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Ecobiology and behavioural aspects of the pink bollworm, *Pectinophora gossypiella* (Saund.) (Lepidoptera: Gelechiidae) infesting cotton*

K.V. HARI PRASAD**

Department of Entomology, Marathwada Agricultural University, Parbhani-431 402, Maharashtra (India)

ABSTRACT : The ecobiology of pink bollworm, *Pectinophora gossypiella* (Saunders) infesting cotton (*cv.* NHH 44) was studied at fluctuating ambient temperatures and also on artificial diet. No significant differences were observed in life-cycle. However, the influence of declining temperature was evident in extending the life-cycle period. This was supplemented with an increse in the duration of life-cycle, *viz.*, 38.95, 42.01 and 42.68 days during Oct-Nov, Nov-Dec and Dec-Jan, respectively. The larva passed through 5 stadia and showed geometric increase in the width of the head capsule at each moult. The moths fed with honey produced an average of 129 eggs as compared to 20.6 eggs when raised on water alone. There was a significant increase in the pupal weight when reared on artificial diet than on cotton bolls for two consequent generations. Sex ratio of the moths reared on artificial diet was in consonance (60.3:29.7 and 53.3:46.7) with those reared on cotton bolls (50.8:49.2). The artificial diet proved to be suitable in rearing pink bollworm across two generations without affecting its fecundity. Among the different foods offered, significantly higher adult longevity was recorded on honey, followed by sugar syrup, fresh cotton flowers, water alone, and without food and water.

The pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) is one of the most important and destructive pests of cotton. It is widely distributed in all cotton-growing countries of the world (Anonymous, 1990). It has not been recorded from Russia, Central America, parts of south America and Australia. In India, it was first recorded in 1842 (Pearson, 1958). The larvae of pink bollworm feed on flower buds, flowers, and bolls including the seeds therein. However, the damage to buds and flowers occurs early in the season, before the appearance of green bolls and is usually of little consequence. The damage to the developing seeds results in consequent arrest of growth, boll-rotting, premature or partial boll opening, reduction in staple and yarn lengths, and overall reduction in quality due to increased trash content in the lint (Ingram, 1995).

In India, the life-history of pink bollworm has been reviewed by Ahmad (1977). In general, seasonal life history indicates that infestation is usually very low during the

*A part of approved M.Sc. thesis submitted to Marathwada Agricultural University, Parbhani-431 402, Maharashtra (India).

**Present address: GREP-Entomology, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru-502 324, Andhra Pradesh (India).

early fruiting period of cotton and may not become noticeable until the plants attain the bloom stage. In the present investigation, the biology on artificial diet has been compared with those reared on natural diet as well as the behavioural aspects of pink bollworm, under Marathwada conditions. The data on stadia specific larval periods would prove extremely useful for sampling in constructing models on population dynamics. Also, such analyses would facilitate to assess more accurately the impact and timing of various control tactics.

MATERIALS AND METHODS

Biology of pink bollworm on natural and artificial diets

P. gossypiella collected from the cotton field were reared individually in plastic boxes till pupation. The pupae were sexed following the method of Paul *et al.* (1979). The moths obtained from this culture were used for detailed biological and morphometric studies.

During 1994 and 1995, the seasonal life-cycle of the bollworm was studied in relation to different temperature regimes. The maximum and minimum temperatures were 31.39°C and 14.41°C (Oct-Nov), 29.34°C and 8.96°C (Nov-Dec), and 28.42°C and 8.51°C and 8.51°C (Dec-Jan), with morning and evening relative humidity as 75.25, 41.60, 72.28, 25.30, 75.00 and 28.07 per cent during Oct-Nov, Nov-Dec, and Dec-Jan, respectively.

Natural diet : Six pairs of newly emerged moths were confined separately in mating cages (20 × 15 cm) to study their longevity and fecundity. They were provided with honey solution (10%) dipped in cotton-swab as a food source and also cotton-twig containing tender squares for oviposition. The twig was always kept fresh with the help of a moist cotton-swab wrapped at the free end of the stalk and changed daily after taking the egg counts. The eggs were transferred to Petri plates (10 cm) to study the incubation period.

On hatching, 30 neonate larvae were transferred individually into small Petri plates containing a slice of young boll of the cotton (*cv.* NHH 44) placed on a moist blotting paper, and changed when necessary. The number of stadia and duration of larvae were recorded on the basis of head capsule exuviae in each stadium. On pupation, the pupae were separated to record their duration when the moths started emerging. Similarly, the morphometrics of pupae were studied individually for both the sexes and compared with the measurements taken from the pupae of pink bollworm obtained on the artificial diet. In order to determine the longevity, five pairs of adults were maintained separately on different foods, *viz.*, honey (10%), sugar syrup (10%), fresh cotton flowers, water alone, and without food and water.

Artificial diet : Artificial diet comprising cotton seed flour 50 g, chickpea flour 35 g, agar 15 g, dried yeast powder 8 g, ascorbic acid 1.2 g, methyl parahydroxy benzoate 1.6 g, multivitamin 1 g, streptomycin sulfate 0.2 g, formaldehyde 40% 1 ml, casein (vitamin-free) 10 g, and distilled water 600 ml was prepared following Paul *et al.* (1987). Adult moths in the ratio of 1:1 were confined in cages provided with honey (10%) as a food source.

Similar procedure was adopted as in the case of natural diet for oviposition. The eggs were transferred to Petri dishes. The neonate larvae on emergence were confined individually to vials containing 0.5 g of artificial diet which was changed as and when required. The larvae were allowed to pupate, and the duration of both the larvae and pupae was separately recorded. The morphometrics of both the sexes of pupae were taken and compared with those obtained on the natural diet. The process of rearing on artificial diet was carried for two consecutive generations and in each generation the morphometrics of the pupae were studied.

The data were recorded on egg incubation, developmental time for larval stadia and pupation. Larvae were observed daily for cast head capsules indiciating change in stadia. The morphometrics of head capsule of each larval stadium was measured using an ocular micrometer.

RESULTS AND DISCUSSION

The average incubation period of eggs was 6.74 days in Oct-Nov, 7.27 days in Nov-Dec, and 7.28 days in Dec-Jan. These findings conform to those reported earlier (Nadakarni, 1951; Awaknawar, 1976; Fye and McAda, 1972). They indicated a significant impact of temperature on the reduction in incubation period i.e., 10.23, 5.53 and 4.43 days at 20, 25 and 30°C. However, Phillip and Watson (1971) and Sohi (1964) reported shorter incubation period of egg. The larval duration in Oct-Nov ranged from 20-23 days with an average of 21.14 days, 20-25 days with an average of 22.54 days in Nov-Dec, and 20-25 days with an average of 22.6 days in Dec-Jan. Similar observations were recorded by Nadakarni (1951), Sohi (1964), and Awaknawar (1976). However, Srivastava *et al.* (1966) reported 10-12 days larval period. This may be attributed to variations in temperatures. The larva passed through 5 stadia, thus supporting the findings of Watson and Johnson (1974) and Awaknawar (1976). But, they reported an increased rate of development in the fifth instar as compared to the duration of the fifth instar which was not observed in the present studies. Morphometrics of larval head capsule showed a linear progression (Table 1),

Table 1. Morphometrics and biological parameters of different stages of pink bollworm, *P. gossypiella* (Saund.) on cotton (cv. NHH 44)

Biological parameters of different stages		Length (mm)		Width (mm)	
		Mean	Range	Mean ± SD	Range
Egg		0.658	0.54-0.75	0.286	0.18-0.38
Larval	I	1.28	1.11-1.50	0.240±0.070	0.183-0.381
instar	II	3.34	3.16-3.48	0.373±0.014	0.348-0.403
	III	9.60	8.00-11.00	0.629±0.031	0.580-0.677
	IV	17.00	15.00-19.00	1.018±0.118	0.860-1.154
	V	19.20	17.00-21.00	1.622±0.316	1.575-1.667
Pupa	Male	6.40	6.21-6.81		
	Female	6.54	6.31-6.93		

Table 2. Biology of pink bollworm, *P. gossypiella* (Saund.) on natural and artificial diets

Stage	Duration (days) on different diets			
	Natural diet		Artficial diet	
	Mean±SD	Range	Mean±SD	Range
Egg	6.74±0.77	6.0-8.0	6.67±0.78	6.0-8.0
Larva	21.14±1.14	20.0-23.0	21.06±1.06	20.0-23.0
Pupa	11.07±1.06	9.0-12.0	10.93±0.99	9.0-12.0
Egg-Adult	38.95±2.51	35.0-43.0	38.53±2.45	35.0-43.0

confirming the Dyar's law (1890). On an average, the pupal periods during Oct-Nov, Nov-Dec, and Dec-Jan were 11.07, 12.2 and 12.8 days, respectively. This is in agreement with the findings of Srivastava *et al.* (1966) and Awaknawar (1976). The average total life-cycle was 38.95 days in Oct-Nov, 42.01 days in Nov-Dec, and 42.68 days in Dec-Jan suggesting that the declining temperatures from October to January had a greater influence in extending the egg-incubation, larval and pupal durations, and consequently the total life-cycle duration. However, no significant differences were observed on the biolgoical parameters when reared on natural and artificial diets (Table 2).

Behavioural aspects of pink bollworm

Immediately after hatching, the neonate larva made its way in search of food. When provided with squares or bolls, it moved quickly before making an entry hole. This was usually found to heal-up with the growth of crop and made difficult to identify the infestation. However, when the bolls were opened, a pimple-like outgrowth with small brownish spot was observed on the lower and inner side of the rind. The larva after entering was found to feed some time on lint causing it yellow, and gradually moved towards the seed. Many a times, it moved to the next locule by making concentric cuts in the septum. The full grown larva always emerged from the boll by making a neat circular hole. Soon after coming out of the infested bolls, the larva was moved actively in search of a suitable substance for pupation. In the laboratory, the larva formed web of white cocoon around it before going for pupation. However, when the soil was provided it moved on and pupated by making an earthen cell. Also, the larva pupated in the lint, seed, leaf or the corner of the cage by making a web-like structure around it.

Adult emergence generally occurred during 10.00-12.00 h and 15.00-17.00 h. Mating occurred between midnight and early morning. Egg were, generally, laid singly but some in batches of 5-10 on green-bolls, leaf axils, lower leaf surface, squares, flowers, and hairy portions of the stalk. But, more eggs were laid at the junction of lamella and pedicel. The egg laying commenced on the 2-day after emergence only in a few cases, but mostly on 3-day after emergence and continued for 15 days (Fig. 1). This conforms to the observations recorded earlier (Lukefahr and Griffin, 1957; Bindra and Butani, 1976).

Significant differences were observed in adult longevity in relation to different foods. Among the foods offered, significantly higher longevity was recorded on honey in

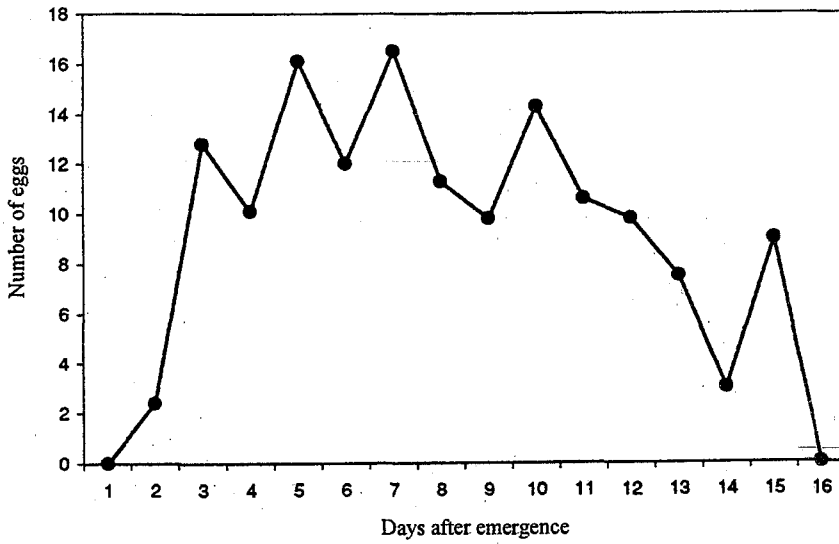

Fig. 1. Fecundity of pink bollworm, *Pectinophora gossypiella* (Saund.) on cotton.

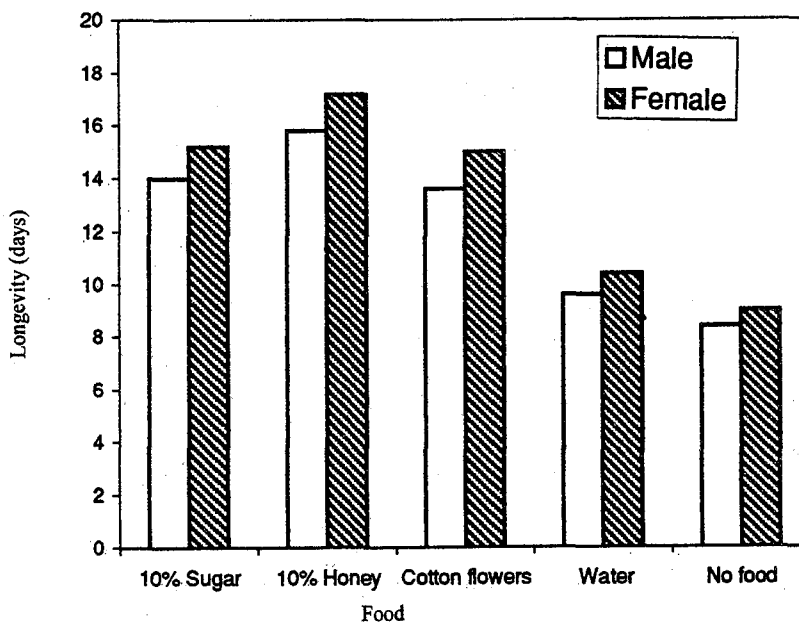

Fig. 2. Longevity of adult pink bollworm, *Pectinophora gossypiella* (Saund.) on different foods.

both the sexes. However, sugar was significantly not different from honey in respect of longevity of females but not for males. On the other hand, cotton flowers showed moderate longevity of both the sexes, and significanlty not different from sugar for the longevity of males. The presence or absence of water alone had a significant impact on the reduction in longevity of both the sexes (Fig. 2). Fecundity of adults fed on honey ranged from 110-147 with an average of 129.1 was in accordance with the findings of Nadkarni (1951), Srivastava *et al.* (1966), and Awaknawar (1976) as compared to water alone, being 9-34 with an average of 20.6 eggs. Lukefahr and Griffin (1962) found that the adults fed on honey solution laid 2-2.5 times more eggs and lived longer. Obviously, the quality of the food had an important bearing in determining the reproductive capacity and longevity of the females.

Table 3. Effect of natural and artificial diets on the morphometrics of pupae and sex ratio of pink bollworm, *P. gossypiella* (Saund.)

Pupa	Morphometrics	Natural diet	Artificial diet	
			Generation-I	Generation-II
		Mean±SD	Mean±SD	Mean±SD
Male	Length (mm)	6.43±0.07	6.41±0.06	6.99±0.11
	Width (mm)	1.41±0.01	1.39±0.01	1.42±002
	Weight (mg)	10.76±0.01	11.32±0.02	12.42±0.05
Female	Length (mm)	6.54±0.08	6.43±0.06	7.01±0.09
	Width (mm)	1.42±0.01	1.41±0.01	1.45±0.02
	Weight (mg)	10.92±0.02	12.12±0.04	12.58±0.06
Sex ratio (F:M)		50.8 : 49.2	60.3:29.7	53.3:46.7

Morphometrics of both male and female pupae reared on cotton bolls were more than those reared on artificial diet in the first generation (Table 3). However, in the second generation, the pupal size increased when reared on the artificial diet than on cotton bolls. Similarly, there was an increase in pupal weight as a result of rearing on artificial diet in the first generation and concomitant succession of increase in the second generation. The sex ratio of adults on the artificial diet was comparable with those reared on cotton bolls (Table 3).

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