



Biology and demography of cassava red spider mite, *Oligonychus biharensis* (Hirst) (Acari: Tetranychidae) on *Manihot esculenta* L.

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ABSTRACT: Development and population performance of mite, *Oligonychus biharensis* was studied on cassava at three different constant temperatures (28°C, 24°C and 32°C) in the laboratory. The developmental period from egg to adult varied from 11.57 days at 24°C to 5.57 days at 32°C. The average longevity of adult mated female ranged from 9.10 days to 15.72 days, while the oviposition period varied from 8.46 days to 13.66 days. Fecundity ranged from 52.03 to 79.42 eggs/ female. At 24°C, each mated female laid 79.42 eggs over 13.66 days and produced a female-biased progeny of 11.48:1 sex ratio. Also, higher Net Reproduction Rate of 69.96 female off-springs/ female/ generation, Mean Generation Time of 20.15 days, Doubling Time of 3.33 days, Intrinsic rate of natural increase (r_m) of 0.2259 female off-springs/female/day were observed.

Keywords: *Oligonychus biharensis*, cassava, life history, population performance

INTRODUCTION

Cassava (*Manihot esculenta* L.) is a primary food crop of South Indian state of Kerala and also an industrial crop. Because of its starchy roots, ease of establishment and nutritional value, it is mostly farmed. In India, there is a scarcity of detailed information on pest species associated with Cassava. Spider mites are the important pests of agricultural crops, damaging all types of economically important cultivated crops, including cereals, pulses, millets, vegetables, plantations, ornamental and medicinal plants (Vacante, 2015). Among them *Oligonychus biharensis* (Hirst), a mite that has been a significant threat as a sporadic pest of vegetables, rose, camphor, litchi and many other plants of economic importance. The overall development and vigor of the plants are generally reduced when mites attack such plants. *Manihot esculenta* L. was successfully used as a laboratory host for studying detailed biology and demography of this emerging spider mite pest *O. biharensis*. Temperature has been the crucial environmental factor affecting development and reproduction of poikilothermic organisms like spider mites. Hence, we felt it is necessary to study mite's biological characteristics at different temperature conditions for the construction of developmental curves which can be used for the prediction of mite's developmental time as a function of temperature factor. Such predictions may serve as population models to study the population fluctuation of pest organisms. Thus, present study was conducted to generate data on the development and population performance of *O. biharensis* under constant temperature conditions between 24°C and 32°C in the laboratory.

MATERIALS AND METHODS

Life history of mite: Developmental biology of the spider mite *O. biharensis* was studied on Cassava leaf discs separately at three different constant temperature conditions viz., 24±1°C; 75-80% RH, 28±1°C; 70-75% RH and 32±1°C; 75-80% RH with 14h: 10h L: D conditions in a BOD incubator. Initially, a cohort of 30 to 50 eggs laid on 5cm x 5cm excised Cassava leaf discs were observed periodically for hatching. Soon after hatching, using a fine camel hair brush, the larvae were individually transferred to 50 different 1.5 cm x 1.5 cm fresh leaf discs kept on wet foam in 9" x 6" polyethylene trays (Excised leaf disc technique). Further the larvae were observed every 3 to 6 hours under a stereo binocular microscope and the data in respect of development from larva to adult including the quiescent stages (larvochrysalis, nymphochrysalis and teliochrysalis) were recorded. Period of development was computed for each stage of development, such as larva, quiescent 1 (larvochrysalis), protonymph, quiescent 2 (nymphochrysalis), deutonymph and quiescent 3 (teliochrysalis) including compiled data for the total development from egg hatching to adult emergence. The sex of the emerging adult was also recorded to compute the developmental time of male and female mite, separately.

Reproduction: Female teliochrysalis stages selected from the nucleus mite culture maintained in the laboratory were individually transferred onto 50 (1.5 cm x 1.5 cm) fresh leaf discs. Subsequent to the emergence of female adult from the teliochrysalis stage, two male adults were released onto each leaf disc to ensure mating. Further,

Table 1. Reproduction and demographic parameters of *Oligonychus biharensis* on Cassava at different constant temperatures in the laboratory

Reproduction attributes	24°C; 75-80% (n=33)	28°C; 70-75% (n=30)	32°C; 75-80% (n=30)
Pre-oviposition period (days)	1.75 ± 0.15 ^b	2.36 ± 0.25 ^b	0.50 ± 0.15 ^a
Oviposition period (days)	13.66 ± 0.58 ^c	10.20 ± 0.60 ^b	8.46 ± 0.26 ^a
Post-oviposition period (days)	0.30 ± 0.11 ^a	0.23 ± 0.09 ^a	0.13 ± 0.63 ^a
Longevity of mated females (days)	15.72 ± 0.56 ^c	12.80 ± 0.63 ^b	9.10 ± 0.25 ^a
Mean no. of eggs/ female	79.42 ± 4.88 ^b	70.50 ± 5.11 ^b	52.03 ± 3.76 ^a
Mean no. of female offsprings/female	70.96	60.03	43.73
Mean no. of male offsprings/female	6.18	9.13	8.00
Sex ratio of progeny (♀: ♂)	11.48:1	6.57:1	5.46:1
Demographic parameters			
Mean Generation Time (days)	20.15 ± 0.16 ^c	17.02 ± 0.13 ^b	12.62 ± 0.12 ^a
Doubling Time (DT)	3.33 ± 0.03 ^c	2.92 ± 0.02 ^b	2.37 ± 0.02 ^a
Net Reproduction Rate (No. of female offsprings/ female/generation)	69.96 ± 0.40 ^c	59.78 ± 0.31 ^b	43.38 ± 0.27 ^a
Gross Reproduction Rate (GRR)	93.45 ± 0.30 ^c	89.67 ± 0.31 ^b	67.60 ± 0.30 ^a
Finite Rate of Increase (No. of female offsprings/female/day)	1.2563 ± 0.003 ^a	1.2953 ± 0.002 ^b	1.3961 ± 0.005 ^c
Intrinsic Rate of Natural Increase (No. of female off-springs/female/day)	0.2259 ± 0.002 ^a	0.2562 ± 0.002 ^b	0.3273 ± 0.004 ^c

n: number of mites observed; Mean values (±SE obtained by boot strapping method) with same alphabetical superscript within the row are not significantly different as per Tukey's HSD test ($p < 0.05$)

observations were made at 24 hours interval to record the pre-oviposition period, eggs laid every day, oviposition period, post-oviposition period *etc.* Observations were recorded from the first day of egg laying until the female completed laying eggs and died naturally. As the life span of male mite was short, it was replaced with fresh male, as and when found dead on the leaf discs. Ovipositing females were carefully transferred to fresh leaf discs everyday and the eggs laid in the previous leaf disc were observed till they developed into adults, simultaneously recording the sex of the emerging adult then. Mite's reproduction attributes *viz.*, pre-oviposition, oviposition, post-oviposition, fecundity and sex ratio (♂: ♀), as proportion of male and female off-springs were recorded across different temperature conditions and compared to know the influence of temperature on the reproduction attributes.

Population performance or demography: Temperature-wise age specific life table of *O. biharensis* was constructed separately. Demographic/Life table parameters such as,

Mean Generation Time (T), Net Reproduction Rate (Ro), Gross Reproduction Rate (GRR), Finite Rate of Increase (λ), Intrinsic Rate of Natural Increase (r_m) and Doubling Time (DT) were computed following the procedure suggested by Birch (1948) and Atwal and Bains (1974) as below and the data were analysed (Chidananda, 2016; Pooja, 2018).

$$\text{Net Reproduction Rate (R}_o\text{)} = \sum l_x m_x$$

$$\text{Mean Generation Time (T)} = \frac{\sum x' l_x m_x}{R_o}$$

$$\text{Finite Rate of Increase in number } (\lambda) = \text{anti ln} \left[\frac{\log_e R_o}{T} \right]$$

$$\text{Intrinsic Rate of Natural Increase (r}_m\text{)} = \ln(\lambda)$$

$$\text{Doubling time, DT} = \frac{\ln 2}{r_m}$$

where,

l_x = proportion of females alive at age interval x

m_x = number of female off-springs produced by the surviving female at the age interval x

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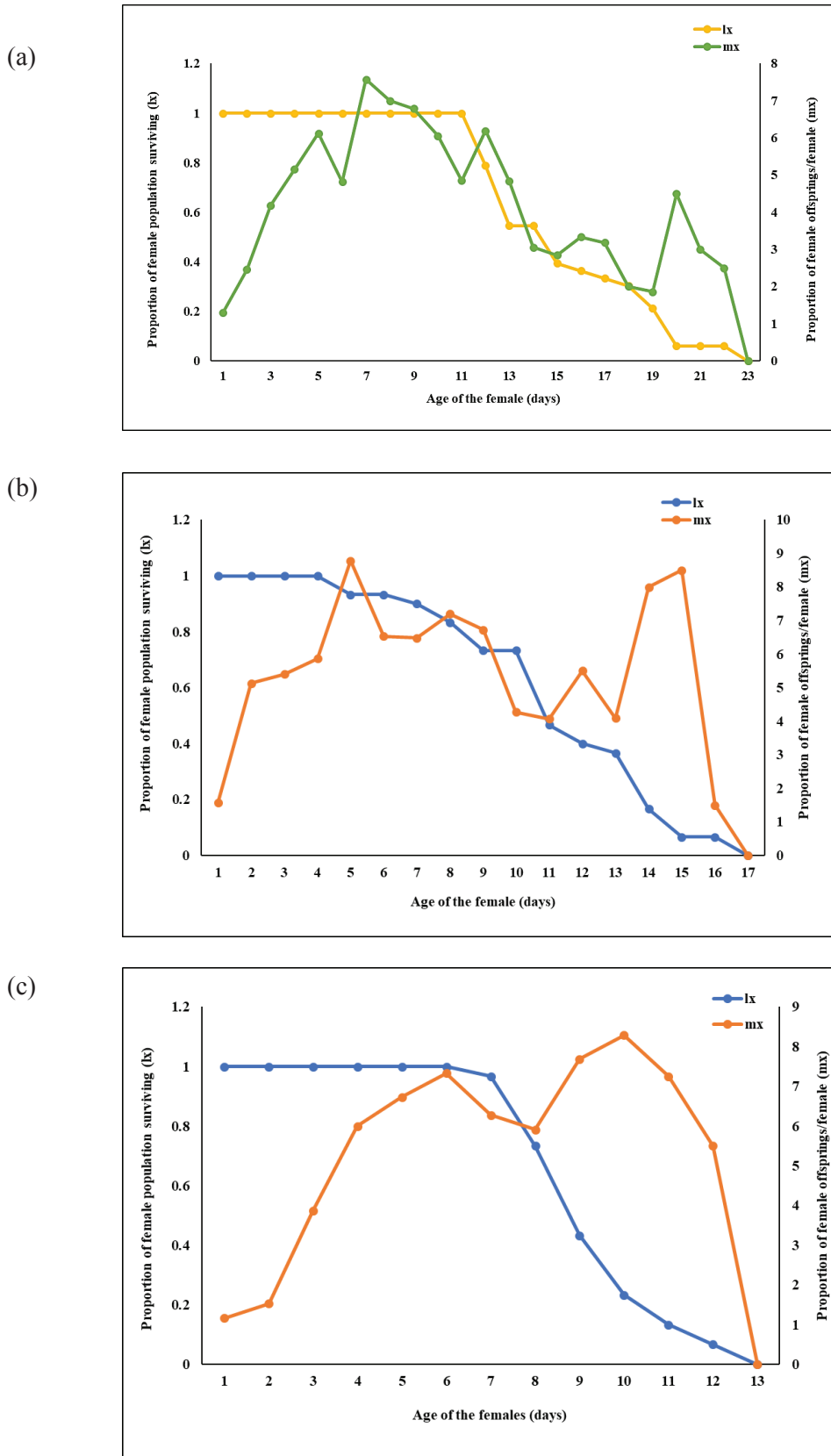


Fig 2. Age specific survival and fecundity of *Oligonychus biharensis* on Cassava at different temperature and humidity conditions: (a) 24°C; 75-80% RH, (b) 28°C; 70-75% RH and (c) 32°C; 75-80% RH

Statistical analysis and interpretation of data

Data in respect of development and different reproduction parameters were expressed as mean \pm SE and the mean data were analysed using One-way ANOVA followed by Tukey's HSD test ($P < 0.05$) using statistical software SPSS 23 to compare the mean values across different temperature conditions. Demographic parameters were computed using the said formulae and expressed as mean \pm SE (determined by bootstrapping method). The data were subjected to one way ANOVA to compare them across different constant temperature conditions.

RESULTS AND DISCUSSION

As the rearing temperature conditions increased from 24° to 32°C at the incremental rate of 4°C, the duration of development at each stage of both the sexes recorded a gradual decrease (fig. 1). Total development of both female and male also decreased reasonably (11.11 to 6.22 days for female & 10.03 to 5.92 days for male). Mean developmental duration of *O. biharensis* (female + male) was lowest, 6.07 days at 32°C on Cassava. Correspondingly, higher developmental duration was 10.57 days at 24°C.

It is evident that at 24 \pm 1°C and 28 \pm 1°C constant temperature conditions the development of both male and female of *O. biharensis* mite was longer whereas, at 32 \pm 1°C the development of both male and female was shorter. The developmental biology of *O. biharensis* was studied by Kaimal and Ramani (2011) on Cassava and the duration was 10.1 days at 30 °C \pm 2°C & 70 \pm 5% RH conditions, which is more than 6.07 days at 32°C and near similar of 9.71 days at 28°C recorded in the present study. However, Roknuzzaman *et al.* (2021), who studied *O. biharensis* biology at 25 \pm 1°C on country bean (*Lablab purpureus* L.) recorded 10.9 for female & 11.00 days for male, which is similar to development period on Cassava 11.11 days for female & 10.03 days for male in our study. Their studies on mung bean (*Vigna radiata* (L. Wilczek)) recorded 12.2 & 12.4 days for female and male, respectively, which is more than the present study data on Cassava host. This variation in the developmental time of *O. biharensis* may be attributed to the difference of host plants used for mite rearing.

Data in respect of longevity of mated females of *O. biharensis* at constant temperatures (24°C, 28°C and 32°C) on Cassava revealed that the females survived for 15.72, 12.80 and 9.10 days, respectively. The mated female laid an average of 79.42, 70.50 and 52.03 eggs over a period of 13.66, 10.20 and 8.46 days (fig. 2). The fecundity of *O. biharensis* female on Cassava, the

fecundity was significantly high at 24°C *i.e.*, 79.42 eggs laid over a period of 13.66 days (Table 1).

Kaimal and Ramani (2011) who studied reproduction features of *O. biharensis* on Cassava leaf stated that the mites' pre-oviposition period lasted for one day, oviposition period for 10.9 days and post-oviposition period for 0.8 days, more than the present study data at 32°C with 0.50 days, 8.46 days and 0.13 days, respectively. However, average fecundity recorded by them, 37.6 eggs was less than in the present study with 52.03 eggs. The sex ratio in the present study was 1: 5.46 which was less than the result of Kaimal and Ramani *i.e.*, 1-2: 10. Kaimal (2013) studied the reproduction of *O. biharensis* mite on cowpea and reported that pre-oviposition, oviposition and post-oviposition periods were 1.5 days, 11.5 days, and 0.9 days, respectively, which is almost similar to the present study data recorded on Cassava at 24°C. The ovipositional rate was 50.9 eggs for mated females which is less than the present study, on Cassava 79.42 eggs. The male-to-female ratio in that study was 1-2: 10 comparable to the ratio of 1: 11.48 on Cassava in the present study. Chen *et al.* (2005) studied the reproduction of *O. biharensis* on four different cultivars of litchi and reported that the pre-oviposition period ranged from 2.42 to 3.15 days, which is similar to our study at 28°C. The oviposition varied from 68.80 eggs on Baitangying to 34.00 eggs on Sanyuehong variety, comparable with 70.50 eggs on Cassava in the study. However, the sex ratio which ranged from 1: 2.74 to 1: 5.83, which is less than our present study.

Net reproductive rate (R_0), intrinsic rate of natural increase (r_m), mean generation time (T), finite rate of increase (λ) and gross reproduction rate (GRR) values of *O. biharensis* were significantly affected by the host plant in the laboratory. The chief demographic parameters were, r_m value of 0.2259, 0.2562 & 0.3273, Net Reproduction Rate of 69.96, 59.78 & 43.38 and Mean Generation Time of 20.15, 17.02 & 12.62 days on Cassava (Table 1). Statistically, there was significant difference in r_m value across three different temperatures, and the value was highest at 32°C *i.e.*, 0.3273. It is evident that the mean generation time decreased as the rearing temperature increased from 24°C to 32°C and it was lowest, of 12.62 days at 32°C. The doubling time was significantly lowest, 2.37 days at 32°C. GRR ranged from 67.60 to 93.45. The higher R_0 , 69.96 females/female/ generation was observed. According to Chen *et al.*, (2005) R_0 and r_m values ranged from 79.3–473.5 females/female/generation and 0.1349–0.2143 female off-springs/female/day, respectively on different cultivars of litchi at 24°C. R_0 and r_m values of *O. biharensis* on Lab lab was 12.30 and 0.1551 and on mungbean, it was 8.19

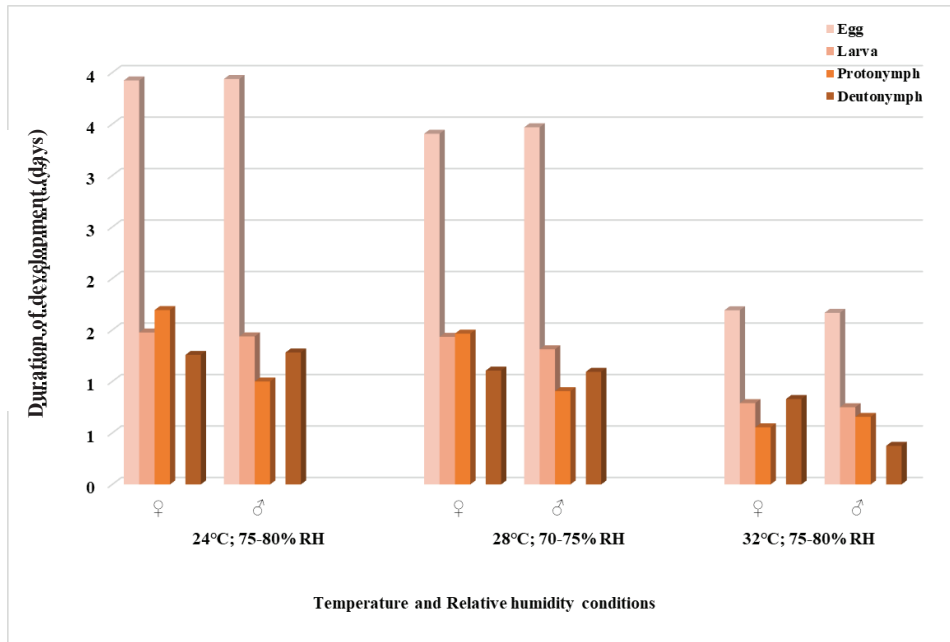


Fig. 1. Development of *Oligonychus biharensis* on Cassava at different constant temperatures in the laboratory

and 0.1254, respectively according to Roknuzzaman *et al.*, (2021). Thus, it is evident that *O. biharensis* showed varying R_0 and r_m values on different host plants like Cassava and litchi. *O. gossypii* had highest r_m value of 0.214 on Cassava was at 31°C (Bonato *et al.*, 1995), while *O. biharensis* had highest r_m value of 0.3069 on loquat leaves was at 35°C (Ji *et al.*, 2008), which indicated the positive influence of temperature of more than 30°C on the reproduction potential of *Oligonychus* mites. As noticed in the present study demography of *O. biharensis* was better for Cassava suggesting it as a more suitable host plant for population performance of the mite, and this mite would be a more potential emerging pest of Cassava.

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