Int. J. Indust. Entomol. Vol. 5, No. 1, 2002, pp. 33~36

Research Article

International Journal of
Industrial Entomology

Life Table Studies of Leaf Roller, *Diaphania pulverulentalis* (Hampson) (Lepidoptera: Pyralidae) - A Major Pest of Mulberry

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(Received 4 May 2002; Accepted 10 July 2002)

Mulberry leaf roller, *Diaphania pulverulentalis* (Hampson), is a major pest of mulberry, *Morus alba*. The life table construction from present investigation reveals the age specific survival (l_x) and the age specific fecundity (m_x) of the pest. The female contributed the highest egg production (m_x = 12.75) in the life cycle on the 27th day and the lowest (m_x = 0.8) on the 37th day of the pivotal age. The female progeny production was observed to be intensive for the first six days after the preoviposition period, beyond which it declines steadily. The fecundity of *D. pulverulentalis* varies between 60 – 140. The first female mortality within the cohort occurred 4 days after the adult emergence and mortality increased thereafter. One generation is completed in 33.08 days. The female dominated sex ratio (1: 7.18 days) was recorded.

Key words: Mulberry, Leaf roller, Pyralid, Life table, Fecundity, Longevity

Introduction

Like other agricultural crops, mulberry (the sole food plant of silkworm, *Bombyx mori*) is also prone to attack of many insect pests, which cause quantitative and qualitative damage resulting in decrease of sericultural productivity. About 300 insects and non-insect pests are known to inflict damage to mulberry in different parts of the world (Kotikal and Devaiah, 1987).

Since 1995, a new pest called the leaf roller, *Diaphania pulverulentalis,* has been recorded to infest mulberry predominantly in the southern silk producing states of India *viz.*, Karnataka, Andhra Pradesh and Tamil Nadu (Geetha Bai *et al.*, 1997; Rajadurai *et al.*, 1999; Siddegowda *et al.*, 1995). Leaf roller is an important pest of mulberry in China (Veeranna, 1998), in Kashmir valley and Jammu (Dar, 1987; Sharma and Tara, 1985), Formosa (Maki, 1920), Burma (Ghosh, 1924), Malaysia (Sengupta *et al.*, 1990) and Japan (Rangaswamy *et al.*, 1976).

Generally, the appearance of leaf roller in mulberry garden coincides the onset of monsoon (June - July) in the southern silk producing states of Karnataka, Andhra Pradesh and Tamil Nadu. Its infestation continues till February, with peak infestation during September - November. The disappearance of this pest from March to May as larva and moth exhibits the possible pupal diapause. The average incidence of leaf roller was 27.85% in Karnataka, 20.98% in Andhra Pradesh and 16.48% in Tamil Nadu. It causes considerable loss of leaf yield (24.18% in field condition and 34.83% in glass house) and during the peak period of incidence (September ñ November) the leaf roller infestation has even reached the economic injury level (Rajadurai *et al.,* 1999).

The objective of the present study is to gather appropriate information for the construction of the life table under laboratory condition, to assess the biotic potential of the pest, to understand population dynamics of the pest, to estimate the age specific survival, fecundity, intrinsic rate of natural increase and optimal sex allocation of the species.

Materials and Methods

The leaf roller rearing was conducted in the laboratory following the method of Anonymous (1998). The larvae were reared under the leaves of K2 mulberry variety in transparent plastic container (1.5 liter capacity) with the lids fitted with wire mesh for ventilation. The adult moths were maintained by confining them to the wooden oviposition cages. The present study was initiated in the

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month of August 2000 and continued till Feb. 2001. The temperature and relative humidity under laboratory condition were maintained for 26 – 28°C and 70 – 80% respectively throughout the period of experiment.

Laboratory culture of *D. pulverulentalis,* which was reared on mulberry leaves (K2 and V1 varieties) for at least two generations was used for the present study. The adults were paired with a member of opposite sex and placed in wooden cages (45 cm width × 45 cm length × 60 cm height), with mulberry twigs for oviposition. Five percent of sucrose solution dipped on cotton wad was kept on a petri dish. Date of laying of each batch of eggs was recorded for each female. Males dying first were replaced with stock males. For each experimental population, 25 pairs were monitored in this manner.

To determine the time of development from egg to mature adult, a subsample of 25 eggs from each test population was monitored separately. Time of hatching and duration from eclosion to adult emergence were recorded and the records were summed up to yield the average interval from egg laying to hatching. This value was added to the maturation time (eclosion to 1st oviposition interval) for each female to give value of absolute age used in life table parameter estimation. The proportion of moth surviving to adult eclosion was also recorded from these subsamples. The experiment was terminated with a natural death of the female.

The life table was constructed with columns X, l_x, m_x, $l_x m_x$ and later the intrinsic rates of increase of population of insects were calculated by using Birch (1948) formula as elaborated by Watson (1964):

$e^{-r} m\ X\ l_x\ m_x = 1$, where e is the base of natural logarithms, X is the age of the individual in days. l_x is the number of individuals alive at age X in proportion of one and m_x is the number of female offspring produced per female in the interval X, while R_o is the sum of products of $l_x\ m_x$. The rate of multiplication of population for each generation measured as the female offspring produced.

The approximate value of cohort generation time Tc was calculated as follows:

$Tc = l_x\ m_x\ X\ /\ l_x\ m_x$

The arbitrary value of innate capacity for increase (r_m) was calculated from the formula $r_c = \log_e R_o / T_c$.

The value of r_c was taken as possible value of r_m and then two trial values were arbitrarily selected on either side of it, differing in the second decimal place. A table was constructed (with the aid of columns of X, l_x, m_x and $l_x\ m_x$) for each trial r_m columns.

1. $r_m\ X$. The trial r_m multiplied by the pivotal age
2. $7 - r_m X$ 7 minus column (1)
3. $e^7 - r_m X$ found from tables by looking up the exponential function of column (2)
4. $e^7 - r_m X\ l_x\ m_x$ column (3) multiplied by the entry in the $l_x\ m_x$ column.

Column (4) was then summed and this gave a value of $e^{7-r}m\ X\ l_x\ m_x$ which departed from 1096.6 by an extent depending on how close the trial r_m is to the true value. The true r_m was formed graphically by plotting the two trial r_m's against their sum of column (4). The precise generation time T was then calculated from the formula:

$T = \log R_o / r_m$

The finite rate of increase (λ) and hypothetical F_2 female were calculated as $_e\ {}^{-}r_m$ and $(R_o)^2$ respectively.

Results

The life table showing age specific survival (l_x) and the age specific fecundity (m_x) of *D. pulverulentalis* is presented in Table 1. The duration of the immature stages of this insect is recorded as 24 days. The first female mortality within the cohort occurred 4 days after the adult emergence and mortality increased thereafter. The female contributed the highest egg production (m_x=12.75) in the life cycle on the 27th day and the lowest (m_x=0.8) on the 37th day of the pivotal age. Reproduction ceased on the 13th day after oviposition commencement. The female progeny production was observed to be intensive for the first six days after the preoviposition period, beyond which it declined steadily (Fig. 1). The population mul-

Table 1. Life table and age specific fecundity analysis of *D. pulverulentalis*

Pivotal age in days (X)	Proportion alive at age (l_x)	No. of female progeny per female (m_x)	$l_x\ m_x$	($l_x\ m_x\ X$)
1-24 days	Developmental period			
25	Pre-oviposition period			
26	1.000	10.850	10.850	282.100
27	1.000	12.750	12.750	344.250
28	1.000	11.900	11.900	333.200
29	0.933	10.400	9.703	281.387
30	0.933	9.940	9.274	278.220
31	0.866	8.100	7.014	217.434
32	0.800	7.380	5.904	188.928
33	0.800	6.100	4.880	161.040
34	0.733	4.140	3.034	103.156
35	0.533	3.500	1.865	65.275
36	0.400	2.700	1.080	38.880
37	0.300	0.800	0.240	8.880
		m_x=88.56	R_o=78.494	2302.750

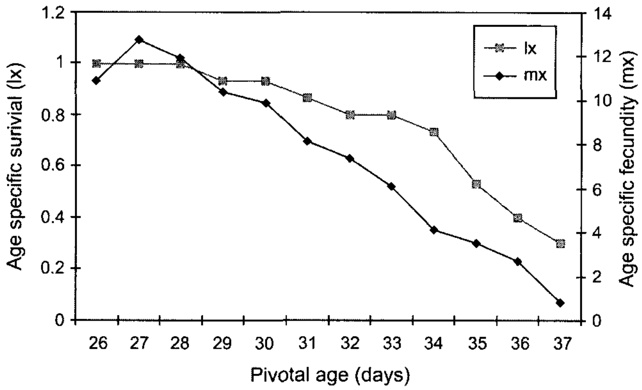

Fig. 1. Age specific survival and fecundity of leaf roller.

Table 2. Life table statistics of *D. pulverulentalis*

Sl. No.	Life table Parameters	Values
1	Developmental time	24 days
2	Maturation time	1 day
3	Age at 1st reproduction (α)	26 days
4	Net reproductive rate (R_o)	78.494
5	Mean generation time (T)	33.08 days
6	Innate capacity for increase (r_c)	0.1487
7	Intrinsic rate of natural increase (r_m)	0.1319 females/female/ day
8	Cohort generation time (T_c)	29.34 days
9	Finite rate of increase (λ)	1.14 females/female/day
10	Hypothetical F_2 females $(R_o)^2$	6161.3
11	Sex ratio (♂:♀)	1: 7.18

tiplication rate is 78.494 (l_x m_x) at the end of each generation.

The data on intrinsic rate of increase (r_m) and finite rate of natural increase in numbers (λ) are summarized in Table 2. The population increased with an intrinsic rate (r_m) of 0.1319 females per female per day with a finite rate of increase (λ) of 1.14 per female per day. One generation is completed in 33.08 days (T). The sex ratio is 1: 7.18. The fecundity of *D. pulverulentalis* varies between 60-140. The estimate of R_o for the female is 78.494. The hypothetical F2 female number is $(R_o)^2$=6161.3.

Discussion

Life table study of an insect pest is essential to utilization in developing its effective integrated pest management. Even with the most extensive investigation to obtain good quantitative information on the number and fate of various life stages of insects, an accurate projection of insect population are difficult. This is particularly true for highly mobile multivoltine population of pest, having a wide spectrum of hosts, especially because the number of foraging adults is difficult to estimate precisely. Thus, a life table data of this pest can be the best to depict the general magnitude of its potential of multiplication when given the chance of an ideal ecosystem with all factors being favorable.

The life table is a concise summary of certain vital statistics of insect population and is a useful technique in the study of population dynamics, providing format for recording the accounting for all population changes in the life cycle of an insect. The construction of fertility tables to calculate certain vital statistics is an important component in the basic understanding of population dynamics of a species (Southwood, 1978). The commonly accepted use of r_m as a biological characteristic describes the rapidity with which the numbers of a population will increase when occupying an environment unlimiting in space and food, containing no natural enemies, unvarying in physical conditions and with the relative proportions of the different ages present in terms of particular and fixed values (Messenger, 1964).

The increasing and decreasing pattern of l_x and $l_x m_x$ in *D. pulverulentalis* was also noticed in many pests such as *Pediculus humanus* (Evans and Smith, 1952) and *Creatonotus gangis* and *Spilosoma obliqua* (Chowdhary and Bhattacharya, 1986). It was observed that the method of rearing could influence the sex ratio and the reproductive rate (Ballal and Ramani, 1999). The sex ratio is more female biased with the number of female progeny being seven times more than the number of male progeny. In the present study the leaf roller sex ratio was estimated as 1: 7.18. The age of the insect determines the oviposition capacity and sex ratio of the progeny (Hernandez and Diaz, 1995, 1996). In the present study the oviposition capacity was found more abundantly in the initial six days, but it declined afterwards.

The higher proportion of females generally leads to an accelerated growth rate. The actual number of eggs laid depends upon factors including the host species, the host density, the temperature, functional and numerical response and nutrition during larval development. The intrinsic rate of increase (r_m) has been useful as predictive and comparative measures of population growth potential. R_o and r_m are generally lower in less fecund species and provides an index to insect fitness. In this study, the leaf roller showed R_o being 78. 494 and r_m 0.1319 which was comparatively lesser than other lepidopteran pests like *Spodoptera littura* (R_o – 479.15; r_m – 0.152) (Dandapani *et al.*, 1985) and *Heliothis armigera* (R_o – 489.23; r_m – 0.1396) in other agricultural crops (Patel and Koshiya, 1998). The relation between r_m and is illustrated and discussed by Birch (1953) and Howe (1953) provides an example of a way in which can be used in study of the physical ecology of an insect.

The life table constructed on leaf roller is clearly describing the reproductive potential of the species in terms of reproductive rate and female progeny production. The information gathered in this study can be utilized for the development of management strategies as it is exhibiting the true age specific longevity and fecundity of the pest besides the derived knowledge of its intrinsic rate of natural increase and hypothetical F2 female level.

References

Anonymous (1998) Management of insect pests in sericulture; in *Annual Report of Central Sericultural Research and Training Institute, Mysore*. Datta, R. K. (ed.), pp. 40-41, CSR&TI Publication, Mysore.

Ballal, R. C. and S. Ramani (1999) Fertility table of an exotic parasitoid, *Telenomus remus* Nixon (Hymenoptera: Scelionidae) on *Spodoptera litura* (Fabricius). *J. Biol. Control.* **13**, 25-31.

Birch, S. (1948) The intrinsic rate of natural increase in an insect population. *J. Anim. Ecol.* 17, 15-26.

Birch, L. C. (1953) Experimental background to the study of the distribution and abundance of insects. I. The influence of temperature, moisture and food on the innate capacity for increase of three grain beetle. *Ecology* **34**, 698-711.

Chaudhary, R. R. P. and A. K. Bhattacharya (1986) Bioecology of lepidopterous insects on winged bean, *Psophocarpus tetragonolobus* (Linnaeus); in *De candoele (1986). Mimoir No.11. Memories of the ESI.* The Entomological Society of India, Division of Entomology (ed.), pp. 3-4, I. A. R. I., New Delhi, India.

Dar, M. A. (1987) Observations and the biology of *Glypodes pyloalis* walkar (Pyralidae: Lepidoptera) a serious pest of mulberry trees. Research Pamphlet. India.

Dhandapani, N., A. A. Kareem and S. Jayaraj (1985) Life table studies of *Spodoptera litura* F. (Noctuidae: Lepidoptera) on banana. *Ann. Ent.*, **3**, 45-48.

Evans, F. C. and F. E. Smith (1952) The intrinsic rate of natural increase for the human louse *Pediculus humanus* L. *Am. Nat.* **86**, 299-310.

Geetha Bai, M. B. Marimadiah, K. C. Narayanaswamy and D. Rajagopal (1997) An outbreak of leaf roller pest, *Diaphania (=Margaronia) pulverulentalis* (Hampson) on mulberry in Karnataka. *Geobios New Reports*-19 **16**, 73-79.

Ghosh, C. C. (1924) Mulberry pests. Annual Report - 1922 and 1923, Mandalaya, Burma.

Hernandez, D. and F. Diaz (1995) Effect of age of the parasitoid *Telenomus remus* Nixon (Hymenoptera: Scelionidae) on its oviposition capacity and sex ratio of progeny. *Buletin de Entomologia Venezolana* **10**, 169-166.

Hernandez, D. and F. Diaz (1996) Effect of age of the host *Spodoptera frugiperda* (Smith) (Lepidoptera: Noctuidae) on parasitism and sex ratio of progeny of *Telenomus remus* Nixon (Hymenoptera: Scelionidae). *Buletin de Entomologia Venezolana* **11**, 27-32.

Howe, R.W. (1953) The rapid determination of intrinsic rate of increase of an insect population. *Appl. Biol.* **40**, 134-155.

Kotikal, Y. K. and M. C. Devaiah (1987) Insect and non-insect pests of mulberry, *Morus alba* L. in Proc. of seminar on Prospects of problems of sericulture in India, Vellore.

Maki, M. (1920) Insect injurious to mulberry trees in Formosa. *Bull. Agri. Exp. Govt. Formosa.* **90**, 21-24.

Messanger, P. S. (1964) Use of life tables in a bioclimatic study of an experimental aphids-Braconid wasp host - parasite system. *Ecology* **45**, 119-131.

Patel, C. C and D. J. Koshiya (1998) Life table and innate capacity of increase of *Helicoverpa armigera* (Hubner) on sunflower. *Gujarat Agricultural University Res. J. Ent.* **24**, 41-48.

Rajadurai, S., D. Manjunath, R. L. Katiyar, K. S. Prasad., A. K. Sen., M. A. Shekhar., M. M. Ahsan and R. K. Datta (1999) Leaf roller- a serious pest of mulberry. *Indian Silk* **37**, 9-11.

Rangaswamy, G., M. N. Narasimhanna, K. Kasiviswanathan, C. R. Shastry and M. S. Jolly (1976). Mulberry cultivation; in *FAO sericultural manual.* Jolly, M. S. (ed.), pp. 45-48, Oxford and IBH Pub. Co., New Delhi, India.

Sengupta, K., B. Kumar, M. Baig and Govindaiah (1990) Handbook on pest and disease control on pest and disease of mulberry and silkworm. United Nations Economic and Social Commission (UNESCO) for Asia and Pecific, Thailand.

Sharma, B. and J. S. Tara (1985) Insect pests of mulberry plants (*Morus* sp.) in Jammu region of Jammu and Kashmir state. *Indian J. Seric.* **24**, 7-11.

Siddegowda, D. K., V. K. Gupta, A. K. Sen, K. V. Benchamin, D. Manjunath, K. S. Prasad, S. B. Magdum and R. K. Datta (1995) *Diaphania* species infests mulberry in South India. *Indian Silk* **34**, 6-8.

Southwood, T. R. E. (1968) Ecological methods. Methewn Co., Ltd., London.

Veeranna, G. (1998) Insect pests of mulberry and their management in China. *Indian Silk* **36**, 5-9.

Watson, K. (1964) Influence of host plant conditions on population of larvae of *Tetranychus telerium* (L.) (Acarina: Tetranychidae). *Hilgardia* **35**, 273-322.