus* would increase the efficiency of a farmer to manage the pest successfully. The information of the life table of this mite pest concerning net reproduction capacity, generation time and intrinsic rate of increase for the population multiplication would help developing effective management.

MATERIALS AND METHODS

The studies were made to analyze the effect of three host plants on red mite, *Tetranychus bioculatus* with special reference to life cycle and life table parameters in winter months of 2004-2005.

Food selection and source of supply

Three different host plants such as marigold, rose, and cosmos were chosen as food for this mite pest. First two host plants were selected on the basis of their growing season to serve as food in a specific season of the year. In order to make the plants available throughout the period of the study marigold and cosmos were grown in two small plots in the field laboratory of the Department of Entomology, Bangladesh Agricultural University (BAU) following standard agronomic practices (Ahmad, 1995). Seedlings were transplanted on different dates in order to obtain a continuous supply of fresh green leaves (immature and mature) as food for immature and adult mites. Only rose leaves were collected from the rose garden of Horticulture Farm of BAU and provided daily.

Stock culture of *Tetranychus bioculatus*

Before commencement of the study, the stock culture of red mite was maintained in the laboratory. The *T. bioculatus* mite infested rose leaves were collected from rose plant of Horticulture farm where pesticides was not sprayed before. The mite- infested leaves were kept in Petri dishes (12 cm x 2.6 cm) in the laboratory provided with fresh green leaves of marigold, rose and cosmos as food. A piece of water soaked cotton ball was placed in each Petri dish slightly touching the petiole of leaves for maintaining moisture level and also for keeping the leaves afresh. Water was added to the cotton ball daily with a squeezing plastic bottle and the leaves and Petri dishes were renewed everyday. The mite population increased within five weeks. This culture was established in order to avoid the effect of previous food plants on the life cycle of the test mites. The male and female adults obtained from various food plants were paired in Petri dishes with fresh green leaves for mating and egg laying. The observations were made daily using a magnifying lens (15x) and binocular stereo-microscope.

Life cycle study on different foods

Red mite was allowed to develop on the host leaf covering another leaf in Petri dishes inside which moisture level was maintained by keeping water-soaked cotton ball. A study on red mite with marigold rose and cosmos leaves as food was conducted in the laboratory. Ten eggs randomly obtained from the stock culture of marigold, rose and cosmos leaves and were placed in Petri dishes (10 cm diameter $\times$ 2.5 cm height). Five replicates per food were used. These Petri dishes were placed randomly on the table. Observation was made daily to examine egg incubation in each replicate. Just after hatching, the larvae were carefully transferred to marked Petri dishes having fresh leaves of three different host plants in separate dishes with the help of a soft camel hair brush (0-0). The larvae were fed on the respective plant leaves supplied earlier in the stock culture. Fresh green leaves were given to the mites at 24 hours interval. Data were taken on the duration of egg hatching, larva, protonymph, deuteronymph and adult. Safe and good hygienic condition within the rearing Petri dishes was maintained by providing fresh leaves and changing dishes daily. The mortality of each stage of mites was also recorded.

The adults emerged from different food plants were allowed to mate in Petri dishes by providing fresh leaves of respective host plant as substrate. Before pairing sexes were identified specially with their size after the emergence of the adults from protonymph and deuteronymph. On completion of mating, the female started laying eggs. The periods of egg deposition and life span of male and female mite were recorded. The eggs laid were counted everyday during oviposition period on each food to determine the fecundity and egg viability.

Life table

Life table of *T. bioculatus* was constructed with the life cycle data such as egg incubation period, immature development time and mortality, adult longevity, age specific fecundity and sex ratio among offspring. The population parameters such as net reproductive rate (R_o), generation time (GT) and innate capacity of increase (r_m) were obtained following the method of Laing (1968).

Data obtained from experiments were analyzed by computer for one factor Completely Randomized Design (CRD) and analysis of variance (ANOVA) with Duncan's multiple range test (DMRT) for comparing means on the effects of different host plants on the life stages, male and female adult longevity, and egg deposition of *T. bioculatus*. Life tables based on different host plants were also constructed to determine the demographic characteristics of *T. bioculatus.*

RESULTS

Egg incubation and immature development

The eggs were laid at random by the females of red mite on both surfaces of the supplied leaf. The eggs were translucent like a drop of honey just after deposition. Immediately before hatching, the area along the periphery of egg became transparent and red eye spots were visible. The incubation period of egg differed among the red mite consuming these different host plants. The mean incubation period was 5.1 days when reared on marigold leaf. This period in the latter two leaves *i.e.*, in rose and cosmos leaves was similar and less than that of marigold leaves (Table 1).

Table 1. Egg incubation and immature developmental duration of red mite (*Tetranychus bioculatus)* feeding on different ornamental hosts

Stages	Duration (days) on different host plants					
	Marigold		Rose		Cosmos	
	Range	$\bar{X}$ ±SE	Range	$\bar{X}$ ±SE	Range	$\bar{X}$ ±SE
Incubation period	5.0-5.4	5.1±0.08	4.0-5.0	4.6±0.24	4.0-5.0	4.6±0.24
Larval duration	2.0-2.7	2.14±0.32	2.0-3.3	2.5±0.31	2.22-2.6	2.52±0.14
Protonymphal duration	2.0-2.5	2.14±0.10	2.0-2.7	2.28±0.17	2.0-2.77	2.45±0.14
Deuteronymphal duration	2.0-2.44	2.20±0.10	2.0-3.0	2.4±0.24	2.0-2.77	2.42±0.17

The egg hatched into active larva which was almost spherical in shape and light amber colored having three pairs of legs. The larva settled along the mid-rib, lateral or sub-lateral veins of the leaf and remained inactive at the time of molting. The mean larval period lasted for 2.14, 2.50 and 2.52 days when feeding on marigold, rose and cosmos respectively (Table 1). The nymph was bearing four pairs of legs at protonymph and deuteronymphal stages. The protonymph was slightly brighter than the larva. The mean duration of the protonymph was 2.14, 2.28 and 2.45 days with little variation in three host plants (marigold, rose, cosmos respectively) used as food (Table 1). The deuteronymph was bigger than the protonymph. It appeared to be more or less oval and red in color. The setae present on the dorsum were long. The mean duration of deuteronymph did not vary among marigold, rose and cosmos hosts and these were 2.20, 2.40 and 2.42 days, respectively (Table 1).

Reproductive periods and adult longevity

The male mite became adult directly from the protonymph without passing through the deuteronymphal stage. But the adult female emerged through the deuteronymph. The male was smaller in size as compared to the female. The males moved actively on the leaf surface. Before

death the color changed to yellowish. The reproductive period consisted of pre-oviposition and oviposition period of the female mite. The female mite commenced oviposition after 1.4-1.6 days of emergence and continued egg deposition for a mean duration with a range of 9.4-13.3 days on different host plants (Table 2). The mean duration of post-oviposition was ranged from 1.13-1.5 days. The average longevity of the female on different host plants was ranged from 11.93-16.4 days and that of male was 10.2-14.2 days (Table 2).

Table 2. Reproductive periods and life span of adult red mite (*Tetranychus bioculatus*) feeding on marigold, rose and cosmos leaves

Stages	Duration (days) on different host plants					
	Marigold		Rose		Cosmos	
	Range	$\bar{X}$ ±SE	Range	$\bar{X}$ ±SE	Range	$\bar{X}$ ±SE
Preoviposition period	1.0-1.5	1.4±0.10	1.5-2.0	1.6±0.10	1.0-1.5	1.4±0.10
Oviposition period	9.0-10.0	9.4±0.19	12.5-14.0	13.3±0.30	11.0-12.8	11.76±0.34
Post oviposition period	0.5-1.6	1.13±0.20	1.5-1.5	1.5±0.00	1.0-1.5	1.3±0.12
Female longevity	11.55-12.11	11.93±0.10	16.0-17.0	16.4±0.24	14.0-15.3	14.46±0.29
Male longevity	10.0-11.0	10.2±0.20	14.0-15.0	14.2±0.20	11.0-12.0	11.6±0.24

Total life cycle duration

The total life cycle of red mite from egg to death of adult on different host plants was obtained by sum of mean duration in days of all life stages. The total duration of life cycle ranged from 19.58 to 23.52 days for male and 23.51 to 28.12 days for female. The total life time of both male and female mite was shorter on marigold and cosmos, and longer on rose plant (Fig. 1).

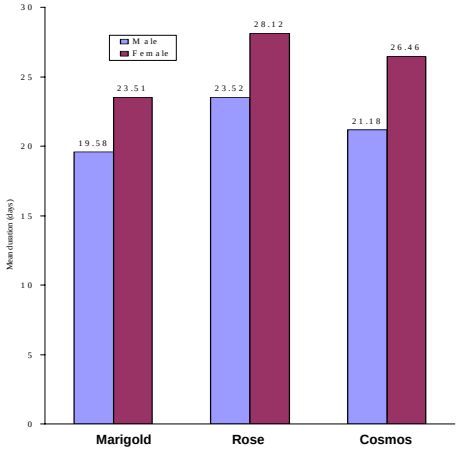

Fig. 1. The mean duration of life cycle of red mite feeding on different ornamental hosts

Fecundity and egg viability

The egg production by red mite, *T. bioculatus* fed on different host plants was found to differ significantly ($p<0.01$). The number of eggs laid per female ranged from 65 to 135 (Table 4) with an oviposition period of 9.0-13.3 days (Table 2). The maximum oviposition was found in early part of the oviposition period. All the female mites commenced laying eggs 1.4-1.6 days preoviposition period after emergence and mating (Table 2). The fecundity was the highest with 109.8 eggs and the lowest of 70.6 eggs per female on marigold and rose, respectively (Table 3). Red mite laid a maximum of 21 eggs on a day, but 3-5 eggs were common. There were 98.61, 89.07 and 93.25% egg viability were observed on marigold, rose and cosmos, respectively (Table 3).

Table 3. Fecundity and egg viability of red mite (*Tetranychus bioculatus*) reared on different ornamental host plants

Host plants	Total eggs laid (no.)		Total eggs hatched (no.)		Egg viability (%)	
	Range	$\bar{X}$ ±SE	Range	$\bar{X}$ ±SE	Range	$\bar{X}$ ±SE
Marigold	85-135	109.8±10.22a	85-133	108.2±9.89	97.69-100.00	98.61±0.43
Rose	65-79	70.6±2.29c	59-69	62.8±1.74	84.29-93.85	89.07±1.82
Cosmos	87-93	89.0±1.05b	81-88	83.0±1.58	88.76-96.59	93.25±1.33

Means having different letters in a column differed significantly ($p<0.01$)

Sex Ratio in F_1 Generation

Total number of male and female mites in F_1 generation were counted on different host plants and sex ratios (♀/(♀+♂)) were obtained and presented in Table 4. The sex-ratio was found to be maximum on marigold as 0.78±0.01 and minimum on rose as 0.56±0.02 which was very close to cosmos (0.64±0.01).

Table 4. Sexes of offspring and sex ratio of red mite feeding on different ornamental host plants in F_1 generation

Host plants	Total egg (no.)		Female offspring (no.)		Male offspring (no.)		Sex ratio (♀/(♀+♂))	
	Range	$\bar{X}$ ±SE	Range	$\bar{X}$ ±SE	Range	$\bar{X}$ ±SE	Range	$\bar{X}$ ±SE
Marigold	85-135	109.8±10.22	66-93	81.0±5.45	15-31	22.4±3.17	0.75-0.83	0.78±0.01
Rose	65-79	70.6±2.29	31-36	33.4±0.93	23-32	25.6±1.69	0.49-0.61	0.56±0.02
Cosmos	87-93	89.0±1.05	45-57	50.4±1.94	25-30	28.2±0.97	0.60-0.68	0.64±0.01

Reproductive potential at different sex-ratios

The reproductive potential of red mite was assessed with the help of polynomal analysis on the fecundity and sex-ratios of F_1 generation females (Figs. 2 and 3). The maximum number of eggs per female was predicted to attain the sex ratios at 0.75, 0.49 and 0.68, the maximum value being 135.0, 79.0 and 93.0 eggs laid on marigold, rose and cosmos leaves, respectively (Fig. 2). A maximum daily number of 11.0, 6.0 and 8.0 eggs per female were predicted at sex-ratios of 0.76, 0.59 and 0.66 on different host plants (Fig. 3).

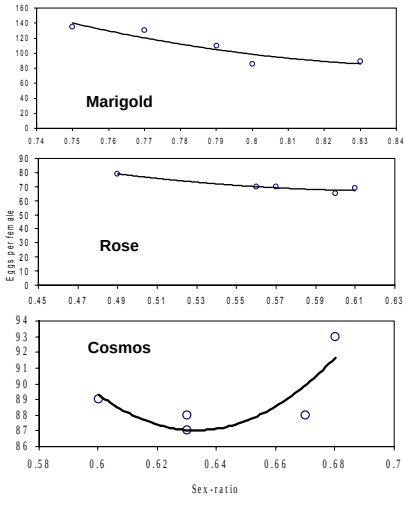

Fig. 2. Observed (circles) and predicted (solid line) number of eggs per female *Tetranychus bioculatus* fed on different host plants as a function of parent sex-ratio

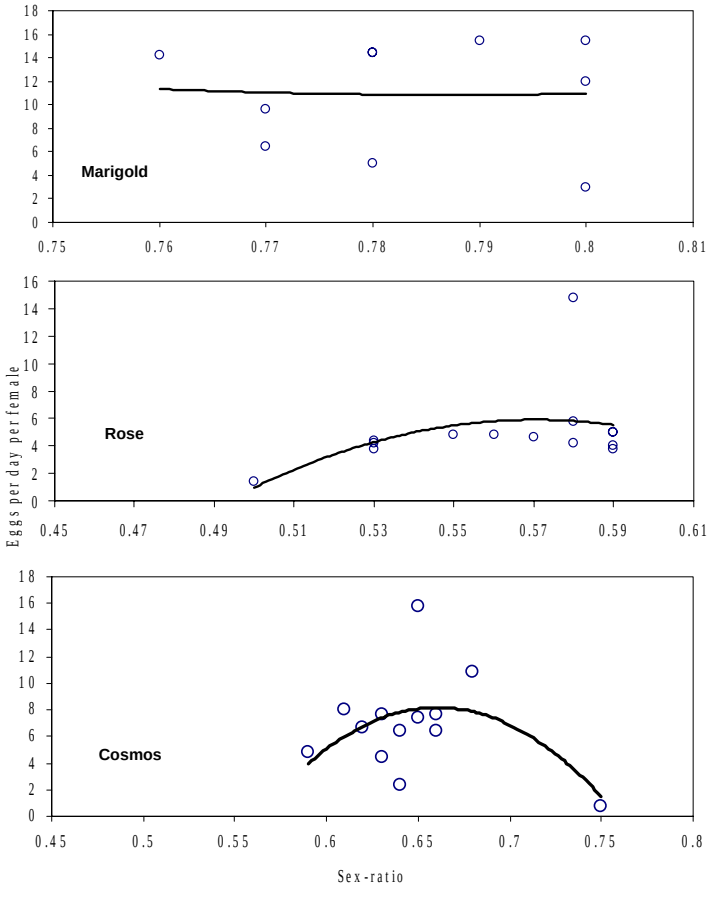

Fig. 3. Observed (circles) and predicted (solid line) number of eggs per day per female *Tetranychus bioculatus* fed on different host plants as a function of parent sex-ratio

Life table

The life table parameters R_o (net reproductive rate), GT (generation time) and r_m (innate capacity of increase) were obtained from life table and these parameters are given against each host plant in Table 5. The R_o of *T. bioculatus* was 78.69 on marigold and the lowest of 37.02 on rose. The GT were 19.68 and 19.18 on rose and cosmos, respecively which were greater than on marigold. The r_m was found to be 0.24 on marigold which was greater as compared to that of other two host plants and ranged from 0.18 to 0.21.

Table 5. Life table parameters (R_0, GT, r_m) of *Tetranychus bioculatus* feeding on different host plants

Host plants	Net reproductive rate (R_0)	Generation time (GT)	Innate capacity of increase (r_m)
Marigold	78.69	18.22	0.24
Rose	37.02	19.68	0.18
Cosmos	53.87	19.18	0.21

DISCUSSION

The experimental results clearly indicated the significant influence of the three host plants as food source on the life style of *Tetranychus bioculatus.* The egg incubation took place in 4.6-5.1 days in which eggs on rose and cosmos hatched within little less time than on marigold. The egg incubation period varied on food source (different leaves) and temperature. The eggs of *T. bioculatus* hatched within 3.5 days on jute and that of spider mites by 2 or 3 days at 23.8^{0}C; after 21 days at 12.7^{0}C but 5-10 days under average greenhouse temperatures of 15.5^0 to 21.1^{0}C (Hazarika 1952, Smith 1952). It took 5.38 days in red mite, *Eutetranychus orientalis* on *Ziziphus mauritiana* under ambient temperature of 17^{0}C (Yadav *et al.,* 2003). The larval and nymphal development took place within the same days. However, each of these immature stages developed earlier by two days than the egg incubation period. The immature development was quicker than the egg stage development presumably due to vigorous feeding. The adult life-span of red mite might be temperature dependent like that of citrus red mite, *Panonychus ulmi* (Khan and Sengonca, 2002) and vegetable mite, *Tetranychus neocaledonicus* (Butani and Jotwani, 1984). Thus the life cycle from egg to adult of red mite was different in both male and female among the ornamental host plants. The male mite survived 19.58-23.52 days and female 23.51-28.12 days feeding on three different host plants. The life cycle of *T. bioculatus* on jute was completed by 7 days (Hazarika, 1952). Sardar and Sarker (1987) stated that the life cycle from egg to adult of *T. bioculatus* on mashkalai (*Vigna mungo*) in the laboratory covered 15 days.

The fecundity of red mite *T. bioculatus* differed significantly when feeding on three different ornamental host plants. It was highest (110 eggs) per female on marigold. The mite laid 39 and 21 less eggs when feeding on rose and cosmos, respectively. Therefore marigold appeared to be most suitable host for *T. bioculatus* in ornamental ecosystem. Yet there is no published report on the biology of red mite including its fecundity on ornamental plants as host. The fecundity of *T. bioculatus* has been known on field crops such as 64.4 eggs per female feeding on blackgram (*Vigna mungo*) (Sardar and Sarker, 1987) and 77 eggs per female on jute (Hazarika, 1952). This egg production was higher than that in vegetable mite, *T. neocaledonicus* with 61 to 93 eggs per female (Butani and Jotwani, 1984). Khan and Sengonca (2002) reported the mean total fecundity of *Panonychus ulmi* from 80 to 51 eggs per female at 25^0 and 30^{0}C, respectively. The egg viability of *T. bioculatus* did not vary on ornamental plants showing no effect on the egg viability of this mite. The sex ratio (♀/(♀ + ♂)) of 0.78 was found on marigold leaves which was higher than those on rose and cosmos leaves. The sex ratio of *Panonychus ulmi* was 0.75 as reported by Khan and Sengonca (2002). The marigold could be considered as the most suitable host for *T. bioculatus.*

The reproductive rate of *T. bioculatus* was 1.5 and 2.0 times more on marigold than on cosmos and rose respectively. It was due to greater fecundity of this mite when feeding on this marigold leaves. The generation time (GT) was less on marigold than on rose and cosmos with almost equal GT in the latter two hosts. Rahman and Sapra (1955) counted 32 overlapping generations in a year in case of *T. cucurbitae.* The number of generations of *T. mariana* under field conditions and laboratory was about 24 to 30 per annum as stated by Moutia (1958). Therefore, low GT and higher r_m on marigold than on other ornamentals indicated that *T. bioculatus* was capable of sustaining and producing more population when feeding on marigold plant. Considering various parameters studied in the life history of *T. bioculatus*, it was evident that out of three host plants marigold proved to be most suitable host. As host this plant showed better development, higher net reproductive rate (R_o) and innate capacity of increase (r_m).

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