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# The times of emergence of the adults tomato leafminer *Tuta absoluta* (Meyrick) in spring and the number of heat units needed for this as well as its relationship to the damage caused by the insects

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## Abstract

The objective of this study was aimed to determine the emergence date of tomato leafminer *Tuta absoluta* (Meyrick) in Essaouira / Wasit governorate fields during the spring seasons of 2015, 2016 and 2017. The results indicated that the adults began to emerge during the first ten days of March in all years of this study. Accumulate of 116.24 degree-days (based on 9.64 C° as a lower threshold developmental) was necessary for the first emergence. the results also showed that the accumulation of 118.84 , 127.20 , 140.06 and 150.42 degree-days were necessary for emergence of 10, 50 , 75 and 100 % respectively of the total over wintering population in 2015 . While the accumulation of 118.68 , 130.04 , 141.90 , 151.90 and 162.70 degree-days were necessary for emergence of 10, 25 , 50 , 90 and 100 % respectively in 2016 , whereas the accumulation of 111.02 , 124.06 , 135.42 , 146.28 and 167.00 degree-days were necessary for emergence of 10, 50 , 75 , 90 and 100 % respectively in 2017, Most adults ( 100%) were able to emerge after 23.67 days during March , the The evolution of sex ratio ( females : males ) for adults of the first generation was nearly 1.33:1.

**Keywords:** *Tuta absoluta* , degree-days, emergence, wintering

## Introduction

Tomato, *Solanum lycopersicum* L. (Solanaceae), is infected with several pests; the Tuta absoluta tomato Leafminer is one of the most important of these pests, which has become an obstacle to the progress of the cultivation of these fruits in most countries of Asia and Africa [1]; The first insect infestation occurred in Iraq was in Rabiaa western of Nineveh province in September 2010 and caused significant economic damage in tomato yield in the open fields, after that, it spread rapidly to another province within a short period to infect the tomato in protected and exposed agriculture [2]

The large-scale cultivation of the tomato in Iraq is with two seasons per year [3], as well as their cultivation in plastic houses, Suitable weather conditions of the insect's living conditions and the absence or lack of natural enemies and the fact that this scourge is difficult to control by chemical due to the nature of feeding its larvae internally in leaves, stems and fruits [4] ,Thus, difficulty pesticide application, in addition the ability of the insect to develop its resistant to the chemical pesticides, and its high reproductive susceptibility [5,6], led to the spread of this insect and increased damage to the fruits of the tomato increased the suffering of farmers due to the poor quality of fruits , and difficulty of marketing the tomato yields [7,15], The area cultivated worldwide is estimated at more than 4.5 million hectares, with an estimated output of 145 million tons [8,18]. It was noted [6] noted that photoperiod, temperatures and food are closely related to hibernation; these factors may be involved either collectively or individually to influence the end of the hibernation process in an insect. I was explained that the end of hibernation often depends mainly on temperatures. Many researchers have studied. The thermal units requirements for many of insect species and Predicting adult emergence [9, 13] pointed out that temperature is one of the most important factors affecting the growth of insect larvae after the hibernation period and the end of the hibernation process varies with the difference types and geographical breeds of the species.

It was also noted [10] that agers larvae which entered hibernation as adults, were appearing before that less age of a lifetime when exposed to conditions that force them to hibernate; insects usually take on the hibernation as a defensive behavior of escaping time. So to the preparation of an integrated control program for tomato leafminer,and to meet some of the requirements for the success of the programme, this study was to determine the specific time for adults hibernation to escape from the winter by using the annual timing and thermal units collected in the monitoring and control programme.

## Materials and Methods

### Lath-house experiments

Some tomato leaf miner larvae were taken from the laboratory colony in the Integrated Pest Control Center ,Directorate of Agricultural Research /Ministry of Science &Technology and then distributed in plastic cages with dimensions (40× 40 × 40) surrounded by a tulle fabric with a 20 cm circular opening from the front of the cage surrounded by an extended cylindrical fabric. The end was tied by a rubber band to facilitate the entry and exit of insects, These cages were placed on a table with their legs were placing in bowls were placing in water to prevent ants from reaching them [4].It was then left in the Lath-house, which was surrounded by a buckle wire with a large-hole during mid-February of each study year. The conditions inside the Lath-house were closer to normal conditions ( light and heat) . 300 pupae were taken from the laboratory, divided into three replicates with 100 pupae per replicates per season until mid of February, then, these cages were observed daily to record number of adults that emerged and the number of males and females to estimate the sexual ratio. Daily temperatures (minimum and maximum) were obtained from the Agricultural Meteorological Station in Esseouira of the Agricultural Research Department /Ministry of Agriculture, which was located in AL-Sewara/ Wasit Governorate at the E 44.82 longitude and the N 33.00 display circle near the test site,°9.64C and used as a developmental threshold [4],The accumulation heat units required for adult emergence were calculated according to the equation :-

DDs = Max. t + Min. t /2 –Dt [27]

DDs = Degree-days

Max= max daily temp.

Min.= min. daily temp.

Dt = development threshold Temp.

## Field experiments

### A. Monitoring experiments

For monitoring the adult emergence in the field' red insects, pyramidal pheromonic traps have been used (Delta trap) type with 12×28×20 cm dimensions produced by Russell IPM in the UNITED Kingdom .at an altitude of 50 cm above ground [19 and 14]. Put down in inside it on adhesive layer paper a 0.5 mg TUA-500 pheromone lure to detect the appearance of adults and monitor their population density during the crop growing seasons.The adhesive paper layer will be replaced whenever it is filled with insects and the pheromones lure will be replaced every month according to the recommendations of the producing company. The number of male insects caught by two readings per month were recorded [5] in each trap from the cultivation of seedlings to the last combined harvester of fruits, Traps were placed in the field early from the first day of each year and continued until the end of the season, six traps used for this study,traps were distributed in the field depending on [8].The study field was selected in a separate area near the Lath-house site and had the lowest insulation distance between the traps of 50 meters.

### B. Study the relationship between the number of adult catched and injury level or the damage caused by the tomato leaf miner

To study the relationship between the number of insects conjoined in the traps and the amount of damage caused by the insect, five samples of the fruit of the tomatoes were taken by 20 fruits per sample and calculated the number of infected fruit , thus found the infection rate according to the equation: -

**Percentage of infection=Number of infected fruits / total fruit number x 100 [9]**

Thus, this ratio was linked to the number of insects caught to finding the relationship and determining adults emergence the outbreak and fluctuations in the population community. The date of taking these samples coincides with the date of readings in traps [10] .

## Results and Discussion

The results in table 1 showed that when the first generation of tomato leafminer emerged in March, with an overall average of 100%, it can be noted that most of the 100% adults came out of the winter during March in the three years. The results of this study also showed, regardless of the method of observation used, that the onset of the first-generation adult was during the first week of March 2016. While it was during the second week of March in 2015 and 2017. The end of the first generation will be on 10th , 5th and 14th of , March for 2015, 2016 and 2017, respectively.

The results in table 2 also showed that the dates of the emergence of first-generation adults was depending on the environmental conditions prevailing during that season.The results revealed that adults began to emerge in 2015 when 118.84 thermal units were collected. That was in 7th of March of this year.Adult emergence rates began to increase after this date as the number of insects emerging from winter pupae began to rise10,50,75 and 100% of adults appeared on 7, 8, 9 and 10 of March, respectively. The total combined thermal units corresponding to these numbers were 118.84, 127.20, 140.06 and 150.42 thermal units, respectively. In 2016, the first appearance of adults was recorded on 1st of March and required to exit of 10, 25, 50, 90 and 100 % of adults assembling thermal units amounting to 118.68, 130.04, 141.90, 151.90 and 162.70 thermal units, which corresponded to dates 1, 2, 3, 4 and 5 of March, respectively.While in 2017 the first adult appeared on 10th of March , when 10, 50, 75, 90 and 100 % of the insect's adults were due to emerge on 10, 11, 12, 13 and 14th of March, and the total combined thermal units needed for the exit of these ratios were 111.20, 124.06, 135.42, 146.28 and 167.00 thermal units, respectively.

The emergence of the tomato leaf miner adults lasted for 24, 19 and 28 days during 2015, 2016 and 2017, respectively, and the rate for the three years was 23.67 days (table 1.(Through daily follow-ups, it was found that the emergence of 100% of adults during March in the three years.In 2015 there was an increase in the number of adults that emerged and an upward rate as of 7th March, which was 10% and continued to increase until it peaked on the 10th of March, when all adults emerged .While the percentages of adult emergence for 2016 were relatively different, as the process of emerging began on the 1st of March and continued to increase until it reached its peak when all adults emerged from winter pupae on the 5th of March. But in 2017 adult emergence was later than the previous two years, starting with the beginning of the 10th of March and continuing to increase until it reached its peak when all adults emerged from winter pupae on the 14th of March and maybe the due was too different environmental factors, especially those related to different temperatures.

**The sexual ratio of tomato leafminer adults which emerged from the Wintering**

The results in table 1 showed that the sex ratio of first-generation adults that emerged from the winter pupae of the tomato leafminer similar in the three years at a general rate (1.33:1) ( female : male ) which was in favor of females the reason may be that females pupae are usually larger and weightier and contained more fatty substances than male pupae and that will helping them to resist hard conditions during winter, especially low temperatures, so they managed to stay and cross winter [29]. From the results in tables 1 and 2, it was noted that there were some differences in the pattern of the emergence of first-generation of tomato leaf borerfrom winter pupae from year to year, most of these differences are caused by different conditions and the prevailing environment.That the duration of the pupae life is controlled by other factors in addition to temperatures and humidity, including the reasons for the snowy related to the last generation, whose females lay eggs that produce long-life adults compared to the adults resulting from previous generations, It is one of the defensive means used by insects to resist poor environmental conditions. The expiry of hibernation for this insect depends heavily on temperatures, especially after exposure to a limited period of cold during the winter months [11] the pattern of adult emergence also varies with changes in temperatures from year to year. Therefore the thermal aggregation programe can be used to predict the emergence of adults more accurately than annual time [1]

Depending on the results of tables 1 and 2, we can conclude that:

1- As of mid of February and on the basis that the minimum development of pupae was (9.64) C°, The overall rate of thermal units collected during the three years of study (2015, 2016 and 2017) required for the emergence of 10, 25, 50, 75, 90 and 100% of the first-generation adults about 116.24, 130.04, 131.05, 137.74, 149.09 and 160.04 thermal units respectively

2- The period required for the emergence of most first-generation adults took approximately 23.67 days as a general average for the three years, that most adults (100%) appeared during March and that the sexual ratios tended slightly in favor of females:males (1.33:1) and this tendency was non significant statistically by using the Chi-squared test.

These results can give an important indication of the timing of the implementation of an integrated control program to monitor the emergence of insects, particularly with regard to the installation of traps to reduce the number of insects that emerge from the winter of the first generation or regarding the scheduling of chemical control [22] or biological control [13].

**Table (1): Adult emergence periods and the sex ratio of insects emerging from winter for years (2015-2017)**

| **Time** | 2015 | 2016 | 2017 | average |
|---|---|---|---|---|
| **Emergence date** | 7 March | 1 March | 10 March | 6 March |
| **The necessary period for adults Emergence (days)** | 24 | 19 | 28 | 23.67 |
| **Adult emergence %** | / | / | / | / |
| | 100 | 100 | 100 | 100 |
| | / | / | / | / |
| **sex ratio (male: female)** | 1 : 1.34 | 1 : 1.32 | 1 :1.33 | 1 :1.33 |

**Table (2): First-generation adult emergence ratios for *Tuta absoluta* and their relationship to thermal units during the years (2015-2017)**

| Adults emergence % | The year | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2015 | | 2016 | | 2017 | | average |
| | Date | Gathered Units Thermal | Date | Gathered Units Thermal | Date | Gathered Units Thermal | Gathered Units Thermal |
| 10 | 7 March | 118.84 | 1 March | 118.68 | 10 March | 111.20 | 116.24 |
| 25 | / | / | 2 march | 130.04 | / | / | 43.35 |
| 50 | 8 March | 127.20 | 3 March | 141.90 | 11 March | 124.06 | 131.05 |
| 75 | 9 March | 140.06 | / | / | 12 March | 135.42 | 91.83 |
| 90 | / | / | 4 March | 151.90 | 13 March | 146.28 | 99.39 |
| All adults emergence | 10 March | 150.42 | 5 March | 162.70 | 14 March | 167.00 | 160.04 |

**Using pheromone traps to determine the first adult emergence in the field**

The results of the study showed that there was a compatibility in terms of the overall trajectory of the numbers of female *Tuta absolutainsects* that emerged from the winter and were collected in the pheromone traps distributed in the fields of the cultivation of the tomato crop during 2015, 2016 and 2017, The first adult was caught in these traps on 15th of March in 2015, 1st March in 2016 and on the 15th of March in 2017, close to the time when adults began to emerge from pupae placed in cages under normal conditions (heat, relative humidity and light( ,The first adult emerged from these cages on the 7th of March , 1st of March and on the 10th of March in 2015, 2016 and 2017, respective.During continuous monitoring, the numbers caught in the traps were affected by abnormal conditions such as strong winds, heavy rains, dust storms or dust, therefore no adult can be caught in the traps.It's the same note that referred to by the researchers [1] and [19] In this study also noted that there was some kind of similarity or match in the emergence dates of first-generation adults recorded in cages that contained wintering pupae. Also the pheromone traps were placed in the fields of tomatoes. Therefore, one or both methods (traps and thermal units collected) can be used to set the date of the emergence of first-generation adults and to schedule control time. This is consistent with what recommend by [3,28].

**The relationship between the number of insects caught in the traps and the amount of damage caused by the *T. absoluta***

Figures 1, 2 and 3 show that the Tuta absoluta began to infect the fruits of the tomato during March in 2015 and 2017, while it started on 1st of April in 2016. These figures also showed that the top peak of the injury was in the fruits of the tomato during the month of June for all the years of study, The reason may be due to that the insect has resorted to putting the highest number of eggs on this date as it is the end of the season. It is a genetic trait that insects resort to survive and resist abnormal conditions. This was what we observed during July and November of each year of study years. These figures also illustrated the number of insects catching in the pheromones traps for 2015, 2016 and 2017 respectively during the months of the year from December to January. All these figures show that the first insect´s catching was during the month of March except 2015 the in first insect´s catching was on the first of February,It is also noted that the peak of the numbers of insect´s catching was during the month of June for all the years of this study , The results consistent with the results we got from the study of the percentage of infection.

We also note from the figures that the infection rate and the number of insects catching in traps began to decline during the month of August and the beganning of September and then began to increase as the autumn planting season progresses, So the optimal time for chemical control was mid of April of each year and the best date for the traps installation was on March and April, where the insect was at its lowest population level. Thus, the first generation of the insect can be eradicated, then reducing its population and reducing the damage caused to the tomato crop.

From this study we concluded that there was a strong relationship between the percentage of infection in the tomato fruits by the insect and the number of insects caught in the traps.We noted that the Infection Ratio began to increase as the planting season progressed and the number of insects catching increased.The highest Infection Ratio was during June and the first half of July in 2015 and 2017 while its summit was in July 2016 .

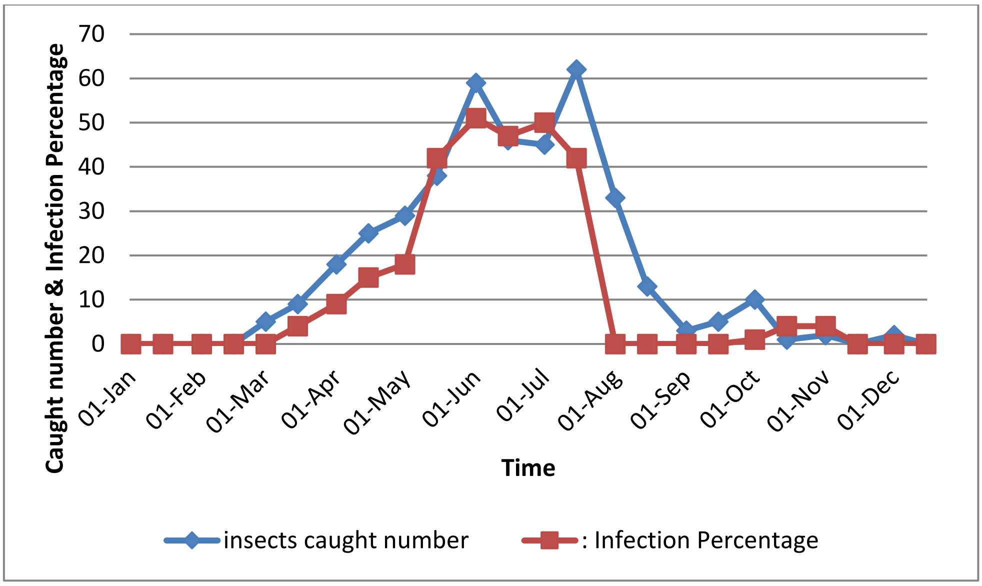


**Figure (1): Percentage of the Infection of *T. absoluta*in tomato fruits and insects caught in the pheromone traps for 2015**

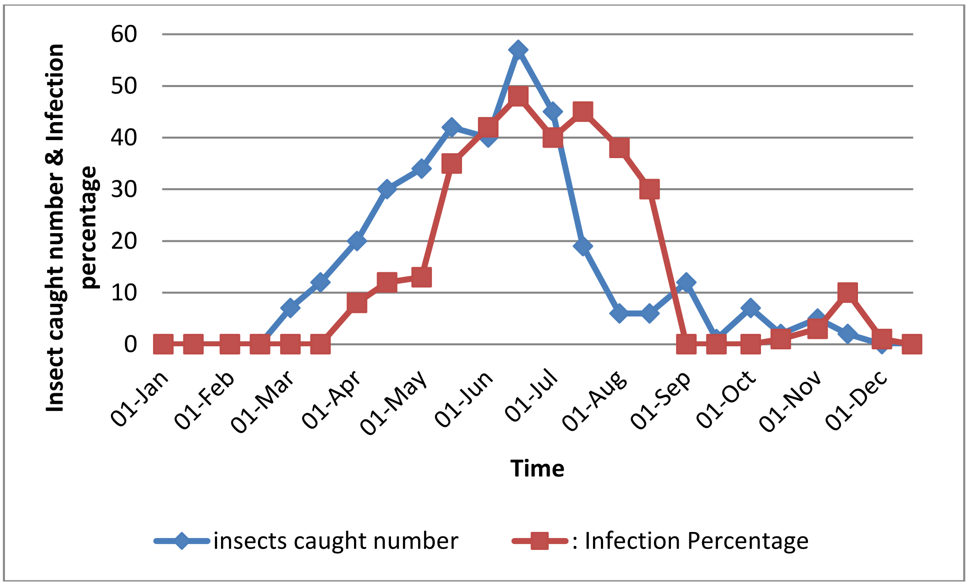


**Figure (2): Percentage of the Infection of *Tuta absoluta* in tomatos fruits and insects caught in the pheromone traps for 2016**

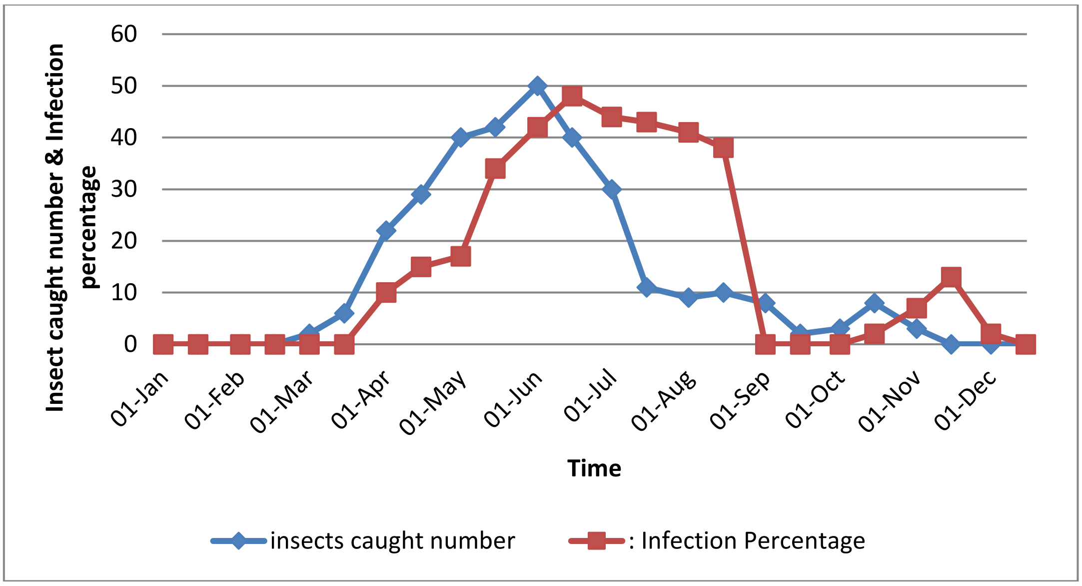


**Figure (3): Percentage of the Infection of *T. absoluta* in tomatos fruits and insects caught in the pheromone traps for 2017**

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