Turk J Agric For
26 (2002) 331-336

The Possibilities of Using Pheromone Traps and Total Thermal Summation in Estimating Adult Emergence of *Pectinophora gossypiella* (Saund.), a Pest of Cotton Growing Areas in Amik Plain*

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Received: 04.05.2001

Abstract: In 1996-1999, studies on the utilization of pheromone traps for the estimation of adult emergence and the observation of the seasonal population dynamics of *Pectinophora gossypiella* (Saund.), which tends to spread in cotton growing areas, and on the determination of day-degree values for its biological stages were carried out in Amik Plain. It was found that adult emergence of the overwintering generation first occurred between late April and early May and lasted for 2-2.5 months. The effective total summation for first adult emergence was 136.43, 137.43 and 186.95 day-degree, and that for maximum adult emergence was 570.80, 460.23 and 479.35 day-degree in 1996, 1997 and 1998 respectively. In the same years, adult emergence of the overwintering generation finished at 980.80, 1090.57 and 1157.50 day-degree respectively. Sex pheromone traps were used to monitor both first adult emergence and population changes in cotton growing seasons. The level of damage in 1997 was significantly related to the number of adults trapped (r: 0.799). It was concluded that sex pheromone traps can be used to monitor pink bollworm populations and that effective total thermal summation can be employed together with sex pheromone traps to observe first adult emergence.

Key Words: Cotton, pink bollworm, *Pectinophora gossypiella*, pheromone trap, day-degree

Amik Ovası'nda Pamuk Alanlarında Zararlı *Pectinophora gossypiella* (Saund.)'nın Ergin Çıkışlarının Tahmininde Feromon Tuzaklardan ve Sıcaklık Toplamından Yararlanma Olanakları

Özet: *Pectinophora gossypiella* (Saund.)'nın Amik Ovası'ndaki ergin çıkışlarının tahmininde ve sezon içerisindeki popülasyon değişiminin izlenmesinde feromon tuzaklardan yararlanma olanakları ile bazı biyolojik dönemlerine ait gün-derece değerlerini belirlemeye yönelik çalışmalar 1996-1999 yılları arasında Amik Ovası'nda yürütülmüştür. Zararlının kışlayan dölüne ait ilk ergin çıkışlarının nisan ayı sonu – mayıs ayı başında gerçekleştiği; kışlayan döle ait ergin çıkışlarının 2-2.5 ay sürdüğü; ilk ergin çıkışlarının 1996, 1997 ve 1998 yıllarında ortalama olarak sırasıyla 136.43, 137.43 ve 186.95 gün-derece değerlerinde; max. ergin çıkışlarının ise 570.80, 460.23 ve 479.35 gün-derece değerlerinde gerçekleştiği saptanmıştır. Aynı yıllarda kışlayan döle ait ergin çıkışları 980.80, 1090.57 ve 1157.50 gün-derece değerlerinde sona ermiştir. Pembekurdun gerek ilk ergin çıkışlarının gerekse sezon içerisinde populasyon değişiminin izlenmesinde eşeysel çekici feromon tuzaklar kullanılmış ve tuzaklarda yakalanan ergin sayısı ile zarar oranı arasındaki ilişki 1997 yılında önemli bulunmuştur (r: 0.799). Çalışmalar sonucunda, eşeysel çekici feromon tuzakların, pembekurdun populasyon takibinde kullanılabileceği ve ilk ergin çıkışlarının izlenmesinde feromon tuzaklarla birlikte etkili sıcaklık toplamlarından yararlanılabileceği ortaya konulmuştur.

Anahtar Sözcükler: Pamuk, Pembekurt, *Pectinophora gossypiella*, Feromon tuzak, Gün-derece değerleri

* A part of project TÜBİTAK-TOGTAG-1615.

Introduction

The importance of the pink bollworm, *Pectinophora gossypiella* (Saund.), amongst harmful pest species in the cotton fields in the Çukurova and Aegean regions has increased in recent years. Therefore, intensive chemical treatments have been initiated to control the pest.

The economical threshold for the chemical control of pink bollworm in cotton fields in Turkey is based on 15% of bolls being infested and/or 900 infested flower rosettes/ha (Anon., 1995). It is very difficult to determine the level of economical threshold during the boll formation period, when the pest causes great yield loss, due to the difficulty of boll sampling. Since the number of individuals caught by sex pheromone traps can be correlated to the damage ratio in fields, it is possible to determine the correct timing for chemical application by using pheromone traps. It was reported that the economical threshold prior to the mid-season was 12-15 adults/trap/night for insecticide application, whilst it was 3.5-4 adults/trap/night in late season (Henneberry and Clayton, 1982). The number of pink bollworm caught by traps also showed a correlation with its oviposition, damaged bolls and number of larvae in bolls. It was reported that using traps showed a positive relationship between the adult catch of *P. gossypiella* and its larval infection in green boll, whilst the adult catch in the traps and its larval infection in green boll increased as the ball formation period progressed. Moreover, it was found that catching 9-12 adults/trap/night equalled the economical threshold level and insecticide applications would be programmed at this level (Qureshi et al., 1993). A positive correlation was reported between the number of male adults caught within 3-4 days prior to the first cotton flower bud invasion by pink bollworm, and the number of larvae in bolls (Campion, 1994). According to one research in Barbados, there was a close relationship between damage in bolls and pheromone trap catches, and 8-9 adults/trap/night catches in traps resulted in 10% damaged boll within 10 days (Ingram, 1994).

Predicting the beginning date of a generation within the season and the adult emergence time of an overwintering generation plays an important role in the successful control of this pest. In some countries, effective total thermal-summation has been used for this purpose by cotton growers (Sevacherian et al., 1977; Toscano et al., 1979; Sevacherian and El-Zik, 1983; Adams et al., 1995; Beasley and Adams, 1996).

In this study, the possibility of the use of pheromone traps and a day-degree model was investigated to observe adult emergence and population dynamics of the pink bollworm within the growing season in Amik Plain.

Materials and Methods

Observation of the adult emergence of overwintering generations of *P. gossypiella*.

In Hatay, the adult emergence of overwintering generations of pink bollworm was detected by means of Delta type pheromone traps in three locations in 1996 and 1997, and in two locations in 1998. Two traps in each location were placed in fields in March and checked every three days until the first adults were caught and, thereafter, once a week. Adults were counted and their numbers were recorded. The observation of the adult emergence of the overwintering generations continued until larvae were noted for the first time.

Observation of the population dynamics of *P. gossypiella*

Studies on the population dynamics of the pink bollworm in Hatay were carried out in three locations in 1996 and 1997 and in two locations in 1998. One cotton field was chosen in each location and two Delta type sex pheromone traps were placed in each cotton field at the beginning of blossom. Traps were placed on the plants at the level of the plant canopy and were 100 m apart. Adults on traps were counted once a week and, thereafter, they were removed.

In order to study the number of bolls damaged by the pink bollworm, 1000 bolls were collected from each cotton field prior to sampling and then the bolls were examined under laboratory conditions to determine proportional damage in bolls per ha. Rosette flowers caused by the pink bollworm were also counted at 50 different locations in each unit along a 25 m-row. This number was multiplied by 10 to calculate the number of rosette flowers per ha.

Effective total thermal summation

Common practice in day-degree methods is to start daily seasonal data collection on January 1st or March 1st (Kenneth, 1983). Thus, in this study, following the method described by Sevacherian et al. (1977), daily seasonal data collection was initiated on January 1 and was performed by use of thermohygrographs placed in cotton fields to investigate effective total thermal summation of critical biological stages of the pink bollworm. For calculation of effective total thermal summation, the developmental threshold was assumed to be 12.8 °C (Anon., 1991) and the two following methods were used:

First,

Day-degree = Maximum temperature + Min. temperature/2-Developmental threshold formula;

Second, if daily minumum temperature is lower than the developmental threshold and the value of maximum temperature is higher than the developmental threshold:

$$\text{Day-degree} = \frac{0.25\ (\text{Max. temperature - Developmental threshold})^2}{\text{Max. temperature - Min. temperature}}$$

If values of minumum and maximum temperature are higher than the developmental threshold, the following formula is used:

Day-degree = 0.25 (Maximum temperature + minumum temperature - 2 x Developmental threshold) (Sevacherian and El-Zik, 1983).

Results and Discussion

Observation of the adult emergence of overwintering generations of *P. gossypiella*

The adult emergence of overwintering generations of the pink bollworm is shown in Figure 1. Although the first adult emergence of the pink bollworm showed different patterns, they emerged at the end of April or at the beginning of May. Adult emergence increased and reached at a peak in the first week of June. The adult emergence of the overwintering generation of the pest continued up to the first week of July. Adult emergence took 2-2.5 months. This could be due to the fact that pest larvae overwintered during different periods.

Observation of the population dynamics of *P. gossypiella*

In order to record changes in the population dynamics of the pink bollworm, the quantity of rosette flowers caused by the pest, the ratio of damaged bolls and adults caught by sex pheromone traps in cotton fields are given in Figure 2.

As seen in Figure 2, the emergence of the pest adults of overwintering generations changed according to given

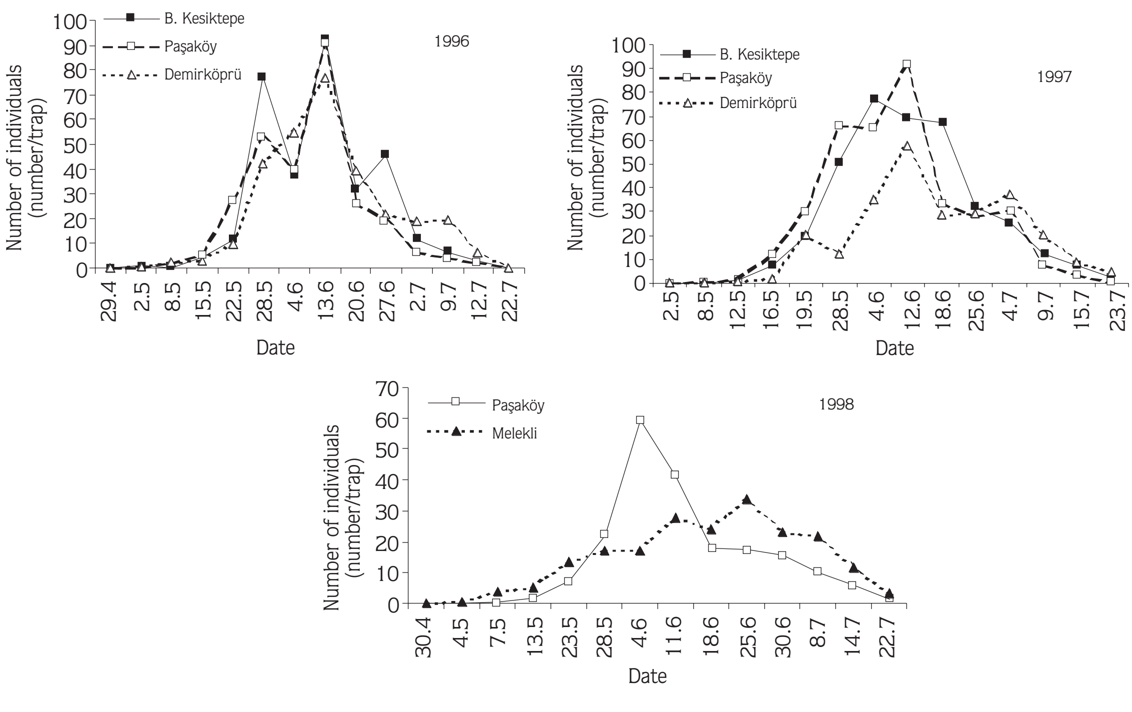

Figure 1. Adult emergence of overwintering generations of *Pectinophora gossypiella* at Amik Plain in 1996, 1997 and 1998.

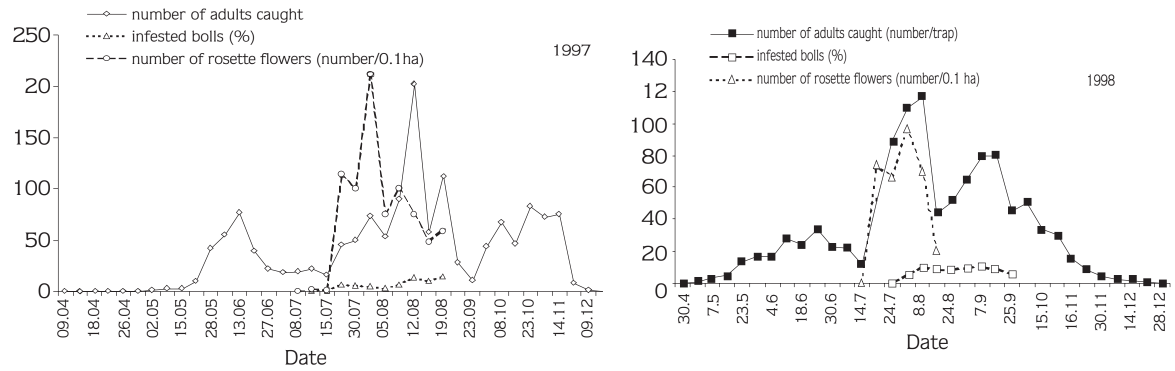

Figure 2. Population dynamics of the pink bollworm, *Pectinophora gossypiella*, in Amik Plain in 1997 and 1998.

years. Adult emergence occurred at the end of April and the beginning of May and the adult population was at its maximum level throughout mid-June. It sharply dropped off at the beginning of July, which was the initiation period of cotton blossoms. The adult population increased after the beginning of July along with the blossom stage, and later the number of rosette flowers, which were caused by the pink bollworm, showed a rising trend.

The pink bollworm population showed a rapid increase from the beginning of boll formation, or in other words from the middle of cotton blossom. During this period control measures are of great importance in preventing pest damage. In a study carried out in China on the relationship between population changes of the pink bollworm and boll formation in cotton, it was found not to be necessary to use pest control against the first and second generations, since there are few green bolls that are susceptible to this pest. It was also reported that the best period to apply control methods was when the maximum formation of bolls synchronized with the end of the second offspring and beginning of the third offspring (Liu et al., 1993).

Although the relationship between the number of adult pink bollworm caught in traps and the damage ratio to bolls caused by the pink bollworm was found to be significant in 1997 (correlation coefficiency r = 0.7992), it was not significant in 1998. All studies conducted around the world and some results found in this study (in 1997) indicated that pheromone traps could be used to monitor pink bollworm populations.

Determination of effective thermal summation

The thermal summation values of overwintering generations for different events are shown in Tables 1 and 2; the cumulative adult emergence of overwintering generations and thermal summation values are given in Figure 3.

As shown in Table 1, in 1996, first adult emergence from overwintering generations of pink bollworm according to classical calculation method was 118.8, 171.7 and 118.8 (mean 136.43) day-degree in B. Kesiktepe, Paşaköy and Demirköprü respectively; in 1997, first adult emergence from overwintering generations of pink bollworm was 151.1, 110.1 and 151.1 (mean 137.43) day-degree in B. Kesiktepe, Paşaköy and Demirköprü respectively; and in 1998, first adult emergence from overwintering generations of pink bollworm was 203.4 and 170.5 (mean 186.95) day-degree in Paşaköy and Melekli respectively. In 1996, maximum adult emergence was 570.8, 570.8 and 570.8 (mean 570.80) day-degree in B. Kesiktepe, Paşaköy and Demirköprü respectively; 397.9, 491.4 and 491.4 (mean 460.23) day-degree in B. Kesiktepe, Paşaköy and Demirköprü respectively in 1997; and 439.3 and 519.4 (mean 470.35) day-degree in Paşaköy and Melekli respectively in 1998. The end of adult emergence in 1996 was 980.8, 980.8 and 980.8 (mean 980.80) day-degree in B. Kesiktepe, Paşaköy and Demirköprü respectively; 1132.2, 1007.3 and 1132.2 (mean 1090.57) day-degree in B. Kesiktepe, Paşaköy and Demirköprü respectively in 1997; and 1157.5 and 1157.5 (mean 1157.50) day-degree in Paşaköy and Melekli respectively in 1998.

As seen in Table 2, calculations according to Day-degree = 0.25 (Maximum temperature + minumum temperature - 2 x developmental threshold) showed that first adult emergence of the overwintering generations of pink bollworm occurred in 1997 at 100.3, 79.6 and 100.3 (mean 93.4) day-degree in B. Kesiktepe, Paşaköy and Demirköprü respectively; and in Paşaköy and Melekli

Table 1. Effective thermal summation values of overwintering generations of *Pectinophora gossypiella* in Hatay in 1996, 1997 and 1998.*

PERIODS	Effective thermal summation (day-degree)							
	1996			1997			1998	
	B. Kesiktepe	Paşaköy	Demirköprü	B. Kesiktepe	Paşaköy	Demirköprü	Paşaköy	Melekli
First adult emergence	118.8	171.7	118.8	151.1	110.1	151.1	203.45	170.45
Max. adult emergence	570.8	570.8	570.8	397.9	491.4	491.4	439.3	519.4
End of adult emergence	980.8	980.8	980.8	1132.2	1007.3	1132.2	1157.5	1157.5

* Calculated by using "Daily min. temperature + Daily max. temperature/2-Developmental threshold".

Table 2. Effective thermal summation values of overwintering offspring of *Pectinophora gossypiella* (Saund.) in Hatay in 1996, 1997 and 1998.*

PERIODS	Effective thermal summation (day-degree)							
	1996			1997			1998	
	B. Kesiktepe	Paşaköy	Demirköprü	B. Kesiktepe	Paşaköy	Demirköprü	Paşaköy	Melekli
First adult emergence	-	-	-	100.3	79.6	100.3	155.2	111.6
Max. adult emergence	-	-	-	223.7	270.4	223.7	246.0	280.3
End of adult emergence	-	-	-	590.8	528.4	590.8	605.4	605.4

*Calculated by using "Day-degree = 0.25(max.temperature + min.temperature - 2 x developmental threshold)".

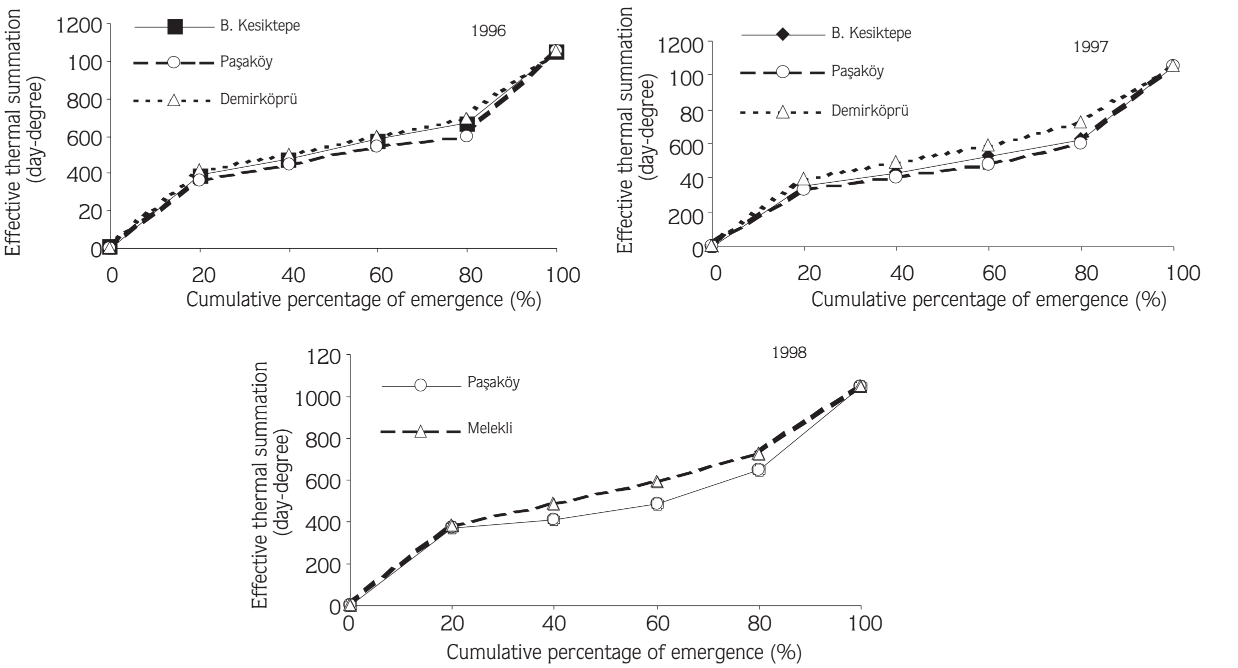

Figure 3. Percentage of emergence and thermal-summation values of overwintering generations of *Pectinophora gossypiella* in Hatay in 1996, 1997 and 1998.

at 155.2 and 111.6 (mean 133.40) day-degree respectively in 1998; maximum adult emergence was at 223.7, 270.4 and 223.7 (mean 239.27) day-degree in B. Kesiktepe, Paşaköy and Demirköprü, respectively; and in 1997, 246.0 and 280.3 (mean 263.15) day-degree in Paşaköy and Melekli respectively. The end of adult emergence occurred at 590.8, 528.4 and 590.8 (mean 570.0) day-degree in B. Kesiktepe, Paşaköy and Demirköprü respectively in 1997; and at 605.4 and 605.4 (mean 605.40) day-degree in Paşaköy and Melekli respectively in 1998.

As seen in Figure 3, 60% of adult emergence occurred in B. Kesiktepe, Paşaköy and Demirköprü at 542.1, 513.6 and 556.8 day-degree respectively. These values were 502.3, 456.0 and 565.5 day-degree in B. Kesiktepe, Paşaköy and Demirköprü, respectively in 1997. Figure 3 indicated the same percentage of adult emergence in Paşaköy and Melekli at 469.0 and 610.9 day-degree, respectively in 1998.

In other studies carried out to determine thermal summation for different biological periods of the pink bollworm, it was observed that 277.8, 486.1 and 1250.0 day-degree were required for first adult emergence, maximum adult emergence and complete adult emergence respectively; and 416.7 day-degree was optimum for the pest to be able to complete one generation (Anon., 1991). According to the same literature cited, first adult emergence, maximum adult emergence, end of adult emergence and completion of one life cycle required 277.8, 655.6, 1222.2, and 444.4 day-degree when the lower and upper limits of the developmental threshold were assumed to be 12.8 ºC and 30.0 ºC, respectively. When the developmental threshold was assumed to be 15.6 ºC, first adult emergence, maximum adult emergence and end of adult emergence occurred at 111.1, 375.0 and 611.1 day-degree respectively (Sevacherian et al., 1977). The pink bollworm can complete its life cycle at 492 day-degree if the lower and upper limits of the developmental threshold are 13.9 ºC and 32.8 ºC, respectively (Beasley and Adams, 1991).

In conclusion, the first adult emergence of pink bollworm occurred between late April and early May and the adult emergence of the overwintering generation lasted for 2-2.5 months. The relationship between the number of trapped adults and the number of larvae in the fields was significant in 1997 and insignificant in 1998. Furthermore, the day-degree values for the first adult emergence of the overwintering generation, for the maximum and the complete adult emergence of pink bollworm, were also determined. Therefore, it can be stated that sex pheromone traps can be used to monitor pink bollworm populations and that effective total thermal summation can be employed together with sex pheromone traps to observe first adult emergence.

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