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A pest that could be posing a threat to mulberry production of Turkey: *Glyphodes pyloalis* (Walker, 1859) (Lepidoptera: Crambidae)

Türkiye dut üretimini tehdit edebilecek bir zararlı: *Glyphodes pyloalis* (Walker, 1859) (Lepidoptera: Crambidae)

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ABSTRACT

Mulberry, *Morus* spp. (Moraceae) is naturally cultivated in Turkey, and no chemical input used during the production process. Hitherto, major and common species of insect and acari caused the economic yield and quality losses in the mulberry production have not been recorded. On the other hand, lesser mulberry snout moth, *Glyphodes pyloalis* (Walker, 1859) (Lepidoptera: Crambidae), considered being one of the most important pests of mulberry around the world was detected in the province of Yalova in the last week of August in 2018 for the first time. Larvae of this pest caused serious damage to leaves of white mulberry (*Morus alba* L., 1753), black mulberry (*Morus nigra* L., 1753), and weeping white mulberry (*Morus alba* cv. 'Pendula') (Urticales: Moraceae) whereas it has newly just occurred. This study was conducted to determine the distribution areas of the pest, mulberry species damaged, and characteristics related to some biological stages of *G. pyloalis* in Marmara Region (Bursa, Yalova, Kocaeli and Sakarya provinces) between 2018 and 2019.

INTRODUCTION

Mulberry (*Morus spp.*) belongs to the genus Morus of the Moraceae family involved in the Urticales order. It has been reported that the number of its species is 12-68 with one subspecies, and it has at least 100 varieties (Ercisli and Orhan 2006, Erdogan and Pırlak 2005). Mulberry is a fruit species that can grow in temperate, tropical, and subtropical climates because of its high adaptability to different climatic and soil conditions. Common mulberry species grown for its fruit are white mulberry (*Morus alba* L., 1753), black mulberry (*Morus nigra* L., 1753), and red mulberry (*Morus rubra* L., 1753) (Urticales: Moraceae). Mulberry grown for its leaves to feed silkworm, Bombyx mori L., 1758 (Lepidoptera: Bombycidae) is *M. alba* and its cultivars. Mulberry is grown in many countries of the world, and it is native to some countries. One of the mulberry species, *M. alba*, is native to China, Japan, Thailand, Malaysia, and Burma. Another species, *M. nigra*, is native to Turkey, Iran, Saudi Arabia, Syria, and parts of South Asia of Russia (Bellini et al. 2000). Turkey, one of mulberry's homeland, has 2.324 000 fruit-bearings, 353.000 non fruit-bearing trees, and its production quantity is 66.647 tons (TUIK 2019). The first five provinces of Turkey in terms of mulberry production amount and numbers of the trees are given in

Table 1. Locations in the top five ranks relating to the mulberry production of Turkey and numbers of trees, cultivation area, quantities of yield, and production in 2018 (TUIK 2019)

Locations (provinces)	Diyarbakır	Malatya	Elazığ	Erzincan	Ankara
Number of fruit-bearings	497.675	143.405	119.320	113.114	76.577
Number of non-fruit-bearings	37.005	12.667	10.076	34.110	14.432
Total area	10.113	590	725	455	511
Yield (kg/tree)	11	56	44	40	56
Production (ton)	5.605	8.075	5.248	4.511	4.251

Mulberry has not been utilized in fresh consumption and food industries sufficiently in Turkey, even though it is native to this country. Turkey's climate conditions and soil structure are suitable for cultivating mulberry, and it grows naturally in almost every region. Mulberry was widely grown for its leaves as the food of silkworm, (*B. mori*) in the provinces of Bilecik, Bursa, and Kocaeli in the past years. The cocoon production of the silkworm in the province of Bursa accounted for 13% of Turkey's production in 1995 (Taşlıgil 1996). There are 58.706, 24.779, and 4.937 mulberry trees in Bilecik, Bursa, and Kocaeli provinces, in recent years, respectively (TUIK 2019). Presently, mulberry fruits have been utilized as traditional products such as molasses, dried fruit pulp, and mulberry churchxela as well as fresh mulberry fruit consumption. Also, the red-coloured fruits are consumed as fresh and are used in marmalades, juices, liquors, natural dyes, and the cosmetics industry (Ercisli and Orhan 2005, Sengül et al. 2005). One of the factors causing yield and quality losses in agricultural crops is insect pests. Insect and acari species determined as mulberry pests in Turkey are mulberry scale, *Pseudaulacaspis pentagona* (Targioni Tozzetti, 1886) (Hemiptera: Diaspididae), Japanese wax scale, *Ceroplastes japonicas* Green, 1921, fig vax scale, *Ceroplastes rusci* (Linnaeus, 1758), cottony maple scale, *Neopulvinaria innumerabilis* (Rathvon, 1854) and brown soft scale, *Parthenolecanium corni* (Bouché, 1844) (Hemiptera: Coccidae), comstock mealybug, *Pseudococcus comstocki* (Kuwana, 1902), citrus mealybug, *Planococcus citri* (Risso, 1813), apple mealybug, *Phenacoccus aceris* (Signoret, 1875) and coconut mealybug, *Nipaecoccus nipae* (Maskell, 1893) (Hemiptera: Pseudococcidae), strawberry spider mite, *Tetranychus turkestani* (Ugarov and Nikolski, 1937) and hawthorn (spider) mite, *Amphitetranychus viennensis* (Zacher, 1920) (Acari: Tetranychidae) (Ataş and Kaydan 2014, Çobanoğlu and Düzgüneş 1985, Elma and Alaoğlu 2008, Kaydan et al. 2014, Telli and Yiğit 2017, Ülgentürk and Mohammed 2016). However, control methods such as cultural, physical, biological, biotechnical, and chemical have not been applied mostly to all the above- mentioned pests. Hence, mulberry grows naturally due to the status of the natural balance between its pest and natural enemies. On the other hand, the considerations mentioned above can not be asserted for *Glyphodes pyloalis* (Walker, 1859) (Lepidoptera: Crambidae) because it is a monophagous pest known as the most important insect fed with mulberry leaves (Hassan and Mir 2017). Additionally, this pest causes considerable damage to the mulberries grown for silkworms and gives 4-5 generations per year (Aruga 1994, Mathur 1980). The larvae of G. pyloalis are alternative hosts of densovirus and picornaviruses, so they are considered to be the vector of silkworm viruses (Watanabe et al. 1988). This pest described by Francis Walker in 1859 referred to, as lesser mulberry pyralid. It is reported in countries like India, China, Korea, Japan, Malaysia, Pakistan, Uzbekistan, Burma, Iran, Indonesia, Sri Lanka, Taiwan, the Democratic Republic of the Congo, and Equatorial Guinea, Mozambique, North America, Eastern Georgia, and Dagestan (Kanchaveli et al. 2009, Madyarov et al. 2006, Poltavsky and Ilyina 2016, WikiMili 2019). It was observed that insect larvae impaired almost all leaves on the tree during feeding, although it has just occurred newly in Turkey. Therefore, this study was conducted to report lesser mulberry snout moth, appeared for the first time in Turkey, and to emphasize a major pest that could pose a threat to mulberry production. Studies were performed in the mulberry cultivation areas in the Marmara Region (Kocaeli, Sakarya, Bursa and Yalova provinces) in 2018-2019.

MATERIALS AND METHODS

It was encountered on the leaves of the mulberry trees, during the routine surveys conducted for other pests in the fruit orchards of Atatürk Central Horticultural Research Institute, Yalova/Turkey (ACHRI) in the last week of August in 2018. It was discerned that lesser mulberry snout moth was in the larval period when the mulberry leaves were examined. Afterward, white mulberry leaf samples with pest larvae were brought to the laboratory in locked polyethylene bags. They were reared with mulberry leaf in the plastic boxes (27x20x16 cm) covered with the net in climate chamber [25 ± 1 °C, 60 ± 5% relative humidity, 16:8 hours (L:D)]. Its pupae and adults were obtained, and then adults were killed in the bottle with ethylene acetate. The samples obtained during the study were diagnosed by the third author based on external and genital morphology according to the diagnostic key used by Kononenko (2003). The other studies were performed through the stereoscopic binocular microscope with an Olympus trademark. Also, every 100 leaves of two mulberry trees which were damaged by *G. pyloalis*, in 2018 were examined with hand binoculars (10X) every three days from three different directions as of 15 April

2019. Furthermore, these leaves examined were brought to the laboratory in zip-locked plastic bags, and the emergence of the first larvae was determined under the binocular microscope. At the same time, each one branch of two mulberry trees was enclosed with the net cage (1.5x80x80 cm) for obtaining larvae, pupae, and eggs. So, the first appeared times of every biological stage related to the first generation were obtained in the natural conditions. In addition to these studies, to determine the spread area of *G. pyloalis* was conducted a delimitation survey study in 2019.

RESULTS AND DISCUSSION

Glyphodes pyloalis was detected for the first time due to damage caused to leaves of two mulberry trees (40°39'31.15"N, 29°17'09.50"E and 40°39'32.63"N, 29°17'03.40"E) in institute orchards in the last week of August in 2018. It was in the larval stage when the pest was noticed, and the different larval instars were together. It has five larval instars until a pupal period (Bhat 2007, Mathur 1980). Likewise, as reported by the same researchers, the first and second larval instars were colorless after hatching of eggs. Following, they turned greenish gradually during feeding with epidermis and mesophyll tissue on the underside of the leaves (Figure 1). It was observed that the larvae of lesser mulberry snout moth impaired almost all the leaves of the tree within two weeks and completely depleted the epidermis and mesophyll tissue of the abaxial surface of the mulberry leaves by leaving only the adaxial epidermis in the form of membranes (Figure 2). Next, they created a sheltered place at the underside of leaves with the strands they secreted when larvae reached their third larval stage (Figure 3) as mentioned by Aruga (1994) and Mathur (1980). Additionally, it was observed that mulberry leaves were left in the form of membranes during feeding of larvae in the fourth and early fifth stages. Also, the leaves were damaged by fully grown larvae by being consumed from edges, smirched with excreta, and folded together. (Figure 4). Pupae and adults were obtained through larvae fed with mulberry leaves in laboratory conditions (Figure 5 and 6). The pupal period occurred between one and two folded leaves in the outdoor condition as well. Genitalia and habitus of male adults were given in Figure 6 and 7. This pest overwinters amongst the fallen leaves on the ground or in cracks and crevices of the tree trunk in the larval period (Bhat 2007, Mathur 1980). Similarly, in this study, it was determined that the pest was found in the larval period among the folded leaves in the last week of November. Eggs of this pest on mulberry leaves were seen in natural conditions in the last week of June 2019, and they were oval and 0.6 x 0.4±0.002 mm SE, (N=10) in diameter (Figure 8). Also, it was observed that eggs were laid singularly along the leaf veins or on trichomes underside of the leaves, and then larvae emerged from eggs after 5-6 days.

Figure 1. First and second instar larvae of *Glyphodes pyloalis*

Figure 2. Mulberry leaves damaged by larvae of *Glyphodes pyloalis*

Figure 3. Third instar larval stage of *Glyphodes pyloalis* and strands formed by it

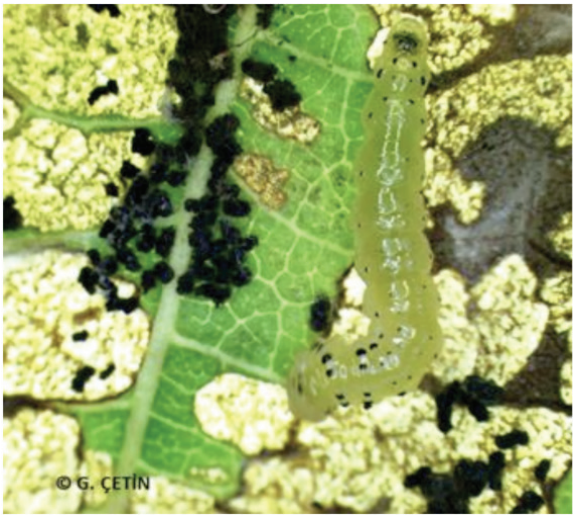

Figure 4. Full-grown larva with its excreta

Figure 7. Male genitalia of *Glyphodes pyloalis*

Figure 5. The pupal stage of *Glyphodes pyloalis*

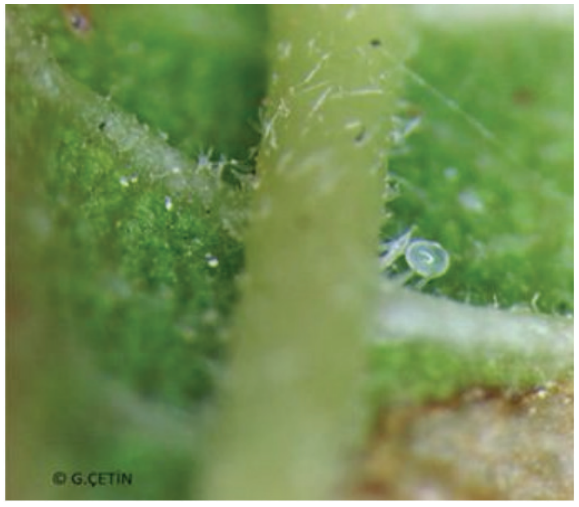

Figure 8. The egg of *Glyphodes pyloalis*

Figure 6. The adult of *Glyphodes pyloalis*

The first and second larval stages lasted seven days with 3-4 days intervals, and they were pale green. Afterward, the larvae feeding with the parenchyma tissue turned into a third and fourth larval stage with 4-5 days intervals. Finally, they became the full-grown larvae after 5-6 days and then transformed into pre-pupae in the case and pupae stage for 3-4 and 9-10 days, respectively. After all, adults appeared in the first week of August. This pest has 5-6 generations per year in Pakistan and varies the number of generations and some biological characteristics depending on environmental and climate conditions (Mathur 1980). Conclusion, the number of generations, durations of egg, larvae, pupae and adult stages belonging to every generation should be studied in detail in Turkey. In addition to these biological studies, the survey studies conducted on the spreading of pest and the obtained findings are given in Table 2 and Figure 9.

Table 2. The results of delimitation surveys in 2019 and the status of the infection

Province	District	Neighborhood/Village	Coordinate	Altitude	Status of infection
Bursa	Orhangazi	Orchard of agricultural directorate	40°29'11.14"N,29°18'29.48"E	126	Infected
		Village of Örnekköy	40°27'36.47"N 29°19'13.09"E	83	No infected
		Next to the highway of İznik	40°29'19.45"N, 29°19'10.20"E	122	No infected
Kocaeli	Karamürsel	Village of Pazarköy	40°40'48.06"N, 29°37'30.03"E	183	Infected
	Gölcük	The neighborhood of Halıdere yalı	40°43'29.45"N, 29°50'23.04"E	1	Infected
		The neighborhood of Yenimahalle	40°43'00.13"N, 29°48'57.64"E	30	Infected
		The neighborhood of Kavaklı	40°43'14.11"N, 29°50'17.39"E	5,25	Infected
		Avenue of Sahil	40°43'29.46"N, 29°50'23.04"E	2	Infected
Sakarya	Serdivan	Village of Aşağı Dereköy	40°44'17.17"N, 30°15'47.47"E	34	No infected
		Village of Yukarı Dereköy	40°44'41.71"N, 30°15'27.08"E	50	No infected
Yalova	Central	Orchard of Institute	40°39'31.15"N, 29°17'09.50"E	1	Infected
		Orchard of Institute	40°39'32.63"N, 29°17'03.40"E	1	Infected
		The neighborhood of İsmet Paşa	40°43'29.46"N, 29°50'23.04"E	20	Infected
		The neighborhood of İsmet Paşa	40°38'55.73"N, 29°18'06.85"E	20	Infected
		The neighborhood of Gazi Osman Paşa	40°39'24.22"N, 29°17'29.03"E	7,5	Infected
		The neighborhood of Gazi Osman Paşa	40°38'58.80"N, 29°18'07.22"E	8	Infected
		Village of Elmalık	40°36'54.15"N, 29°18'37.89"E	270	Infected
		Village of Elmalık	40°36'50.69"N, 29°18'37.91"E	270	Infected
		Village of Kirazlı	40°36'51.08"N, 29°17'15.54"E	270	Infected
		Village of Kirazlı	40°36'45.61"N, 29°17'18.92"E	270	Infected
		Village of Safran	40°36'28.22"N, 29°14'37.00"E	79	Infected
		Village of Hacı Mehmet	40°36'49.60"N, 29°14'35.52"E	34	Infected
	Çınarcık	Village of Kocadere	40°37'51.00"N, 29°01'57.00"E	6	Infected
	Termal	The neighborhood of Yenimahalle	40°36'35.83"N, 29°12'28.70"E	42	Infected
		Village of Akköy	40°37'35.37"N, 29°11'37.13"E	92	Infected
	Altınova	Village of Kaytazdere	40°41'26.09"N 29°32'14.89" E	185	Infected
		Village of Çavuş çiftliği	40°41'20.06"N 29°28'15.56" E	4	Infected
		Village of Tokmak	40°41'24.20"N, 29°32'12.85"E	2	Infected

Figure 9. Infested area with *Glyphodes pyloalis* Walker (locations pinned with yellow) and map of Turkey (upside on the left)

According to Table 2 and Figure 9, the 16 locations out of a total of 20 mulberry cultivation areas of 8 districts belong to 3 different provinces were infested by *G. pyloalis*. However, the mulberry cultivation was not commercially, so the total number of pest-infected trees was 300 approximately. These infected trees were white mulberry (*M. alba*), black

mulberry (*M. nigra* L.), and weeping white mulberry (*M. alba* cv. 'Pendula') at a rate of 80%, 15%, and 5% respectively. *G. pyloalis* is a serious pest for mulberry production due to direct damage to mulberry leaves. Also, it causes silkworm not to feed because of the pollution of the mulberry leaves. Besides, it is a vector for some viruses like bombyx adenoviruses and picornaviruses (Watanabe et al. 1988). As a result, if the measures against this pest are applied timely according to the integrated pest management, its spreading to the other regions might be prevented or at least delayed. Otherwise this pest can pose a threat to naturally produced mulberry products.

ÖZET

Dut, *Morus* spp. (Moraceae) Türkiye'de doğal olarak yetiştirilmekte ve üretim aşamalarında kimyasal girdi kullanılmamaktadır. Bu güne kadar, dutlarda ekonomik olarak verim ve kalite kaybına yol açacak önemli zararlı böcek ve akar türlerine rastlanılmamıştır. Bununla birlikte, Dünya'da dutun en önemli zararlılarından biri olarak kabul edilen Dut güvesi, *Glyphodes pyloalis* (Walker, 1859) (Lepidoptera: Crambidae) ilk kez 2018 yılı ağustos ayının son haftasında Yalova'da tespit edilmiştir. Henüz yeni görülmesine karşın bu zararlı larvalarının beyaz dut (*Morus alba* L., 1753), kara dut (*Morus nigra* L., 1753) ve sarkık beyaz dut (*Morus alba* cv. 'Pendula') (Urticales: Moraceae), yapraklarına ciddi zarar verdiği belirlenmiştir. Bu çalışma *G. pyloalis*'in Marmara Bölgesi'ndeki (Bursa Yalova, Kocaeli ve Sakarya) yayılış alanlarını, zarar verdiği dut türlerini ve bazı biyolojik dönemlerine ilişkin özellikleri belirlemek amacıyla 2018 ve 2019 yıllarında yapılmıştır.

Anahtar kelimeler: Dut güvesi, *Glyphodes pyloalis*, Morus spp., Crambidae, Lepidoptera

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