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Life Table and Reproductive Table Parameters of *Scolothrips Longicornis* (Thysanoptera: Thripidae) as a Predator of Two-Spotted Spider Mite, *Tetranychus Turkestani* (Acari: Tetranychidae)

Mehdi Gheibi and Shahram Hesami

Abstract—*Scolothrips longicornis* Priesner is one of the important predators of tetranychid mites with a wide distribution throughout Iran. Life table and population growth parameters of *S. longicornis* feeding on two-spotted spider mite, *Tetranychus turkestani* Ugarov & Nikolski were investigated under laboratory condition (26±1ºC, 65±5% R.H. and 16L: 8D). To carry of these experiments, *S. longicornis* collections reared on cowpea infested with *T. turkestani* were prepared. The eggs with less than 24 hours old were selected and reared. The emerged larvae feeding directly on cowpea leaf discs which were infested with *T. turkestani*. Thirty females of *S. longicornis* with 24 hours age were selected and released on infested leaf discs. They replaced daily to a new leaf disc and the laying eggs have counted. The experiment continued till the last thrips had died. The result showed that the mean age mortality of the adult female thrips were between 21-25 days which is nearly equal life expectancy (e_x) at the time of adult eclosion. Parameters related to reproductive table including gross reproductive rate, net reproductive rate, intrinsic rate of natural increase and finite rate of increase were 48.91, 37.63, 0.26 and 2.3, respectively. Mean age per female/day, mean fertile egg per female/day, gross hatch rate, mean net age fertility, mean net age fecundity, net fertility rate and net fecundity rate were 2.23, 1.76, 0.87, 13.87, 14.26, 69.1 and 78.5, respectively. Sex ratio of offspring also recorded daily. The highest sex ratio for females was 0.88 in first day of oviposition. The sex ratio decreased gradually and reached under 0.46 after the day 26 and the oviposition rate declined. Then it seems that maintenance of rearing culture of predatory thrips for mass rearing later than 26 days after egg-laying commence is not profitable.

Keywords—*Tetranychus*, *Scolothrips*, Demography, Life table, Reproductive table

I. INTRODUCTION

POPULATIONS of all living organisms are, to some degree, reduced by the natural actions of their predators, parasites, antagonists, and diseases. This process has been referred to as ''natural control,'' but the use of living organisms to suppress the population of a specific pest organism, making it less abundant or less damaging than it would otherwise be [5], [9]. Two-spotted spider mite, *Tetranychus turkestani* Ugarov & Nikolski, is an important pest of many plants including tomatoes, cucumbers, beans, roses, cotton, maize, soybean, strawberries and many orchard crops and ornamental plants [10], [13], [14], [16]. Defoliation, leaf bronzing, and even plant death occur due to direct feeding damage in severe infestation [13], [14]. Indirect effects of feeding may include decreases in photosynthesis and transpiration [16]. Diverse natural enemies have an important role in the ecology of two spotted spider mite [2]. The orders of Arthropoda that prey on the pest include Thysanoptera, Coleoptera, Hemiptera, Neuroptera, Diptera, Acarina, and Araneida [12]. Species of the thrips genus *Scolothrips* are well known as predators of mites on the leaves of plants [7] and under the name "six-spotted thrips" these insects are sometimes marketed as biocontrol agents. The predatory thrips, *Scolothrips longicornis* Priesner has been recognized as a promising predator of spider mites.

Demographic studies including life table, reproductive table and stable population parameters have great importance in integrated pest management programs and mass raring of natural enemies. A life table describes the development, survival and fecundity of a cohort and provides basic data on population growth parameters. A life table may be used to estimate fitness of a population as influenced by various biotic and abiotic factors [6]. The cohort life table gives the most comprehensive description of the survivorship, development, and reproduction of a population, and, as such, is fundamental to both theoretical and applied population ecology. The collection of life table data for relevant species at different trophic levels in a food chain is a basic and important task for conservation [1] or pest management [15]. Hassell [11] pointed out that the inclusion of the predator and prey age structure is an important step in understanding predator-prey relationships.

M. Gheibi is with the Department of Plant Protection, College of Agricultural Sciences, Shiraz branch, Islamic Azad University, Shiraz, Iran (Phone: 98-711-6410047, e-mail: mehgheibi@yahoo.com)
Sh. Hesami is with the Department of Plant Protection, College of Agricultural Sciences, Shiraz branch, Islamic Azad University, Shiraz, Iran (e-mail: s_hesami@yahoo.com)

Life table studies on *S. longicornis* will provide the necessary data for its mass production in a pest management programs. In this study biology, life table as well as some ecological aspects of *S. longicornis* on *T. turkestani* were investigated under laboratory to further elucidate its biological properties and effectiveness as a biological control agent of spider mite.

II. Materials And Methods

The stock culture of the *S. longicornis* was collected from cowpea (*Phaseolus vulgaris*) in the laboratory. The two spotted spider mite, *T. turkestani* were use as prey in the stock culture and the experiments. All studies were conducted in a climatic chamber maintaining a temperature of 26±1 °C and relative humidity of 65±5%. A 16h photo phase was maintained with a light intensity of approximately 4000 Lux. In the experiments the thrips were held singly on leaf discs cut from cowpea leaves (*Phaseolus vulgaris*), 30 mm in diameter, according to the modified leaf-island method [17].

Fecundity, sex ratio and longevity were determined for females of *S. longicornis*. Leaf-disc arenas prepared with 20 females mite. 30 female thrips were taken from the stock as mature pupae, and each was held at 26 °C on an arena with three 7- to 10-day-old males. The male thrips were removed 12-24 hr after female eclosion. Progeny sex ratios were determined for period 24 hr. The sex ratios were established by incubating, hatching and rearing the progeny to adult. The parent female thrips were transferred daily to new arenas. Eggs laid on every day of all replicates were incubated, hatched and reared to adults. On days when progeny were not hatched and reared to adults, the leaf discs were cleared and stained, and the thrips eggs were counted. To collect complete life table data, the sex ratio was determined daily for all progeny produced. By the females thrips which were incubated, hatched, reared and held as adult. The experiment continued till the last thrips had died. Carey's method [3] used to constructed experimental life table parameters of *S. longicornis*.

The parameters of life table and fecundity schedule were constructed including: the pivotal age for the age class in units of time (X), the number of surviving individual at the beginning of age class (l_x), the number of individual alive between age x and x+1 ($x.L_x$), total number of individual x age units beyond the age x (T_x), the number of individual dying during the age interval x (d_x), the expectation of life remaining for individuals of age x (e_x), number of female eggs laid by age class x (m_x), total number of female eggs laid in age class x ($l_x m_x$), net reproductive rate ($R_o = \Sigma\ l_x m_x$), Cohort generation time in days ($T = \Sigma\ X l_x m_x / \Sigma l_x m_x$), the intrinsic rate of natural increase or the innate capacity for increase which is defined as the actual rate of increase of a population under specified constatnt environmental conditions in which food and space are unllimited (r_m) [calculated by iteration of Euler's equation, $\Sigma e^{-r}.m^x\ l_x m^x x=1$], the finite rate of increase, number of female offspring per female per day (λ), Gross reproduction rate calculated by Σm_x (GRR) and other parameters.

III. Results And Discussion

The adults of *S. longicornis* females lived an average of 39.3 days. *S. longicornis* adults mated within 18-24 h after emergence, and mated female began laying eggs in 2-3 days with an average pre-oviposition period of 1.7d. *S. longicornis* is a facultative arrhenotokous species and females are polyandrous. Mating period is taken about 19.6 min. Mating is not necessary to induce oviposition. Unmated females produced only male progeny.

The age specific survival rate, the number of individual dying during the age interval x, the expectation of life remaining for individuals of age x and age specific fecundity (m_x), are shown in fig 1-a, b, c, d. The results indicate that the stages overlapped during the developmental period. The male adults emerged approximately one day earlier, but lived a few days shorter than females. The result showed that the mean age mortality of adult female thrips were between 21-25 days which is nearly equal life expectancy (e_x) at the time of adult eclosion. The life expectancy is showing the estimations of individuals at age x are expected to live. A newly emerged female is expected to live up to 35.89 days.

The age specific fecundity or average numbers of female offspring produced per female per day were shown that mated females produced a mean of 226 eggs on cowpea during oviposition period of 37.5 days. The major reproductive table parameters are shown in table 1. The r_m value was 0.26 with the T being 12.43 days, so after this period 37.63 eggs/female added to the population. The mean egg per female/day, mean fertile egg per female/day, gross hatch rate, mean net age fertility, mean net age fecundity, net fertility rate and net fecundity rate were 2.23, 1.76, 0.87, 13.87, 14.26, 69.1 and 78.5, respectively.

This present study revealed that *S. longicornis* females required 14.84 days to complete the life cycle from egg to adult at 26 ºC. Gilstrap & Oatman [7] reported a considerably longer than developmental time of 22.1 days at 24 ºC for the related species *S. sexmaculatus*. They reported Sex ratio of offspring also recorded daily. The highest sex ratio for females was 0.88 in first day of oviposition. Coville & Allen [4] reported that the intrinsic rate of natural increase for *T. urticae* was 0.37 at 27 ºC on beans. The sex ratio decreased gradually and reached under 0.46 after the day 26 and oviposition rate declined. Then it seems that maintenance of rearing culture of predatory thrips for mass rearing later than 26 days after egg-laying commence, is not profitable.

In theory, a predator that has a population growth rate lower than its prey could not regulate the population of its prey. In biological control, the r value is one of the most important criteria in selecting biological control candidates on the basis of its reproductive potential and to predict the outcome of interaction of the pest and the beneficial agent once a beneficial agent is introduced into a crop system. There are several advantages of using *S. longicornis* as a biological control agent of spider mites. *S. longicornis* adults can fly to the colonies of spider mites, in comparison with the predacious mites, which can only spread by walking, so they may fail to find patches of high spider mite density. Large numbers can be easily reared on mites on bean or cowpea. The results of the study suggest that this species show promising qualities as a predator of spider mites.

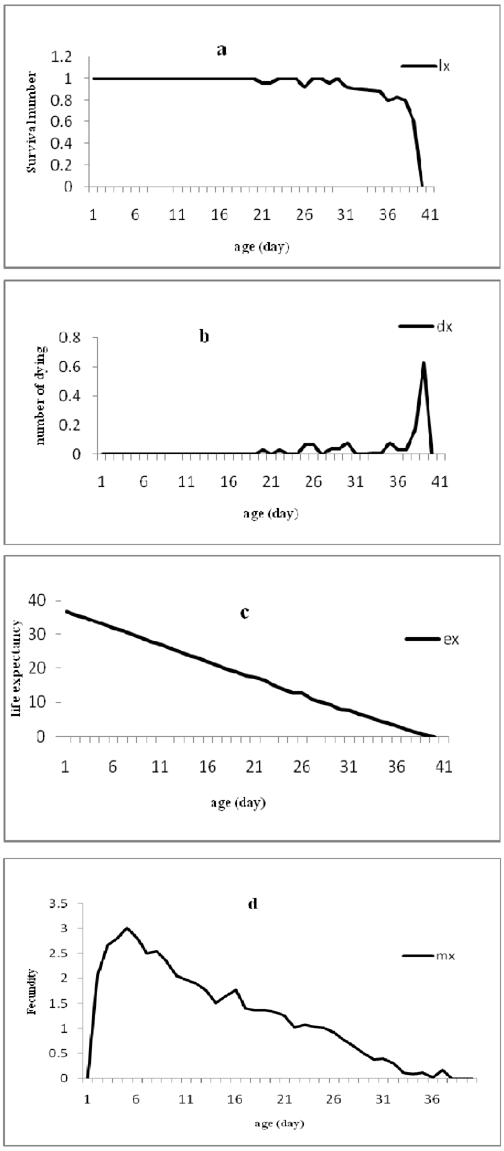

Fig. 1 Age specific survival rate (a), the number of individual dying during the age interval x (b), the expectation of life remaining for individuals of age x (ex) and age specific fecundity (m_x) of *Scolothrips longicornis* feeding on *Tetranychus turkestani* females

TABLE I
POPULATION AND REPRODUCTIVE OF *S. LONGICORNIS* FEEDING ON *T. TURKESTANI* FEMALES

Category	N	Formula	Values
gross reproductive rate (GRR)	30	Σm_x	48.91
net reproductive rate (R_0)	30	$\Sigma\, l_x m_x$	37.63
intrinsic rate of natural increase (r_m)	30	$\Sigma e^{-r}.m^x\, l_x m^x x=1$	0.26 d^{-1}
mean generation time (T)	30	Σ Xlxmx / Σlxmx	12.43 d^{-1}
finite rate of increase (λ)	30	e^r	2.3 d^{-1}

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