An important pest in Erzurum: White peach scale (WPS) (*Pseudaulacaspis pentagona* (Targ.-Tozz.) (Hemiptera: Diaspididae)

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ABSTRACT: *Pseudaulacaspis pentagona* (Targioni-Tozzetti) (Hemiptera: Diaspididae), is an important mulberry pest in Turkey, is known to cause economic damage to stone fruits as well. Since it is a polyphagous pest, it is also seen in ornamental and forest plants. In 2015, some observations were made on the bioecology of the species in Ayvali village, Oltu District of Erzurum. In the last week of March (24 March 2015), it was determined that *P. pentagona* spent the winter as a fertilized female. Samples were taken from the field every 4-7 days and brought to the laboratory. The first eggs were found in the second week of April (April 14) in the samples received on April 10, 2015, and a very dense egg laying was observed on April 19 and 20. The first nymphs hatched from these eggs on April 20-21, and on April 27-28, nymphal emergence intensified. In field conditions, the first eggs were found on 20 April and the first nymphs on 3 May. In field conditions, the first eggs were found on 20 April and the first nymphs on 3 May. The presence of *P. pentagona* was recorded for the first time with this study in the Eastern Anatolia Region (Erzurum-Oltu). In addition, the distribution and hosts of the species in Turkey are given. It is of great importance to know the existence of such an important species and to carry out studies to control it accordingly.

Keywords: White peach scale, *Pseudaulacaspis pentagona*, Brief biology, Erzurum, Türkiye

INTRODUCTION

Turkey is known for its wide geographic distribution of little-known plants, including its rich flora and fruits (Özkan, 2019; Cengiz and Korkut, 2020; Maras-Vanlioğlu et al., 2020).

Mulberry belongs to the *Morus* genus in the Moraceae family of the Urticales order, with 10-12 species found worldwide (De Candolle, 1967). *Morus alba* L. (white mulberry), *Morus nigra* L. (black mulberry), and *Morus rubra* L. (red mulberry) are the most common species globally (Bellini et al., 2000; Datta, 2002; Choudhary et al., 2013; 2015; 2018a,b). In Turkey, which experiences temperate, subtropical, and even small tropical climatic regions, numerous fruit species exhibiting rich biological diversity and valuable genetic resources have been cultivated in the wild for centuries (Can et al., 2021).

Mulberries have high adaptability to different climates and soil conditions. The species is resistant to abiotic stress conditions such as low soil fertility or harsh climates. Due to this characteristic, this little-known fruit is naturally grown in fruit valleys, high-altitude plateaus, and even at elevations above 2500 m (Engin and Mert, 2020; Özkan et al., 2020).

Mulberry is one of Turkey's most important traditional fruits and is consumed either fresh or transformed into various traditional products. Mulberry trees (genotypes) belonging to *M. alba*, *M. nigra* and *Morus rubra* L. exhibit high phenotypic diversity (Orhan et al., 2020).

Mulberries contain significant amounts of biologically active compounds that may be associated with certain potential pharmacological activities. Therefore, they are beneficial for health and categorized as superfoods. In most countries where mulberries are grown, the fruit is typically consumed fresh, dried, or processed. Due to its delicious taste, pleasant color, low-calorie content, and high nutritional value, it is used to make wine, fruit juice, and jam (Güngör and Şengül, 2008; Yuan and Zhao, 2017; Zhang et al., 2018).

Like all cultivated plants, harmful insect species exist that can reduce the quality and yield of the mulberry plant. One of these is the white peach scale (=mulberry scale) (*Pseudaulacaspis pentagona* (Targioni-Tozzetti) (Hemiptera: Diaspididae)). This pest feeds on the plant's sap by forming colonies on its thin and thick branches, causing the branches to dry out and the leaves to fall off. If the pest's population continues to be dense for several years, the trees can completely dry up and die (Anonymous, 2008).

Although WPS was first recorded in Italy by Targioni in 1886, it is believed that this pest originated from China or Japan (Brancsome, 2016). White peach scale, which is distributed worldwide, threatened the silk industry in Italy by killing mulberry trees and also caused damage to the peach industry in the United States in the early 1900s (Gossard, 1902; Van Duyn and Murphey, 1971) due to its ability to kill trees. According to Hanks and Denno (1993), *P. pentagona* destroyed numerous peach orchards in Florida and southern Georgia at the beginning of this century.

WPS has caused epidemics in many regions of the world areas (EPPO Global Database, 2022) (Figure 1) in recent years, particularly in peach, mulberry, kiwi, and ornamental plant (Whitmore and Medina Gaud, 1974; Kozarzhevskaya and Vlainic, 1981; Kozarzhevskaya et al., 1986; Ram and Pathak, 1987; Hickel et al., 1996; Ben-Doy *et al.*, 2015). It has been reported that the epidemic has also spread to regions with different climatic conditions in Europe, and its severity has increased (Kozár and Dávid, 1986; Kosztarab and Kozár, 1988; Kozár et al., 1994; Jansen, 1995; Kozár et al., 1995; Kozár, 1997; Mani et al., 1997). Various researchers have reported that the severity of epidemics is increasing with global warming (Kozár and Dávid, 1986; Kozár, 1992; Yamaguchi et al., 2001; Kozár and Szentkirályi, 2005).

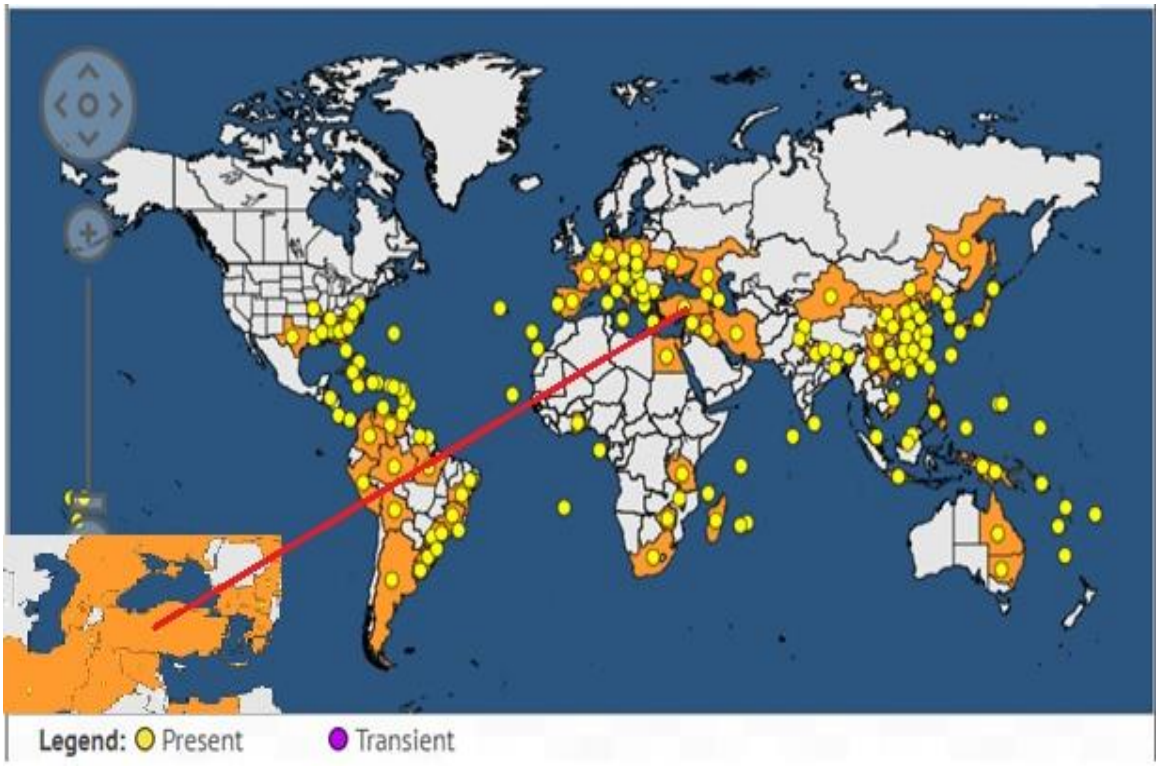


Figure 1. Distribution of *Pseudaulacaspis pentagona* (Targioni-Tozzetti) in the world (EPPO Global Database, 2022)

P. pentagona was first identified in Turkey in 1912 by Süreyya ÖZEK around Istanbul (Bodenheimer 1949). The first study on this species was conducted by Keyder (1952). Although it is called "Dut Kabuklubiti" in Turkey, it is known as "White Peach Scale (WPS)" around the world. Mulberry Scale was named "Oleander Scale" in Bermuda in 1920, where it caused significant damage to oleander trees (Collins and Whitcomb, 1975). It is the primary pest of not only peach trees but also mulberry trees in Turkey (Kıroğlu 1981, Zeki et al., 2004; Güncan, 2009; Mohammed, 2017; Yaşar, 2020). Its locations in Turkey are reported as Adana, Ankara, Antalya, Aydın, Balıkesir, Bartın, Bilecik, Burdur, Bursa, Giresun, Hatay, Istanbul, Izmir, Kocaeli, Kastamonu, Kayseri, Manisa, Mersin, Muğla, Ordu, Rize, Sakarya, Samsun, Tekirdağ, and Trabzon (Yaşar, 2020) (Figure 2).

Coccoidea (Hemiptera), known as scale insects and mealybugs, have waxy coverings or shield-like shells on their bodies. These covers provide protection against adverse weather conditions, natural enemies and control measures. They are typically immobile or have limited mobility, anchor themselves to plants and feed by sucking plant sap with their stinging-sucking mouthparts. As a result of their feeding, color changes in the feeding places, slowing of plant growth, yellowing, early leaf fall, fruit and flower drop can be seen. If the damage continues to increase, the ends of the branches begin to dry out and eventually lead to the complete drying of the plant. In addition, they play a role in the transmission of some plant diseases (Kosztarab and Kozár, 1988).



Figure 2. Distribution of *Pseudaulacaspis pentagona* (Targioni-Tozzetti) in Turkey (Source: Yaşar, 2020)

Detailed studies have been conducted on WPS in the Black Sea Region (Kıroğlu, 1981), Marmara Region (Keyder, 1952; Gürkan, 1982), Mediterranean Region (Erkılıç and Uygun, 1995), Aegean Region (Güncan, 2009), and Central Anatolian Region (Mohammed, 2017) regarding its harmful effects. Additionally, various studies on WPS and other shellfish in the Aegean region (Bodenheimer, 1949, 1953; Aysu, 1950; Göker, 1973; Yaşar, 1990, 1995a, 1995b; Öncüer et al., 1999, 2001; Karsavuran et al., 2001; Ülgentürk and Çanakçıoğlu, 2004) have been conducted, all of which focus on its host and distribution.

It is reported that WPS causes damage to 108 plant species belonging to 58 families (Miller and Davidson, 2005) and is a polyphagous pest. It is the main pest of mulberry, peach, and nectarine trees. It is also present in many other plants such as apricot, almond, walnut, poplar, willow, rose, apple, plum, kiwi, cherry laurel, lilac, geranium, blackberry, raspberry, grape, silk tree, and horse chestnut (Anonymous, 2008)

Nowadays, species of the Diaspididae family, which has the highest number of species in the Coccoidea (Hemiptera) superfamily with about 2400 species belonging to 380 genera, cause significant damage by feeding on the phloem or parenchyma of plants (Miller and Davidson, 2005). Adult female individuals of this family are called "scale insects" because they are hidden under a hard, waxy and scaly structure that they create by secreting from their specialized pygidia (Foldi, 1990). Scale insects have been recorded to live on host plants of more than 1380 genera belonging to 182 families (Borchsenius, 1966). Thanks to their adaptations and biotic relationships in morphology, reproduction, and life cycle, scale insects have developed better survival skills than other insect groups (Gullan and Kosztarab, 1997).

Approximately 199 species are known to cause damage worldwide (Miller and Davidson, 1990), and 96 species have been identified in Turkey (Kaydan et al., 2007). One of most important of these species is the White Peach Scale, *P. pentagona*.

The studies conducted on *P. pentagona* in Turkey over the past 15 years are listed below.

Ülgentürk et al. (2008) investigated the species of the Coccoidea superfamily in Istanbul, providing information on the host plants of a total of 42 species belonging to 7 families, and reported that WPS was heavily present on mulberry trees. Güncan (2009) conducted a study on the status of WPS in peach trees in important districts producing peaches in İzmir province between 2006 and 2009, and determined the distribution areas, hosts, and natural enemies of WPS in İzmir province. In addition, Güncan (2009) determined that WPS gives 3 generations per year in İzmir province. Ülgentürk et al. (2009) reported WPS in kiwi gardens in Rize as the first record of the species and also noted that it is widespread and potentially harmful for kiwi. Kaydan et al. (2013) investigated the Coccoidea superfamily in Turkey, updating it to include a total of 359 species belonging to 134 genera in 18 different families. They reported that the family Diaspididae, with 134 species belonging to 42 genera, had the most species, followed by the families Pseudococcidae with 101 species belonging to 32 genera, and Coccidae with 67 species belonging to 28 genera.

Ülgentürk and Ayhan (2014) detected 11 scale insect species on the fruits sold in markets and bazaars in Ankara and determined that WPS from these species is most commonly found in kiwi fruits. Ülgentürk and Mohammed (2016) also identified eight coccoid species on mulberry trees in various cities, including Ankara, with WPS being the most common and significant pest. Mohammed et al. (2016) recorded WPS as a widespread and damaging pest on 23 ornamental and park plants in Ankara, with *M. alba* being particularly economically important in the Ayaş district.

In March 2015, an application was made to the Dean of Atatürk University Faculty of Agriculture by mulberry growers in Ayvali village of Oltu district of Erzurum. Producers reported that a pest creates a dense population on mulberry trees and asked for help in its control. The members of the Department of Plant Protection and Horticulture and the officials of the Oltu Agriculture District Directorate conducted fieldwork in the region. According to our research in the village of Ayvali, *P. pentagona* has become a serious threat to mulberry production, and some growers have even cut their trees. It caught our attention that this species was seen for the first time in the region and caused an important epidemic. The aim of this study is to reveal biological data about the species so that mulberry producers can apply effective control methods at the right time.

MATERIAL AND METHOD

Material

Egg, nymph and adult stages of WPS obtained from mulberry plants in Erzurum Province Oltu District Ayvalı village (Figure 3) and brought to Atatürk University Faculty of Agriculture Plant

Protection Department Insect Systematics Laboratory formed the main material of the study. The obtained specimens were kept in 30 × 45 × 30 cm plastic containers at 25 ± 2 °C temperature, 65 ± 5% relative humidity, and 16-hour light: 8-hour dark conditions, and some information was attempted to be obtained on the bioecology of the species.

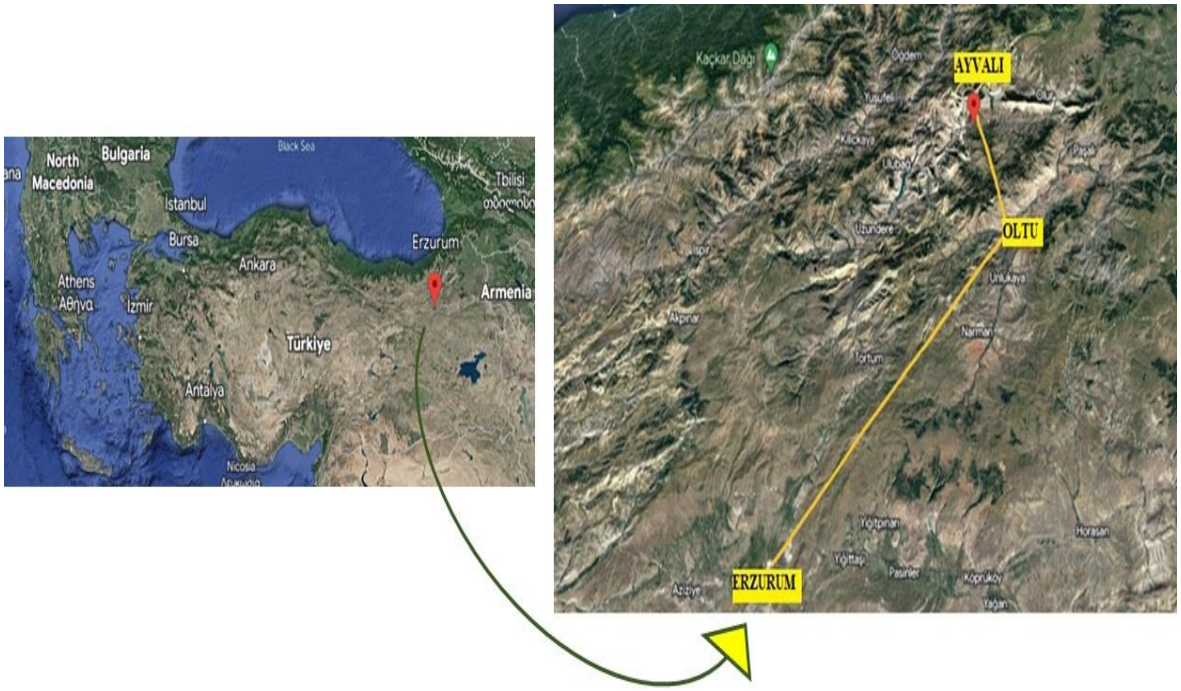


Figure 3. Study area where *Pseudaulacaspis pentagona* (Targioni-Tozzetti) was detected

Method

From the beginning of March to the end of May, samples were taken from the field every 4-7 days and related observations were made in the laboratory.

RESULTS AND DISCUSSION

Pseudaulacaspis pentagona (White Peach Scale)'s place in the animal kingdom (Burckhardt and Watson, 2004).

Domain: Eukaryota

Kingdom: Animalia

Phylum: Arthropoda

Subphylum: Uniramia

Class: Insecta

Order: Hemiptera

Suborder: Sternorrhyncha

Superfamily: Coccoidea

Family: Diaspididae

Tribus: Diaspidini

Genus: *Pseudaulacaspis* Macgillivray, 1921

Species: *pentagona* (Targioni-Tozzetti, 1886)

The adult females of *P. pentagona* have a circular, convex, dirty-white colored shell with a diameter of 2.0-2.5 mm (Figure 4a). The bodies of the adult females located beneath the shell are orange-yellow, have a broad pear shape, and have a body length of 0.9-1.5 mm (Figure 4b). The eggs seen beneath the female shell are uniformly oval (Figure 4c), with female individuals being pinkish-orange and male individuals being yellowish-white (dichroism). After hatching, the nymphs are mobile and wander around on the host for a certain period before anchoring themselves. The adult males have a body length of approximately 0.7 mm and a wingspan of 1.4 mm (Figure 4d). They are found in groups and have a pair of wings when they have completed their development. Their movements are quite slow, and they only live for about 24 hours.

As a result of the applications made by the farmers, the first samples were taken from the Ayvali Village of the Oltu district on March 4, 2015 by the officers of the Oltu District Directorate of Agriculture and sent to the Plant Protection Department. As a result of the examination of the samples, it was determined that the species was *Pseudaulacaspis pentagona*. These samples were then cultured in the Insect Systematics Laboratory. It was also determined that the species spent the winter as a fertilized female.

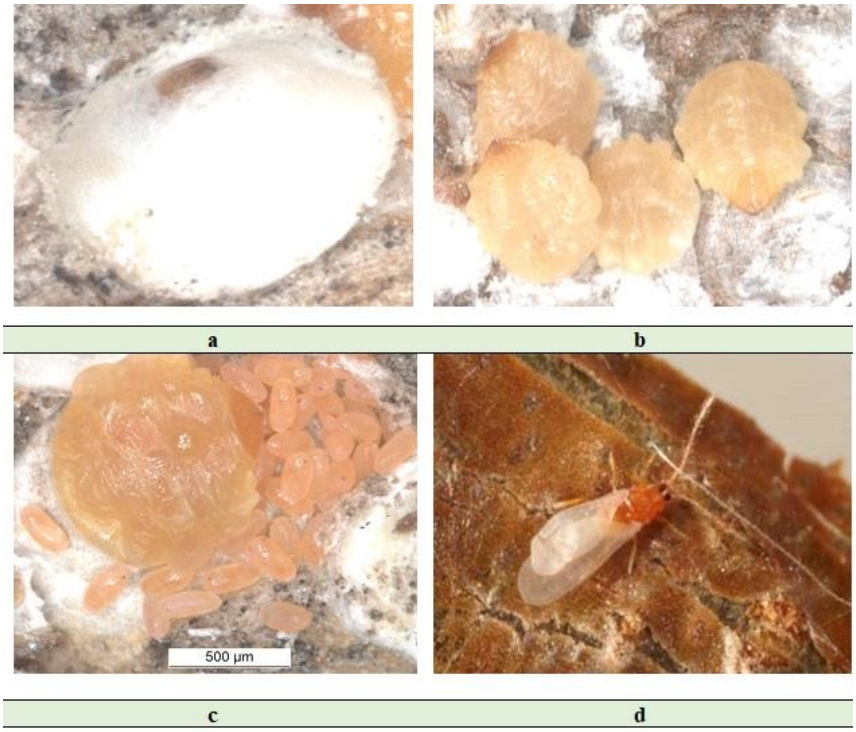


Figure 4. Some biological stages of *Pseudaulacaspis pentagona* (Targioni-Tozzetti), a. adult female shell (Original), b. adult female (Original), c. egg (Original), d. adult male (Source: Anonymous, 2023)

In samples taken from the field on March 18, 2015, the first eggs were observed on March 28 and 29. Similarly, the first nymph emergence from these eggs was observed on April 5th and 6th, and the

nymphs were seen moving on the branches.

Field inspections and sample collections were conducted on March 24th, 2015, and it was observed that the females under the shells had not yet laid eggs. The same situation continued in the samples collected on March 31st, April 6th, April 10th, April 13th, and April 16th.

In samples brought from the field on April 10th, the first eggs were found in the laboratory on April 14th. The egg density increased on April 19th and 20th. In the egg counts conducted on April 14th and 15th, 2015, the number of eggs laid by 10 females was 11, 21, 51, 13, 88, 24, 22, 94, 32, and 74 (average of 43). The first eggs were observed in samples brought on April 6th on April 18th.

In samples taken from the field on April 20th, 2015, the first eggs were found. Again, it was noted that the females laid a significant number of eggs on April 19th to 21st, in the samples brought on April 13th and April 16th. In the samples brought on April 10th, the first nymph emergence occurred on April 20th and 21st.

Eggs were observed in samples from the field on April 24th and 28th. Intense nymph emergence was observed in the samples brought on April 6th, April 13th, and April 16th during the laboratory checks on April 27th and 28th. The nymphs were very active. During the laboratory checks on May 3rd, eggs were seen in samples from the field on April 24th and 28th, and eggs as well as nymphs were observed in samples taken on April 26th. Eggs and first nymphs were observed in samples taken from the field on May 3rd and 6th. Intense nymph emergence was detected in the laboratory on May 5th and 6th. On May 8th, in samples taken from the field, nymphs were seen scattered on the branches, and unopened eggs (transparent white and orange-colored) were found under the shells. During the laboratory checks on May 18th, only a small number of nymphs and eggs were found in samples taken on May 6th. On May 8th, intensive spraying was carried out by the producers in the field under the supervision of the Agricultural District Directorate staff. Therefore, sample collection from the field was discontinued as the results would not be reliable. Only samples taken on May 26th were examined, and it was determined that the spraying significantly affected the population. It was also learned that the producers sprayed once again in the first week of June. The biological stages of *P. pentagona* observed under field conditions are given in Table 1.

Table 1. Biological stages of *Pseudaulacaspis pentagona* (Targioni-Tozzetti) determined in field conditions

Sampling dates	Biological stages		
	Fertilized female	Egg	Nymph
18 March 2015			
24 March 2015			
31 March 2015			
06 April 2015			
10 April 2015			
13 April 2015			
16 April 2015			
20 April 2015			
24 April 2015			
28 April 2015			
03 May 2015			
06 May 2015			
08 May 2015			

This study is of great importance as it is the first record of WPS detected in mulberry trees in the Eastern Anatolia Region (Erzurum-Oltu-Ayvali Village). It is seen that the species can give two generations in the region and has the potential to negatively affect the quality and quantity of mulberry production in a very short time. The climate data of 2015, when the study was conducted, are given in Table 2.

It is reported that WPS gives 2 generations per year in Marmara, Black Sea and Central Anatolia regions, and 3 generations in Aegean and Southern Anatolia regions (Anonymous, 2017). It is also recorded that the first generation started in the last week of March, the second generation started at the end of June and the third generation started in mid-July in İzmir (Güncan, 2009).

Table 2. Monthly average temperature, humidity and precipitation at Oltu (Erzurum, Turkey), in 2015 (Taken from the records of Republic of Türkiye Ministry of Environment, Urbanization and Climate, General Directorate of Meterology)

Monthly Average Temperature (°C)												
Year/Months	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
2015	-1.5	1.4	5.4	8.7	13.8	19.5	23.6	24.3	21.4	12.1	4.6	-2.8
Monthly Average Humidity (%)												
Year/Months	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
2015	65.2	60.6	53.2	54.2	57.1	50.0	38.7	39.6	33.8	62.0	59.8	62.1
Monthly Average Precipition (mm)												
Year/Months	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
2015	9.40	27.6	22.80	60.80	70.40	0.20	0.00	30.60	5.60	47.20	43.60	4.80



Figure 5. Damage of *Pseudaulacaspis pentagona* (Targioni-Tozzetti) (Original)

CONCLUSION

This study is the first conducted on *P. pentagona* (WPS), which is a harmful pest for mulberry trees in the Eastern Anatolia Region (Erzurum-Oltu-Ayvalı).

The study revealed that *P. pentagona* has the potential to negatively impact both the quality and quantity of mulberry production. Given the risk of the pest quickly spreading to large areas, measures, especially internal quarantine, need to be taken urgently. This is especially important since fruit cultivation is carried out in the neighboring Yusufeli, İspir, Oltu, Uzundere, and Tortum districts. Obtaining detailed bio-ecological data that can be used in the fight against this new pest in the region, especially identifying the emergence times of nymphs from eggs, is of great importance. Furthermore, it is believed that the pollution (especially the dusting of leaves) caused by the dam construction process in the region negatively affects the natural enemy populations.

It is of great importance for Agricultural and Forestry District Directorates to conduct surveys and inform farmers considering the natural enemy status and climatic conditions (such as temperature, humidity and precipitation) of the pest. Although a mite species was obtained as a natural enemy during the observations, its species description has not yet been confirmed.

It is thought that this cosmopolitan species with a polyphagous feeding habit can reproduce and limit mulberry production in the region when suitable conditions are present.

The fact that mulberry growers cannot choose the appropriate time for chemical control leads to excessive use of chemicals and thus often insufficient results In addition, the wide host range (polyphagous) of the mulberry scale species plays an important role in its survival and re-emergence in production areas.

As a result, producers should be informed about *P. pentagona*, and control programs that take into account the environment and human health should be implemented within the scope of integrated pest management.

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