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A Study on the Biology of the Barred Fruit-tree Tortrix [*Pandemis cerasana* (Hübner, 1786) (Lepidoptera: Tortricidae)] be Detected in the Cherry Orchards in Turkey

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ABSTRACT

Pandemis cerasana (Hübner, 1786) (Lepidoptera: Tortricidae) causes economic damage by wrapping the leaves and bouquet of cherry fruit with the secreted silky strands and by gnawing the ripe fruits. This study was carried out in 2007-2009 to determine morphological characteristics and biology of *P. cerasana* in 0900 Ziraat variety cherry orchard in Sultandağı district of Afyonkarahisar province, Turkey and laboratory conditions. The relationship of *P. cerasana* biology with climate and cherry phenological features has been investigated. As a result of biological studies, adults were caught to pheromone trap in the cherry orchard in the third week of May in 2007-2008, reach to peak twice and continue to fly until October in both years. Adults laid eggs on the upper surface of the leaves in May-June for the first generation and in July-August for second generation. The larvae caused damage from April to October 2007-2008. Some second-generation larvae were overwintered as the first and second instar larva, and this pest has two generations per year. In the laboratory conditions, the average lifespan of *P. cerasana* was 8.48 days for males, 10.12 days for females, egg hatching time was 7.08 days, developmental time of larva was 32.58 days and developmental time of pupa was 7.21 days.

Key words: *Pandemis cerasana*, Totricidae, biology, morphology, cherry.

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INTRODUCTION

Cherry [(*Prunus avium* L.) (Rosales: Rosaceae)] is an important fruit for Turkish pomiculture. It has an important position in the Turkish economy so that it matures in early season and it is produced for domestic market and as an export product. Turkey is one of the biggest cherry producing country in the world. According to 2018 data cherry production was 639.564 tonnes (Anonymous, 2019). Cherries are grown for export in Afyonkarahisar province and it is the most important source of income for local farmers. 80% of the cherry produced from Afyonkarahisar province, where was conducted this study, are exported. In Turkey, many insect species are harmful in the cherry orchards (Anonymous, 2017).

Family Tortricidae belongs to the order Lepidoptera and is one of the widest families in Microlepidoptera (Meijerman & Ulenberg, 2000). It includes 10,000 species andmost of them are considered as pests (Gilligan & Epstein, 2014). The barred fruit-tree tortrix, *Pandemis cerasana* (Hübner, 1786) (Lep.: Tortricidae) is a member of this family and lives in the Palearctic region from Western Europe to Asia. *P. cerasana*, a common leaf roller of deciduous trees in northern Eurasia, was found in North America for the first time at Victoria, B.C., in 1964 (Evans, 1970).

In Turkey, *P. cerasana* was detected in Afyonkarahisar, Ankara, Bolu, Bursa, Düzce (Özdemir, Özdemir, Seven, & Bozkurt, 2005), and Çanakkale (Ercan & Özpınar, 2014) provinces. The pest damages both leaves and fruit (Zangheri et al, 1992). Although its biology is very similar to the other members of the Tortricidae family, it causes much more economic damage. When its population increases, they damage complete of the fruits and the leaves in bouquet. They also negatively affect the quality of fruit with its silky strands and excreta (LaGasa, 1996). Gilligan & Epstein (2012) identified many plant variety belonging to 15 different families which were eaten by *P. cerasana* larvae. This species mainly causes damage by gnawing and eating ripen cherry fruits at the harvest time (Özdem, Bozkurt, & Özdemir, 2014). This leads to unnecessary usage of insecticide. Yet farmers usually fails to prevent the damage. *Pandemis cerasana* causes direct economic losses. Before 2004, this species was rarely seen in Turkish cherry orchards. But after 2004, its population dramatically increased and became an important pest for the cherry orchards of Turkey. In Turkey, nobody has conducted a detailed study on its biology. The aim of this study was determination of biology and morphological features of *P. cerasana* in cherry orchard and laboratory conditions in 2007-2009.

MATERIAL AND METHODS

The material of this study consisted of collected *Pandemis cerasana* samples, a cherry orchard planted with 0900 variety, Pherocon IC type pheromone traps, species-specific pheromone capsules, artificial bait (Southland Products Incorporated, U.S.A), climate-controlled cabinets, culture cages (40cm x 45m x 50cm), plastic glasses, and other laboratory equipments.

Morphological studies

Morphological studies of *P. cerasana* were performed on at least 20 individuals in adult, egg, larva and pupa stages. In morphological studies were taken of photos using Leica Z 16 Apo and assessed these pictures according to Razowski 2001.

Biological studies

Biological studies were conducted both in the cherry orchard and in the laboratory. In the orchard study, it was checked the cherry orchard twice a week in the critical weeks for pest control and once a week in other weeks. In this searched it was tried to determine of first adult, egg, larva and and their duration time, flight activity of adults and the number of generations. Studies were conducted in a cherry orchard in Sultandağı district of Afyonkarahisar. This orchard were consisted of 300 0900 Ziraat variety cherry tree. It was used Pherocon IC pheromone traps in order to determine the first *P. cerasana* adults appear and flight activity. It was also recorded the number of total adults caught to the traps. Sticky tables of traps were changed when dirty and pheromone capsules were renewed in every 4-6 weeks.

Egg stage

In order to determine the time egg clusters were laid and the length of period for *P. cerasana* eggs it was observed trunks, branches, leaves and fruits every week following the time when first adults were seen. It was determined that the length of incubation period by following the egg clusters after they were first seen for every generation. This process was repeated until the last egg cluster was seen.

Larva stage

In order to detect the time of finding for every generation of *P. cerasana* larvae, it was recorded the time when first and last larvae were seen. It was also placed grooved cardboards to the upper trunk and branches of 20 trees in 12th of September in order to determine the overwintering larvae.

Pupa stage

In order to observe the time of finding for every generation of *P. cerasana* pupae, it was recorded the time when first and last pupae were seen. This process was repeated until the last pupa was seen.

Number of generations

The number of generations in a year was obtained by following *P. cerasana* in the orchard and by determining its biological periods in the laboratory.

Meteorological data

Meteorological data was obtained with climate sensors placed in the orchard. Air temperature and relative humidity values were given as a pentad.

Phenological records

It was observed that the phenological periods of cherry trees during the study. Also it was recorded the necessary data for phenological periods

Laboratory studies

The different biological stages of *P. cerasana* were collected from the cherry orchard and kept until adult. Adults were released in 2 litre plastic container containing adult diets of honey soaked cotton and water supply from a piece of sponge inserted into a pot, polyethylene sheet on the bottom for oviposition and wet clothes for keeping moisture both side of the container. Eggs were laid on polyethylene sheets by adults. Plastic containers were controlled daily, and eggs are transferred to separate plastic container every 24 hours. Hatched larvae on polyethylene sheets were placed in separate plastic container and culture cages. Larvae were fed with fresh cherry leaves and artificial food. The larvae were placed on a roll of corrugated paper board of 5 cm in diameter for prepupal stage in the plastic container and kept until being adult. It was calculated the lifespan of male and female adults, the number of egg cluster laid by females, the average number of eggs in a cluster, the hatching time of eggs, and the duration of larva and pupa periods from the data collected from at least 20 individuals in every stage. Laboratory studies were carried out 25°C±1, 65%RH and 16:8 photoperiod conditions.

RESULTS AND DISCUSSION

Morphological features

Adult of *P. cerasana* frons and labial palpus light or dark brown or sometimes gray-white. Antennas of males slightly ribbed, notched in basaly, brownnish yellow in upper side. Basal of females not notched or notches are very slight. Ground color of forewings from light brownnish yellow to gray-brown, towards apically with reticulate stripes in light brown color. Markings browner or hazel color, outer sides of the basal fascia wavy and slightly crisscrossed. Median fascia is strongly crisscrossed, and outer margine slightly convex starting from the costa. The internal side of the preapical spot distinct but weak towards apically. Cilia is darker than the base color. Costal margine without costal fold, basal half convex. Dorsum strongly convex in basaly, slightly concave towards the tornus. Hindwings gray-brown, but cilia lighter, with subbasal stripes. Gilligan & Epstein (2012) states that *P. cerasana* can be distinguished from the other *Pandemis* spp. with the gray-brown pincers of males above the second abdominal sternite and with its darker scales. According to the measurements males have a wingspan of average 18.20±0.17 (16-19) mm (Fig. 1), whereas females have a wingspan of average 21.3±0.25 (18-22) mm (Fig. 2).

P. cerasana lays its eggs on the surface of leaves in clusters. Egg clusters have a very light green color when first laid, they take a darker green shade as time passes. When the hatching time comes, the eyes of larvae can be clearly seen. After hatching, eggs clusters take a milk-white color and transparent.

The last stage larvae of *P. cerasana* measures 20.15±0.26 (18-23) mm on average and their body has a translucent turquoise color (Fig. 3). Pinaculum light green, head light coloration like body with brownish dots. Thorax plate in light color and brown dots in the lower part. Thorax legs light brown. Pinaculum in color as body. Anal plate lighter brown. Anal scallop yellow, with 6-8 denticles.

In early stage pupa of *P. cerasana* light brown and green color but in later stages, they turn to dark brown. Pupa length is average 7.25±0.12 (6-8) mm.

Fig.1. Adult of *Pandemis cerasana* male (Photo by M. ÖZDEMİR).

Fig. 2. Adult of *Pandemis cerasana* female (Photo by M. ÖZDEMİR).

Fig. 3. Larvae of *Pandemis cerasana* (Photo by A. ÖZDEM).

Biology

Adult pheromone traps were hung up in the cherry orchard in April 26, 2007 and May 6, 2008 in order to observe the first flights of adult and adult flight activity of *P. cerasana* and the results in 2007 and 2008 are given in Fig. 4 and Fig. 5, respectively. As can be seen on the figures, first adults were caught in traps on May 21, 2007, and May 20, 2008. Temperature and humidity values in these days were respectively 17.5 and 18.8 °C, and 60.6% and 67.2% (Figs. 6-7). There was also rained 1.2 mm of in 2008 In this period, 80-85% of fruits early maturing cherry varieties turned into their color from raw green to yellow and 10-15% pink. Fruits of early maturing cherry varieties were at the size of a chickpea, whereas fruits of late maturing cherry varieties were green colour and at the size of lentil.

The adult population was reached to peak twice in both years. In 2007, the first peak was occured one week after the first flight on May 30, 2007. In that day, pentad temperature was 17.0 °C and relative humidity was 81.8%. In 2008, the first peak was occured on May 27, 2008. In that day, pentad temperature was 19.4 °C and relative humidity was 61%. It rained during the same week. In that period, 50-60% of Fruits of early maturing cherry varieties were became sweet and 40-50% of them were pinky yellow. But only 10-15% of fruits of late maturing cherry varieties had a pinky yellow color and 85-90% of them had a yellowish green color. In 2007, the second peak of adult population was reached on August 1, 2007. That day, pentad temperature was 25.3°C and relative humidity was 50.8%. In 2008, the second of adult population peak was reached on August 12, 2008. That day, the temperature was 19.4 °C and relative humidity was 51.4%. In both years, the second peak of adult population were occured after the cherry harvest. Flights ended on October 24, 2007, and October 21, 2008.

In the first year, the first generation started to fly on May 21, 2007, and flights ended on June 13, 2007. The second generation started to fly on July 18, 2007, and the flights ended on October 24, 2007 (Fig. 4). In the second year, the first generation started to fly on May 21, 2008, and flights ended on July 15, 2008. The second generation started to fly on July 21, 2008, and flights ended on October 21, 2008 (Fig. 5). In both years, the flying period of two generations differed and the first generation flew for a shorter period than the second generation. It is well known that *P. cerasana* had one or two generations in Europe and the first generation were seen in field in June and July, whereas the second generation were seen in August and September (Gilligan & Epstein, 2012). When we considered the results of this study together with our findings, we can conclude that the first generation adults start to fly late, and second generation complated flying a month earlier. Carter (1984) stated that *P. cerasana* was found in field between June and August and they fly at twilight. Alford (2012) stated that the adults of *P. cerasana* were found in field in June and August. Duration of adults stay in cherry orchard is longer in our findings compared to the findings of these researchers.

There was no significant difference between the years in terms of the length of the flying period. In general, adults flew between May and October in both years. Ercan & Özpınar (2014) studied the peach, apple and cherry orchards in the districts of Çanakkale

province and they concluded that *P. cerasana* does not damage apples and cherries, but only damages peaches. They also concluded that the adults of *P. cerasana* were active in orchard between May and August. It is thought that the difference between the adult flight time may be due to ecological and climate conditions as well as host differences.

It was determined that the number of adults that caught to pheromone traps differed between years. In 2007, average 16.1±7.58 (1-112) adults were caught on traps whereas in 2008, average 15.7±5.45 (0-94) adults were caught on traps.

Egg: In 2007, the first *P. cerasana* egg cluster was found on May 30, 2007, but subsequent year it was found on June 2, 2008. In that time, pentad temperature and relative humidity values in these two days were respectively 19.2°C-63.4% and 15.9°C-69.4% (Figs. 6-7). Egg cluster of the first generation were found between May 30 and June 13, 2007. And no new egg cluster was found in the following five weeks. Fig. 4 shows that adults were not caught in pheromone traps between June 20 and July 11. Thus, it is normal not to find any egg cluster. Gilligan & Epstein (2012) state that females lay their egg on leaves or branches in clusters and sometimes eggs hatch at the end of summer. But, contrary to this, it was not found egg cluster on branches in this study. It was determined that the egg cluster belonging to the second generation between July 25 and August 28. In that week pentad temperature and relative humidity values was 25.3 °C and 50.4%. As seen Fig. 4, shows that traps were started to caught adults on July 18.

In 2007, weekly records showed that the number of egg clusters of first generation of *P. cerasana* was average 5.13±0.54 (1-8) and the number of egg clusters of second generation was average 6.60± 0.60 (1-10). In 2008, eggs clusters of the first generation were seen between June 2 and 18.

The egg cluster belonging to the second generation were first observed on July 29 and pentad temperature and humidity values in that week were 20.6° C and 60.8% (Fig 7). The last egg cluster belonging to the second generation was seen on August 27. As examined Fig. 4 that the number of adults that caught to the pheromone traps in the cherry orchard, it is seen that this number drastically decreased between June 18 and July 21. It can be can explained this decrease with the start of the flying period. That is, it is understood that the absence of egg cluster occurred in parallel with the adult flight. Weekly records showed that, in 2008, the number of egg cluster belonging to the first generation was avarage 3.40±2.60 (1-7) and the number of egg cluster belonging to the second generation was avarage 4.16± 2.31 (1-7).

Egg cluster of *P. cerasana* stayed in orchard for 15 and 35 days, respectively for the first and second generation in 2007, whereas this was 17 and 30 days in 2008. In 2007, eggs cluster belonging to the first generation was seen in orchard between May and June and egg cluster belonging to the second generation was seen between July and August. In 2008, egg cluster belonging to the first generation was seen in orchard in June and egg cluster belonging to the second generation was seen between July and August (Figs. 8-9). Matthey (1967) observed the egg clusters of *P. cerasana* in orchard between June and July. Our study showed that egg clusters stay in orchard longer.

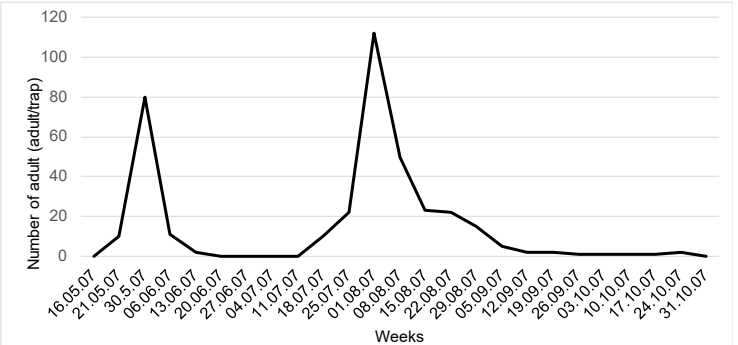

Fig. 4. Flight activity of *Pandemis cerasana* in 2007.

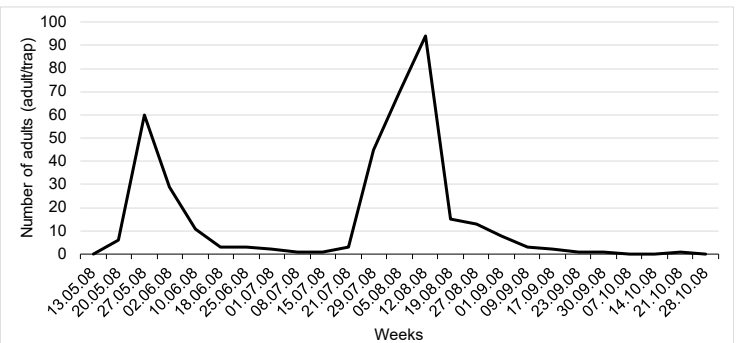

Fig. 5. Flight activity of *Pandemis cerasana* in 2008.

Overwintering larvae was searched on the trunk, branches and buds of trees from the last week of March to April in 2007 and 2008. It was found diapausing larvae at the first or second stage cocoon under the tree barks and inside bud scales. During this period, it is very hard to detect larvae since they are very small. Overwintering larvae began to actively feed when cherry trees were budding period. In 2007, larvae became active in 12th of April, whereas in 2008 they became active in 15th of April. In that week pentad temperature and relative humidity values were respectively 12.1°C-62.2% and 8.5 °C-65.8% and there was no rain in these days. Overwintering larvae of *P. cerasana* firstly feed on the buds. As a larva develops, it is easy to detect the location of the pest during this period. They consume the fruit inside this bouquet very quickly. They contaminate the fruits with their silky strings and excretions during feeding. The first generation larvae usually fed on the ripe or almost ripe fruits, whereas the second generation usually fed on the epidermis of leaves. Because cherry fruits were already harvested when the second generation larvae were active. Barbara, Faccioli, & Antropoli (1994) stated that the density of *P. cerasana* larvae varies from generation to generation and the second generation caused much more damage than the first generation. But our study showed that the first generation causes much more damage by directly affecting ripe fruits. Polat & Tozlu (2010) reported that *Arcips*

rosana L. winters over in Erzurum in form of an egg, the hatched larvae first feed on buds, then on leaves and cause great damage by wrapping leaves with silky strands. Besides, although they are from the same family, the damage form of *P. cerasana* is different from *A. rosanus*. *P. cerasana* generally causes serious damage on ripen fruits in addition to the damage to the leaf.

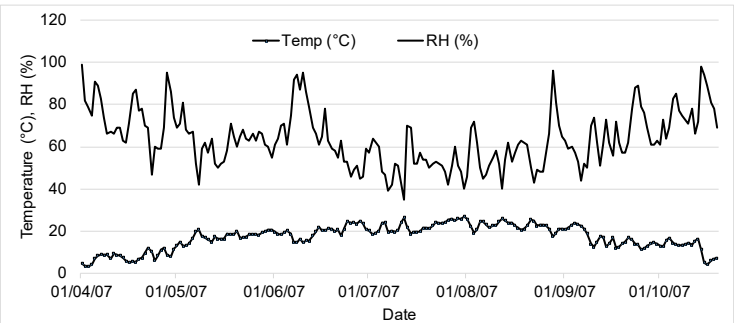

Fig. 6. Climate data in 2007 in Sultandağı district of Afyonkarahisar.

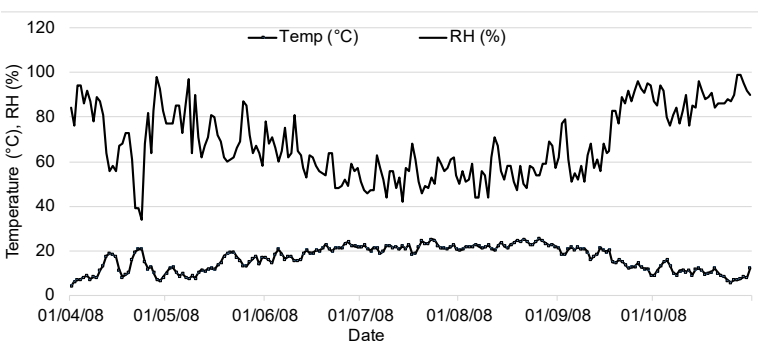

Fig. 7. Climate data in 2008 in Sultandağı district of Afyonkarahisar.

In 2007 and 2008, first generation larvae were active in the orchard between the end of June and the beginning of July, whereas second generation larvae were active at the end of October (Figs. 8-9). During the season weekly records showed that the number of *P. cerasana* larvae were avarage 15.73±3.60 (5-61) in 2007, and average 12.26±2.70 (1-47) in 2008. There were not seen any active larvae in orchard after October 10, 2007 and October 6, 2008.

It was observed that some of the second generation larvae became adults before the winter. But we also observed some of these second generation larvae wintered over as first or second stage larvae and became active in the April of next year. It was determined that some of the wintering larvae changed skin under the bark. Also, wintering larvae were either at the first or second stage. Approximately 80% of the wintering larvae were in second stage larva. Gilligan & Epstein (2012) stated that larvae winter over as second or third stage larvae, feed on leaves in spring, and turn

into pupae. Similarly, Carter (1984) stated that *P. cerasana* were overwinter as second and third stage larvae and start to feed in spring when trees start to bud. Contrary to our findings, the other researchers found that *P. cerasana* winters over in the form of second and third stage larvae. On the other hand, Alford (2012) states that this pest lays its eggs on tree branches and leaves, most of the eggs hatch in a couple of weeks, but some winter over as eggs. However, it was not found any evidence that *P. cerasana* spent in the egg period during winter. In order to follow the overwintering larvae, we examined the corrugated cardboards in November. But larvae didn't prefer cardboards to overwintering. However, larvae of another species belonging to the same family Codling moth, *Cydia pomonella* L. (Lep.: Tortricidae)] prefer to overwinter in corrugated cardboards (Anoymous, 2008).

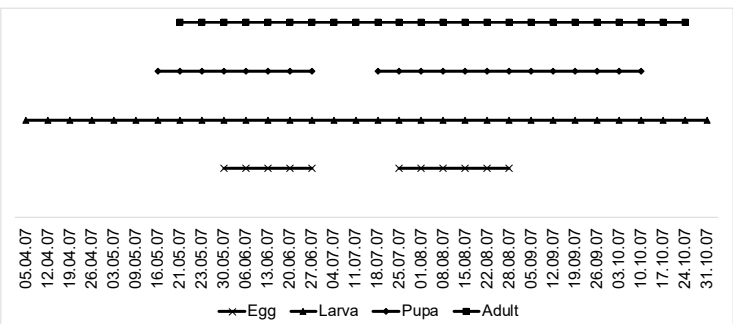

Fig. 8. Biological stages of *Pandemis cerasana* in 2007 in cherry orchard.

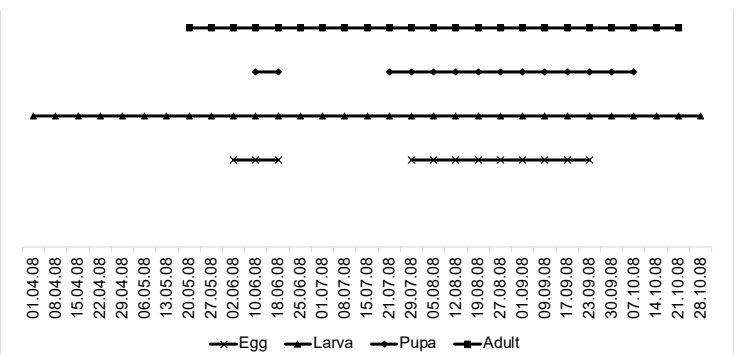

Fig. 9. Biological stages of *Pandemis cerasana* in 2008 in cherry orchard.

The first pupa was observed in orchard on May 16, 2007, and May 12, 2008. Pentad temperature and humidity values in these days were 18.4 °C-61.4% and 11.9 °C-72.4% respectively (Fig. 6 and Fig. 7). Pupae were active until June 27, 2007, and June 18, 2008. No pupae were observed in orchard two weeks after June 27, 2007, and four weeks after June 18, 2008. Pupae belonging to the second generation were first observed in orchard on July 1, 2007, and July 21, 2008. The last date they were seen in orchard was October 10, 2007, and October 14, 2008 (Figs. 8-9). In that

week pentad temperature and humidity values in 18th of June and 21st of July were respectively 21.0 °C-65.2% and 22.9 °C-53.8%. According to the weekly records, the number of *P. cerasana* pupae belonging to the first generation is 12.2±11.9 (1-32), and the number of pupae belonging to the second generation is 5.76±6.31 (1-21). Alford (1995) stated that *P. cerasana* larvae feed on leaves, spin cocoon and winter over, became active by spring, feed on offshoots and leaves, feed during May and June and turn into a cocoon inside leaf bouquet. Also, Carter (1984) and Alford (2012) stated that pest turns into a pupa inside a cocoon spun where they feed during May and June. I was determined that the last stage larvae of *P. cerasana* turn into pupa inside the leaf bouquets. Our findings are parallel with these studies.

Number of Generations: It was showed that the overwintering *P. cerasana* larvae become active by the third week of April, adults continue to fly until the third week of October and adult flights reach to peak twice a year. It was observed that some of second generation larvae were overwinter as the first and second stage larvae. It was determined that *P. cerasana* given two generations in a year.

Laboratory studies were carried out in 2009. According to laboratory studies; It was determined that adult males live 8.48±2.04 (5-13) days, and adult females live 10.12±2.36 (5-15) days on average. Egg hatching time for *P. cerasana* was average 7.08±1.16 (6-9) days, the number of eggs in a cluster was average 49.03±48.3 (6-230) and the number of egg cluster laid by a female was average 2.60±1.87 (0-7). Larva was developed in average 32.58±293 (30-39) days, and pupa was developed in average 7.21±1.34 (5-10) days.

There are still very few studies on *P. cerasana* in the global literature. This is the first comprehensive study on this insect which investigations the biological stages, phenology of the host and weather conditions.

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