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Determination of Predators and Parasitoids of *Tuta absoluta* (Lepidoptera: Gelechiidae) in Different Tomato Varieties Cultivated in Open Fields in Diyarbakır Province

Diyarbakır İlinde Açık Alanda Yetiştiriciliği Yapılan Farklı Domates Çeşitlerinde *Tuta absoluta* (Lepidoptera: Gelecehiidae)'nın Predatör ve Parazitoitlerinin Belirlenmesi

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ABSTRACT

This study was conducted to determine predators and parasitoids of the tomato leafminer [*Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae)] in open field tomato cultivation areas in Diyarbakir province during 2021–2022. Threeparasitoids and 10 predator insects were detected in survey areas. The determined parasitoid species were *Bracon hebetor* (Say, 1836), *Bracon didemie* Beyarslan, *Bracon (Habrobracon) viktorovi* Fischer, and the predatory insects *Nysius graminicola* (Kolenati, 1845), *Geocoris megacephalus* (Rossi, 1790), *Macrolophus costalis*, *Macrolophus pygmaeus* (Rambur) *Campylomma diversicornis* Reut., *Chrysoperla carnea* (Stephens), *Orius* spp., *Orius niger* (Wolff), *Coccinella septempunctata* (L.), and *Hippodamia variegata* (G.). The results of this study are important for biological and integrated pest management in tomato fields. Additionally, it is believed that the maintaining and increasing of the effectiveness of existing natural enemies is crucial in pest control.

Keywords: Tomato leaf miner, natural enemy, biological control, integrated control

ÖZ

Bu çalışma; Diyarbakır ili açık alan domates üretim alanlarında zarar yapan domates güvesi [*Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae)]'nin predatör ve parazitoitlerini belirlemek amacıyla 2021–2022 yıllarında yürütülmüştür. Sürvey alanlarından üçü parazitoit, 10'u predatör olmak üzere toplam 13 böcek türü tespit edilmiştir. Belirlenen parazitoit türler; *Bracon hebetor* (Say, 1836), *Bracon didemie Beyarslan*, *Bracon (Habrobracon) viktorovi* Fischer, predatör türler de *Nysius graminicola* (Kolenati, 1845), *Geocoris megacephalus* (Rossi, 1790), *Macrolophus costalis*, *Macrolophus pygmaeus* (Rambur) *Campylomma diversicornis* Reut., *Chrysoperla carnea* (Stephens), *Orius* spp., *Orius niger (Wolff)*, *Coccinella septempunctata* (L.), *Hippodamia variegata* (G.) olmuştur. Zararlıyla mücadelede doğal düşmanların korunması ve etkinliklerinin artırılması önemli olduğundan bu çalışmanın sonuçları domates üretim alanlarında biyolojik ve entegre mücadele çalışmaları için önem taşımaktadır.

Anahtar Kelimeler: Domates güvesi, doğal düşman, biyolojik mücadele, entegre mücadele

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Introduction

Vegetables have a significant role in human nutrition. The necessity of consuming vegetables for human health is increasingly understood every day, as they have many health benefits such as containing no fat, being rich in water and fiber, being easy to digest, and not causing weight gain. Tomato, which is

the most widely utilized vegetable in Turkish cuisine nowadays, is used directly in meals and as ketchup in many dishes during the summer months and it has become a vegetable that we can hardly think of without.

This pest, which was initially detected in tomato fields in the Urla district of Izmir Province in Turkey in 2009 (Kılıç, 2010), was found in the Kumluca district of Antalya, where covered cultivation is widespread, in January 2010 (Erler et al., 2010). Since with a high damage potential, it has quickly become the main pest in open fields and covered tomato cultivation. If not controlled in infested areas, it can lead to product losses reaching 80–100% in tomatoes and threatens all covered and open field tomato production (López, 1991).

In Türkiye 13.2 million tons of tomatoes were produced in 2020 and 13.095 million tons in 2021. The provinces of Antalya, Bursa, and Manisa were among the top producers in 2021. Türkiye ranked fifth with a 7% share of exports in 2020. Syria, Romania, and Russia accounted for the countries with the largest share of Türkiye's tomato exports. In the first four months of 2022, Turkey's tomato exports were around 205 thousand tons. According to TURKSTAT (Turkish Statistical Institute) data, Turkey's tomato production decreased to 12.8 million tons in 2022 (Anonymous, 2022a; Anonymous, 2022b).

In Türkiye, tomato is one of the most consumed vegetables throughout the year, but there are many diseases and pests that significantly limit its productivity (Anonymous, 2008). Tomato leaf miner [*Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae)] is one of the most important pests that threaten tomato cultivation.

As it is understood, combating pests in agricultural production is an important issue, and using only chemical pesticides is not sufficient for this fight. Therefore, it is necessary to have detailed knowledge about pests and to identify their natural enemies. By identifying natural enemies, it is possible to control pests naturally and reduce the use of chemical pesticides. These methods are part of sustainable agriculture criteria.

This study focuses on the identification and recognition of predators and parasitoids of pests. It is aimed to lead the studies to be carried out in the region on pest control, to reveal new information, to make production more economical and efficient. In this way, farmers will be supported to use more sustainable and environmentally friendly methods in pest control.

Another important point is that this study is just a starting point. The process of identifying and recognizing the predators and parasitoids of pests requires a long-term study, and the applicability of the knowledge gained form this study is also important. Nevertheless, this study can encourage farmers in the region to try new methods in the fight against pests and to produce according to the criteria of sustainable agriculture

In conclusion, combating pests in agricultural production is an important issue, and using only chemical pesticides is not sufficient for this fight. The identification and detection of predators and parasitoids helps in the development of new methods to combat pests and is part of criteria for sustainable agriculture. This study can help farmers in the region to use more sustainable and environmentally friendly methods in the fight against pests.

Methods

The number of tomato areas examined was determined according to Bora and Karaca (1970) taking into account the labor force, time, distance between areas, evaluation of collected samples, and the size/number of production areas. Field sampling was conducted at a rate of 2% for districts with a production area of 50–100 ha, 1% for districts with a production area of 101–1000 ha, and 0.1% for districts with a production area of 1001–10,000 ha. In the samplings, 20 plants per decare were randomly selected by entering the corners of the field diagonally, and all parts of the plants were examined with the help of a magnifying glass and a microscope.

Provincial Directorate of Agriculture and Forestry data

Studies were conducted in a production area of 15,950 hain 10 districts in order to represent the areas of tomato growing in open fields in the province of Diyarbakır (Table 1).

FDR 8565, H-2274, Falcon, Elibol, Karacadağ, and Lice tomato varieties are grown in the survey areas.

Sampling of Predators and Parasitoids

Visual Inspection Method

Sampling of predators: The whole parts of the plants designated for the purpose of determining the natural enemies were examined, and the known predators identified during the observation were recorded. The adults of the unidentifiable species were

Table 1.
Districts of Diyarbakır Province Where Tomato Is Grown in Open Fields and Examined Production Areas

District Name	Tomato Planting Area for Table (da)	Table Tomato Planting Area (da)	Tomato Planting Area for Drying (da)	Total Area (da)	The Area Needing Examination (da)
Bağlar	200	300	0	500	5
Bismil	1000	1400	200	1600	2
Ergani	1500	2500	1000	5000	5
Kayapınar	100	400	2500	3000	3
Lice	0	3000	0	3000	3
Yenişehir	0	1100	150	1250	1
Sur	50	250	100	400	4
Silvan	200	400	0	600	6
Çınar	0	1450	0	1450	1
Kulp	240	360	0	600	6
Total	3290	9710	3950	15,950	36

collected using aspirators, while their larvae and pupae were transferred to culture vessels to obtain adults and were transported to the laboratory to be made ready for diagnosis.

Sampling of parasitoids: Pest-infested plant samples were collected from tomato fields and were cultured under climate chamber conditions (25 ± 1°C temperature and 60 ± 5% humidity, 16:8 light–darkness). The larvae were cultured in jars and the emergence of parasitoids was monitored daily by routine examinations.

D-Vac Sampling Method

The D-Vac sampling method is a sampling technique used to detect pests in plant materials. In this method, plant samples are collected using a special vacuum device. The D-Vac device has a feature that allows pests on the plants to be collected by airflow (Vincent et al., 2003).

The sampling process is usually done to detect pests on the leaves and stems of the plant. During the sampling process, all parts of the plant are scanned with the device, and the pests collected in the device's filter are later counted and their species are identified.

In open tomato cultivation areas in the Diyarbakır province, samplings were conducted by walking along the rows for two minutes, taking samples from three different points along the diagonals. For each sampling, a 1-type mesh bag with a rubber-tipped end, 30 cm wide and 45 cm long, was used. The samples were kept in these bags, labeled, and brought to the laboratory. The species in the samples collected in a plastic container with a mouth aspirator and frozen to death, and possible natural enemies present in the samples were identified by subsequent examination.

The predators and parasitoids obtained at the end of the sampling were prepared for diagnosis and sent to subject experts. The diagnosis of species belonging to the family Braconidae was made by Prof. Dr. Ahmet BEYARSLAN (Retired Faculty Member, Department of Biology, Trakya University), the diagnosis of species belonging to the family Coccinellidae was made by Dr. Derya ŞENAL (Department of Plant Protection, Faculty of Agriculture and Natural Sciences, Bilecik Şeyh Edebali University), and the diagnosis of species belonging to the order Hemiptera was made by Dr. Gülten YAZICI (Ankara Plant Protection Research Institute).

Results

This study conducted in open tomato cultivation areas in Diyarbakır province revealed the presence of many predator and parasitoid species in 2021 and 2022 (Table 2).

The predatory insect species found in this study generally prey on a variety of harmful insect, and *Coccinella septempunctata* L., *Hippodamia variegata* G., *Macrolophus pygmaeus* R., *Nysius graminicola* K., *Chrysoperla carnea*, *Orius* spp., and *Geocoris megacephalus* in Table1 have also been reported as predators of T. absoluta (Altun-Aksu & Çıkman 2019, Türkmen 2019, Ferracini et al. 2019; Bayram et al. 2014; Güven et al. 2017; Keçeci & Öztop 2017; Polat 2014; Urbaneja et al. 2009; Öztemiz 2012). The other predatory insects *Campylomma diversicornis*, Macrolophus costalis, *Orius niger*, and *Nysius graminicola* are general predators and can consume eggs or larvae of *Aphis* spp., *Tetranychus urticae, Myzus persicae, Bemisia tabacci,* etc., but their effects on pest species cannot be determined.

Table 2.
Predators and Parasitoids Identified in the Study

Order	Family	Organism
Hemiptera	Miridae	*Campylomma diversicornis Reuter*
		Macrolophus pygmaeus (Rambur) *Macrolophus costalis Fieber*
	Anthocoridae	*Orius* spp.
		Orius niger (Wolff)
	Lygaeidae	*Geocoris megacephalus* (Rossi) *Nysius graminicola* (Kolenati)
Coleoptera	Coccinellidae	*Coccinella septempunctata* (Linnaeus)
		Hippodamia variegata (Goeze)
Neuroptera	Chrysopidae	*Chrysoperla carnea* (Stephens)
Hymenoptera	Braconidae	*Bracon hebetor* (Say)
		Bracon (Habrobracon) didemie Beyarslan
		Bracon (Habrobracon) viktorovi Fischer

Macrolophus pygmaeus Rambur is commercially used. According to a study, it consumes 2 larvae and 30 eggs daily while feeding on the eggs and larvae of *T. absoluta* (Urbaneja et al., 2009).

In addition, two larval parasitoids, *Bracon hebetor* (Say, 1836) and *Bracon didemie* Beyarslan, have been determined. These two species have been reported as parasitoids of *Tuta absoluta* in many studies (Altun-Aksu &Çıkman 2019, Türkmen 2019, Ferracini et al. 2019; Bayram et al. 2014; Güven et al. 2017; Polat 2014; Urbaneja et al. 2009; Öztemiz 2012).

Among predator species, *M. pygmaeus* was the most common and had the highest population. *C. diversicornis* was the second species. Among parasitoid species, *B. hebetor* was the most common species. *B. didemie* was the most common species with the second highest population.

In addition, *Bracon* (*Habrobracon*) *viktorovi* Fischer has not been previously reported as a *T. absoluta* parasitoid in previous studies. However, it has been reported to be present in vegetable gardens in Ordu and Malatya provinces (Beyarslan et al. 2008, Beyarslan & Çetin Erdoğan, 2012). Further studies are needed to determine whether this species is a parasitoid of *T. absoluta*

The species *Bracon didemie* Beyarslan and *Bracon* (*Habrobracon*) *viktorovi* Fischer have been detected for the first time in tomato cultivation areas within the borders of Diyarbakır province.

Discussion and Conclusions

In this study, three parasitoids and ten predator insects were detected. Some of these predator insects are effective on the tomato leaf miner while the others are general predators whose effect on the pest cannot be determined. Since the presence of parasitoids and predators as an alternative to chemical control, biological and biotechnical control methods should be considered together and integrated with other control methods, and the possibility of natural enemies being affected more during chemical control should not be overlooked.

In a study conducted in Antakya province of Turkey, nine parasitoid species belonging to four families of the Hymenoptera order (Eulophidae, Chalcididae, Pteromalidae, Braconidae) were found among the natural enemies of *T. absoluta*, including *Closterocerus clarus* (Szelenyi), *Ratzeburgiola christatus* (Ratzeburg), *Ratzeburgiola incompleta* Boucek, *Baryscapus bruchophagi* (Gahan), *Brachymeria secundaria* (Ruschka), *Hockeria unicolor* Walker, *Pteromalus intermedius* (Walker), *Bracon hebetor* Say, and *Bracon didemie* Beyarslan. The parasitism rates of these species were reported to vary between 0.7% and 37% (Doğanlar et al., 2011). Furthermore, in a study conducted in Şanlıurfa, which is a region in Turkey, *Bracon hebetor* (Say, 1836) was reported as a parasitoid of *T. absoluta* (Altun-Aksu & Çıkman, 2019).

Furthermore, the pest has many hosts so the possibility of turning to these host plants in the winter and spring when the first adult females cannot find tomato plants should be taken into account, weed control should be performed, and plant debris should not be left in and around tomato fields.

Natural enemies are biological control agents used to control pests in agricultural production. Biological pest control is preferred as an alternative to the use of chemical pesticides and is environmentally friendly.

Detecting natural enemies is crucial in agricultural production as it helps to identify the presence and effectiveness of them that can be used for controlling harmful organisms. Biological control agents are often highly specific to their target pests. This specificity reduces the risk of harming nontarget organisms, including beneficial insects, humans, and pets. This reduces the dependence on chemical inputs, minimizing environmental impact and promoting long-term ecological balance. Some biological control agents act both preventatively and curatively. They can prevent pest populations from reaching harmful levels and also help control existing infestations. Biological pest control is often a key component of integrated pest management, where different methods of pest control are combined into a comprehensive and sustainable approach.
Due to the use of broad-spectrum pesticides as part of intensive chemical control, the numerical values of predator and parasitoid species were found to be at a very low population level.

Specifically, the determination of natural enemies can help in the development of integrated pest management strategies in agricultural production. Integrated pest management strategies are methods of pest control that minimize the use of chemical pesticides by incorporating natural enemies. This allows farmers to control pests in a more cost-effective and environmentally friendly manner.

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