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Aphid Species, Their Natural Enemies in Vegetables from Erzincan, Turkey: First Record of the Parasitoid Wasp *Aphelinus mali* (Haldeman) parasitizing *Lipaphis erysimi* (Kaltenbach)*

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ABSTRACT
Aphid species, their parasitoids and predators on vegetables (bean, cucumber, eggplant, melon, okra, pepper, pumpkin, tomato and watermelon) grown in Erzincan province, Turkey were determined. Surveys were carried out at weekly intervals from the seedling period until the end of the harvest period in Central and Üzümlü districts of Erzincan province in 2014-2016. 30-40 plants were randomly selected in the surveys and all parts of plants were investigated with a magnifier. Ten aphid, seventeen predator and seven parasitoids species were found. According to results, *Lipaphis erysimi* (Kaltenbach) (Hemiptera: Aphididae) was first recorded as a host of *Aphelinus mali* (Haldeman) (Aphelinidae: Aphelininae) in the world. In addition, parasitism rates of aphids were also established. The mean parasitism rate changed between 17.5% in 2015 and 4.39% in 2016. The relationship between parasitism rate, total parasitized aphid number and total aphid number were found. According to the analysis result, there was a very weak or a high positive correlation (r= 0.126-0.721) between total aphid number and total parasitized (mummified) aphid number, and not a correlation existed between parasitism rate and total aphid number as for years.

Keywords: *Aphid, Natural enemy, Parasitism rate, Vegetable, Turkey*

1. Introduction

One of the food groups that people need for healthy and balanced nutrition is vegetables and fruits. Vegetables; vitamins, minerals and other ingredients in terms of human nutrition are a very important place (Thompson & Kelly 1990).

Vegetable production could be decreased by few pest organisms. One of the most important of these pests is aphids. Aphids (Hemiptera: Aphididae) are recognized worldwide as economically important (Remaudière & Autrique 1985). Aphid species are polyphagous, feed on plant sap and multiply rapidly under favorable conditions. They feed on the leaves, shoots, branches, stems, fruits and roots of plants and cause serious damage and also lead to the formation of fumagine. This formation reduces the photosynthesis and respiration capacity of plants (Lodos 1986; Ölmez Bayhan & Ulusoy 2002; Tepecik et al. 2011). In addition to these damages, aphids also vectors to viruses and other similar organisms, which are often more important than other damages (Lodos 1986; Matheus 1993).

It is reported that there are 510 genus (that have reached 5.000 species) of aphids on the earth (Blackman & Eastop 2018). Important vegetable pest species of the Aphididae family (Hemiptera) are mainly belong to the genera *Aphis* (Linnaeus 1758), *Aulacorthum* (Mordvilko 1914), *Brevicoryne* (van der Goot 1915), *Macrosiphum* (Passerini 1860) and *Myzus* (Passerini 1860). Among these species, *Aulacorthum solani* (Kaltenbach 1843), *Aphis fabae* (Scopoli 1763), *Aphis gossypii* (Glover 1877), *Brevicoryne brassicae* (Linnaeus 1758), *Macrosiphum euphorbiae* (Thomas 1878) and *Myzus persicae* (Sulzer 1776) are the most important vegetable pest species in Turkey (Düzgüneş & Tuatay 1956; Çanakçıoğlu 1975; Göksu & Atak 1976; Ölmez Bayhan 2000; Toros et al. 2002; Sangün 2010).

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Although many studies have been carried out on vegetable aphids in Turkey, no comprehensive study has been done on vegetable aphids in Erzincan until now. This study was carried out to establish aphid species and their parasitoids, predators, parasitism rates on vegetables growing in Erzincan province. Thus, within the scope of integrated pest management and organic vegetable cultivation, basic data of biological control against aphids were found out. Potential natural enemies determined as a result of this work, will be tackle of later, and it will lead to subjects such as increasing of natural enemy activity and mass production.

2. Material and Methods

Aphid species and their parasitoids, predators were collected on plants of *Abelmoschus esculentus* L., *Capsicum annuum* L., *Citrullus lanatus* Thunb., *Cucurbita pepo* L., *Cucumis sativus* L., *Cucumis melo* L., *Lycopersicon esculentum* Miller, *Phaseolus vulgaris* L., *Solanum melongena* L. grown in greenhouse or open field in Erzincan province.

To determine aphid species on vegetable plants in Center and Üzümlü district of Erzincan province, surveys were carried out at weekly intervals from the seedling period until the end of the harvest period in 2014 and 2016. In surveys, according to the field size 30-40 plants selected by chance and all part of the plants were examined by means of magnifier. Samples collected to determine aphid species were brought to laboratory for diagnosis by puting into codded tubes including 70% ethyl alcohol.

In order to determine the parasitoids and predators, firstly vegetables containing aphids had been observed and then detected parasitized aphids and predators were collected and they were brought to the laboratuvary for further identification with their host aphids. While collecting immature stages of parasitized, suspect aphids thought to be parasitized and both predators and their hosts from vegetables, they carefully were swathed with paper towels and placed into polyethylene bags. Immediateley, samples were placed in a portable refrigerator to prevent damage from the hot, and then brought to the laboratory in order to rear adults.

Non-adult (immature stages) predators collected were reared to become adults in a culture box (the dimensions of the culture box was 30x35x15 cm and the top of them surrounded by tulle) in laboratory and they were daily controled. When it was needed, aphid infected fresh plant shoots were added into the culture box and then, obtained adult predators were diagnosed (Yumruktepe 1993; Aslan 2002). After cleaning all the pests except from the aphids, suspect aphids and aphid mummies were placed in parasitoid extraction boxes. Following that daily emerging parasitoids were transferred into eppendorf tube with 95% ethyl alcohol and diagnosed (Yumruktepe 1993).

All vegetable plants were randomly sampled to establish the rate of natural parasitism. During this study, while determining the rate of parasitism, total parasitized individual numbers obtained from the colonies including mummy was compared with total aphid numbers in the sample (Praslicka & Huszar 2005).

In this study, correlation and regression analyses were done on data by using SPSS 17.0 packet program to determine whether there was a relationship between total parasitized (mummified) aphids and total aphids and between parasitism rate and total aphids.

3. Results and Discussion

In conclusion, it was found that there were ten aphid species, *Acyrthosiphon pisum* (Harris), *Aphis craccivora* Koch, *Aphis fabae* Scopoli, *Aphis gossypii* Glover, *Aphis nasturtii* Kaltenbach, *Aphis spiraecola* Patch, *Aulacorthum solani* Kaltenbach, *Lipaphis erysimi* (Kaltenbach), *Myzus (Nectarosiphon) persicae* Sulzer and *Macrosiphum euphorbiae* (Thomas) (Aphididae) on grown vegetables in Center and Üzümlü district of Erzincan province in 2014-2016 (Table 1). It was found that aphids on *Capsicum annuum* L., *Cucurbita pepo* L., *Phaseolus vulgaris* L. was more intense in terms of distribution and intensity among other vegetable plants. The species with the highest number of host plants were identified as *A. gossypii* and *M. persicae*. *Acyrthosiphon pisum*, *Aphis nasturtii* and *L. erysimi* respectively determined only on the *P. vulgaris*, *C. pepo* and *Cucumis sativus* L. Holman (2009), found that total 42 aphids species on vegetables in Palearctic region and reported that these vegetable plants (bean, cucumber, eggplant, melon, okra, pepper, pumpkin, tomato and watermelon) were the host of *Acyrthosiphon pisum*, *Aphis craccivora*, *A. fabae*, *A. gossypii*, *A. nasturtii*, *A. spiraecola*, *Aulacorthum solani*, *L. erysimi*, *M. persicae* and *M. euphorbiae*. Bayram & Bayhan (2016), determined that *A. gossypii* species were found commonly and consisting of high population on watermelons in Diyarbakır province in Turkey. Alaserhat & Canbay (2017), found that *A. craccivora*, *A. gossypii*, *A. fabae* and *M. persicae* on pepper plant (*C. annuum*) in Erzincan province in Turkey.

Table 1- The aphid species detected in vegetables in Erzincan province in 2014-2016

Host plants	*Aphid species*
Phaseolus vulgaris L.	*Acyrthosiphon pisum* (Harris 1776)
	Aphis craccivora Koch, 1854
	Aphis fabae Scopoli, 1763
	Myzus (*Nectarosiphon*) *persicae* (Sulzer 1776)
Cucumis sativus L.	*Aphis gossypii* Glover, 1877
	Aphis spiraecola Patch, 1914
	Lipaphis erysimi (Kaltenbach 1843)
Solanum melongena L.	*Aphis gossypii* Glover, 1877
	Myzus (*Nectarosiphon*) *persicae* (Sulzer 1776)
Cucumis melo L.	*Aphis gossypii* Glover, 1877
	Aulacorthum solani (Kaltenbach 1843)
Abelmoschus esculentus L.	*Aphis craccivora* Koch, 1854
	Aphis gossypii Glover, 1877
Capsicum annuum L.	*Aphis craccivora* Koch, 1854
	Aphis fabae Scopoli, 1763
	Macrosiphum euphorbiae (Thomas 1878)
	Myzus (Nectarosiphon) persicae (Sulzer 1776)
Cucurbita pepo L.	*Aphis gossypii* Glover, 1877
	Aphis nasturtii Kaltenbach, 1843
	Aulacorthum solani (Kaltenbach 1843)
	Myzus (*Nectarosiphon*) *persicae* (Sulzer 1776)
Lycopersicon esculentum Miller	*Aphis spiraecola* Patch, 1914
	Macrosiphum euphorbiae (Thomas 1878)
	Myzus (Nectarosiphon) persicae (Sulzer 1776)
Citrullus lanatus (Thunb.)	*Aphis fabae* Scopoli, 1763
	Aphis gossypii Glover, 1877
	Myzus (*Nectarosiphon*) *persicae* (Sulzer 1776)

As a result of this study, seventeen predator species viz. *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae), *Deraeocoris (Camptobrochis) punctulatus* (Fallen), *Deraeocoris (Camptobrochis) serenus* (Douglas & Scott) (Hemiptera: Miridae), *Orius (Orius) niger* (Wolff) (Hemiptera: Anthocoridae), *Adalia bipunctata* (L.), *Adalia decempunctata* (L.), *Adalia fasciatopunctata revelierei* Mulsant, *Coccinella septempunctata* (L.), *Hippodamia (Adania) variegata* (Goeze), *Exochomus nigromaculatus* (L.), *Oenopia (Synharmonia) conglobata* (L.), *Stethorus punctillum* Weise, *Psyllobora vigintiduopunctata* (L.) (Coleoptera: Coccinellidae), *Episyrphus balteatus* De Geer, *Sphaerophoria scripta* (L.), *Scaeva dignota* (Rondani) (Diptera: Syrphidae) and *Leucopis* sp. (Diptera: Chamaemyiidae) were identified on aphid species found on the study (Table 2). While determining these species, it was observed that adult and pre-adult stages of predator species were fed directly on aphid species found on the study. In previous studies were done on these aphid species in Turkey, many other predatory species were determined including predator species were found in our study (Düzgüneş et al. 1982a,b; Zeren & Düzgüneş 1983; Ölmez Bayhan & Ulusoy 2002; Aslan & Uygun 2005; Ayyıldız & Atlıhan 2006; Aslan & Uygun 2007; Güleç 2011; Alaserhat 2015; Alaserhat & Canbay 2017). In addition, it was reported on the world that *Chrysoperla carnea*, *Chrysoperla pallens* (Rambur) (Neuroptera: Chrysopidae), *Geocoris pulvisculatus* Distant (Hemiptera: Lygaeidae), *A. bipunctata*, *A. fasciatopunctata revelierei*, *Brumoides sturalis* (F.), *Coccinella septempunctata*, *Cheilomenes sexmaculata* (F.), *Coccinella undecimpunctata* L., *Coccinella transversalis* F., *Harmonia axyridis* Pallas, *Hippodamia dimidiata* (F.), *Hippodamia (Adania) variegata*, *Menochilus sexmaculatus* (F.), *Microaspis discolor* (F.), *Micromus variegatus* (F.), *Oenopia kirbyi* Muls., *Oenopia quadripunctata* Kapur, *Oenopia sauzeti* Muls., *Pania luteopustulata* (Muls.), *Propylea quatuordecimpunctata* (L.), *Pseudoaspidimerus circumflexus* (Motschulsky), *Scymnus (Pullus) castaneus* (Sicard), *Scymnus guimeti* Muls., *Scymnus pyrocheilus* Muls., *Scymnus quadrillum* (Motschulsky), *Scymnus xerampelinus* Muls., *Spitocaria bisellata* (Muls.) (Coleoptera: Coccinellidae), *E. balteatus*, *Scaeva pyrastri* L., (Diptera: Syrphidae) fed on these aphid species found on the study (Agarwala & Ghosh 1988; Singh & Bali 1993; Irshad 2001; Brown & Mathews 2008; Guo et al. 2008; Sapathi 2009; Chaudhary & Singh 2012; Jaferi 2013; Vandereycken et al. 2015; Rocca & Messelink 2017).

Table 2- Predators of aphid species found on vegetables in Erzincan province in 2014-2016

Aphid species	*Predator species*	
	Familia	*Species*
Acyrthosiphon pisum (Harris 1776)	Anthocoridae	*Orius* (*Orius*) *niger* (Wolff)
	Miridae	*Deraeocoris* (*Camptobrochis*) *punctulatus* (Fallen)
	Coccinellidae	*Coccinella septempunctata* (Linnaeus)
		Hippodamia variegata (Goeze)
		Oenopia (*Synharmonia*) *conglabata* (Linnaeus)
Aulacorthum solani (Kaltenbach 1843)	Anthocoridae	*Orius* (*Orius*) *niger* (Wolff)
	Miridae	*Deraeocoris* (*Camptobrochis*) *punctulatus* (Fallen)
	Coccinellidae	*Adalia bipunctata* (Linnaeus)
		Adalia fasciatopunctata revelierei Muls.
		Coccinella septempunctata (Linnaeus)
		Hippodamia variegata (Goeze)
	Syrphidae	*Scaeva dignota* (Rondani)
	Chamaemyiidae	*Leucopis* sp.
Aphis craccivora Koch, 1854	Anthocoridae	*Orius* (*Orius*) *niger* (Wolff)
	Miridae	*Deraeocoris* (*Camptobrochis*) *punctulatus* (Fallen)
	Coccinellidae	*Coccinella septempunctata* (Linnaeus)
		Hippodamia variegata (Goeze)
		Oenopia (*Synharmonia*) *conglabata* (Linnaeus)
Aphis fabae Scopoli, 1763	Anthocoridae	*Orius* (*Orius*) *niger* (Wolff)
	Miridae	*Deraeocoris* (*Camptobrochis*) *punctulatus* (Fallen)
	Chrysopidae	*Chrysoperla carnea* (Stephens)
	Coccinellidae	*Coccinella septempunctata* (Linnaeus)
		Hippodamia variegata (Goeze)
Aphis gossypii Glover, 1877	Anthocoridae	*Orius* (*Orius*) *niger* (Wolff)
	Miridae	*Deraeocoris* (*Camptobrochis*) *punctulatus* (Fallen)
		Adalia bipunctata (Linnaeus)
		Adalia decempunctata (Linnaeus)
		Adalia fasciatopunctata revelierei Muls.
		Coccinella septempunctata (Linnaeus)
	Coccinellidae	*Exochomus nigromaculatus* (Goeze)
		Hippodamia variegata (Goeze)
		Oenopia (*Synharmonia*) *conglabata* (Linnaeus)
		Psyllobora vigintiduopunctata (Linnaeus)
		Stethorus punctillum Weise
		Episyrphus balteatus De Geer
	Syrphidae	*Scaeva dignota* (Rondani)
		Sphaerophoria scripta (Linnaeus)
	Chamaemyiidae	*Leucopis* sp.
Aphis nasturtii Kaltenbach, 1843	Miridae	*Deraeocoris* (*Camptobrochis*) *punctulatus* (Fallen)
	Coccinellidae	*Adalia bipunctata* (Linnaeus)
		Adalia decempunctata (Linnaeus)
		Coccinella septempunctata (Linnaeus)
		Hippodamia variegata (Goeze)
	Syrphidae	*Scaeva dignota* (Rondani)
	Chamaemyiidae	*Leucopis* sp.
Aphis spiraecola Patch, 1914	Miridae	*Deraeocoris* (*Camptobrochis*) *serenus* (Douglas & Scott)
Lipaphis erysimi (Kaltenbach 1843)	Coccinellidae	*Coccinella septempunctata* (Linnaeus)
		Hippodamia variegata (Goeze)
Macrosiphum euphorbiae (Thomas 1878)	Miridae	*Deraeocoris* (*Camptobrochis*) *serenus* (Douglas & Scott)
	Coccinellidae	*Coccinella septempunctata* (Linnaeus)
		Hippodamia variegata (Goeze)
Myzus (*Nectarosiphon*) *persicae* (Sulzer 1776)	Anthocoridae	*Orius* (*Orius*) *niger* (Wolff)
	Miridae	*Deraeocoris* (*Camptobrochis*) *serenus* (Douglas & Scott)
		Deraeocoris (*Camptobrochis*) *punctulatus* (Fallen)
	Chrysopidae	*Chrysoperla carnea* (Stephens)
	Coccinellidae	*Adalia bipunctata* (Linnaeus)
		Adalia decempunctata (Linnaeus)
		Coccinella septempunctata (Linnaeus)
		Hippodamia variegata (Goeze)
		Oenopia (*Synharmonia*) *conglabata* (Linnaeus)
		Stethorus punctillum Weise
	Syrphidae	*Episyrphus balteatus* De Geer
		Scaeva dignota (Rondani)
	Chamaemyiidae	*Leucopis* sp.

Aphelinus mali (Haldeman) (Aphelinidae: Aphelininae), *Aphidius ervi* Haliday, *Aphidius colemani* Viereck, *Aphidius matricariae* Haliday, *Lysiphlebus fabarum* (Marshall), *Binodoxys angelicae* (Haliday) and *Praon volucre* (Haliday) (Braconidae: Aphidiinae) were found on aphids as parasitoids (Table 3). According to earlier studies conducted in Turkey it was determined that *Binodoxys acalephae* (Marshall), *Praon dorsale* (Haliday) and *P. volucre* (Braconidae: Aphidiinae) were parazitoids of *A. pisum*; *Aphelinus* sp. (Aphelinidae: Aphelininae), *A. colemani*, *B. acalephae*, *B. angelicae*, *Ephedrus persicae* Froggatt, *Lysiphlebus cardui* (Marshall) and *L. fabarum* (Braconidae: Aphidiinae) were parazitoids of *A. craccivora*; *Aphelinus* sp. (Aphelinidae: Aphelininae), *Adialytus ambiguus* (Haliday), *A. colemani*, *A. matricariae*, *B. acalephae*, *B. angelicae*, *Diaeretiella rapae* (M'Intosh), *L. fabarum* and *P. volucre* (Braconidae: Aphidiinae) were parazitoids of *A. fabae*; *Aphelinus* sp. (Aphelinidae: Aphelininae), *A. colemani*, *A. matricariae*, *B. angelicae*, *Lipolexis gracilis* (Foerster), *L. fabarum* and *P. volucre* (Braconidae: Aphidiinae) were parazitoids of *A. gossypii*; *Aphelinus* sp. (Aphelinidae: Aphelininae), *A. colemani*, *P. volucre, B. angelicae*, *E. persicae*, *Lysiphlebus ambiguus* Halliday and *L. fabarum* (Braconidae: Aphidiinae) were parazitoids of *A. spiraecola*; *Aphelinus asychis* Walker, (Aphelinidae: Aphelininae), *Adialytus ambiguus*, *Aphidius abjectus* (Haliday), *Aphidius funebris* Mackauer, *A. colemani, A. ervi, A. matricariae, B. angelicae, Ephedrus cerasicola* Stary, *E. persicae, P. volucre, Lipolexis gracilis, D. rapae*, *Lysiphlebus cardui* (Marshall) and *L. fabarum* (Braconidae: Aphidiinae) were parazitoids of *M. persicae*; *Adialytus salicaphis* (Fitch), *P. volucre* and *B. angelicae* (Braconidae: Aphidiinae) were parazitoids of *M. euphorbiae* (Düzgüneş et al. 1982b; Zeren & Düzgüneş 1983; Ayyıldız & Atlıhan 2006; Güleç 2011; Alaserhat 2015; Alaserhat & Canbay 2017). Furthermore, it was reported that numerous parasitoid species (including these species) were determined on aphids in the world (Atwal et al. 1971; Singh 1980; Tomanovic et al. 1998; Stary et al. 2000; Wiackowski et al. 2001; Kavallieratos et al. 2004; Rakhshani et al. 2005, Tomanovic et al. 2005; Kavallieratos et al. 2006; Stary 2006; Rakhshani et al. 2007; Talebi et al. 2009; Kavallieratos et al. 2010; Mossadegh et al. 2011; Dassonville et al. 2012; Nazari et al. 2012; Barahoei et al. 2013; Rakhshani et al. 2013; Taheri & Rakhshani 2013; Anonymous 2018).

Table 3- Aphid and their parasitoid species on vegetables in Erzincan province in 2014-2016

Aphid species	*Parasitoid species*	
	Subfamily	*Species*
Aulacorthum solani (Kaltenbach)	Aphidiinae	*Aphidius colemani* Viereck
Aphis craccivora Koch	Aphidiinae	*Aphidius ervi* Haliday
Aphis fabae Scopoli	Aphidiinae	*Aphidius matricariae* Haliday *Lysiphlebus fabarum* (Marshall) *Praon volucre* (Haliday)
Aphis gossypii Glover	Aphidiinae	*Aphidius colemani* Viereck *Aphidius matricariae* Haliday *Binodoxys angelicae* (Haliday) *Praon volucre* (Haliday)
Aphis spiraecola Patch	Aphidiinae	*Praon volucre* (Haliday)
Lipaphis erysimi (Kaltenbach)	Aphidiinae Aphelininae	*Aphidius matricariae* Haliday *Aphelinus mali* (Haldeman)
Macrosiphum euphorbiae (Thomas)	Aphidiinae	*Praon volucre* (Haliday)
Myzus (*Nectarosiphon*) *persicae* (Sulzer)	Aphidiinae	*Aphidius colemani* Viereck *Aphidius ervi* Haliday *Aphidius matricariae* Haliday *Praon volucre* (Haliday) *Lysiphlebus fabarum* (Marshall)

Two parasitoid species viz. *Aphelinus mali* (Aphelinidae: Aphelininae) and *Aphidius matricariae* (Braconidae: Aphidiinae) were determined on *L. erysimi*. *Aphidius* sp., *A. colemani*, *Aphidius hortensis* Marshall, *A. matricariae*, *Aphidius rosea* Haliday, *Binodoxys brevicornis* (Haliday), *Binodoxys indicus* (Subba Rao & Sharma), *Diaeretiella rapae*, *Ephedrus* sp., *Ephedrus laevicollis* (Thomson), *Ephedrus plagiator* (Nees), *Lipolexis gracilis*, *Lysiphlebus fabarum*, *Lysiphlebus testaceipes* (Cresson) and *Praon volucre* (Braconidae: Aphidiidae) are pointed out as parasitoids of *L. erysimi* (Atwal et al. 1971; Singh 1980; Stary & Ghosh 1983; Stary et al. 2000; Stary 2006; Talebi et al. 2009; Mossadegh et al. 2011; Rakhshani et al. 2013). Consequence, *Aphelinus mali* (Aphelinidae: Aphelininae) was first recorded as a parasitoid's of *Lipaphis erysimi* (Hemiptera: Aphididae) in the world.

Aphids' parasitism rates in 2015 are given (Table 4). Starting from the first week of July and continued until the first week of November, natural parasitism with aphids on vegetables was observed. At the end of the vegetation, the maximum parasitism was recorded (third week of October–first week of November). The highest parasitism rate was recorded as 84.93% on 21 October 2015 with cultured sample, while the mean rate of parasitism was 17.15%.

After analyzing the 2015 data, it was found that, there was a very weak positive correlation (r= 0.126) between the the number of total parasitized (mummified) aphids and number of total aphids. Also, there was not a correlation between the parasitism rate and the number of total aphids. Regression analysis was performed on the data to detect the relationship between the number of total parasitized (mummified) aphids and the number of total aphids and a linear relationship between them was found (Figure 1).

Table 4- The rate of parasitism of aphids on vegetables in 2015 in Erzincan province

Host plant	*Date of sampling*	*Aphid species*	*Total aphid number*	*Total parasitized (mummified) aphid number*	*Parasitism rates (%)*
Abelmoschus esculentus	15.07.2015	*Aphis gossypii*	350	18	5.14
	28.07.2015	*Aphis gossypii*	620	38	6.13
Capsicum annuum	03.11.2015	*Aphis fabae* *Myzus (Nectarosiphon) persicae*	150	80	53.33
Lycopersicon esculentum	21.10.2015	*Aphis spiraecola* *Macrosiphum euphorbiae*	73	62	84.93
Phaseolus vulgaris	15.09.2015	*Acyrthosiphon pisum* *Aphis fabae*	480	38	7.92
	20.10.2015	*Acyrthosiphon pisum* *Aphis fabae*	105	16	15.24
Cucumis sativus	26.08.2015	*Aphis gossypii*	58	0	0
	08.10.2015	*Lipaphis erysimi* *Aphis gossypii*	342	31	9.06
Cucurbita pepo	28.07.2015	*Myzus (Nectarosiphon) persicae*	475	7	1.47
	06.08.2015	*Myzus (Nectarosiphon) persicae* *Aphis gossypii*	1250	46	3.68
	13.08.2015	*Aphis nasturtii* *Myzus (Nectarosiphon) persicae*	625	45	7.20
	09.09.2015	*Aphis gossypii*	440	25	5.68
Cucumis melo	08.07.2015	*Aphis gossypii*	1230	61	4.96
	28.07.2015	*Aphis gossypii*	185	16	8.65
	19.08.2015	*Aphis gossypii* *Aulacorthum solani*	306	23	7.52
Solanum melongena	03.11.2015	*Aphis gossypii*	200	107	53.50

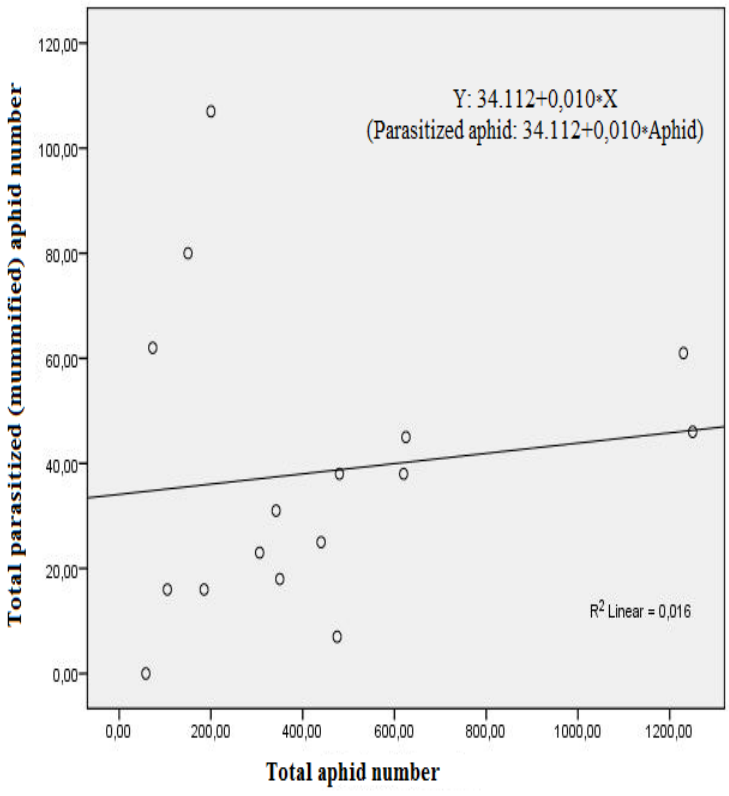

Figure 1- The relationship between the number of total parasitized (mummified) aphids and the number of total aphids in 2015

Parasitism rates in 2016 are given in Table 5. Starting from the fourth week of June and continued until the end of October, natural parasitism with aphids on vegetables was observed. Maximum parasitism was in 2016 first and fourth week October. The highest parasitism rate was recorded as 21.43% on 04 October 2016 with cultured sample, while the mean rate of parasitism was 4.39%.

Table 5- The rate of parasitism of aphids on vegetables in 2016 in Erzincan province

Host plant	*Date of sampling*	*Aphid species*	*Total aphid number*	*Total parasitized (mummified) aphid number*	*Parasitism rates (%)*
Capsicum annuum	28.10.2016	*Macrosiphum euphorbiae*	45	5	11.11
Lycopersicon esculentum	10.08.2016	*Macrosiphum euphorbiae*	59	1	1.69
	28.06.2016	*Aulacorthum solani*	64	0	0
Cucurbita pepo	11.08.2016	*Aphis gossypii*	2340	26	1.11
	15.08.2016	*Aphis gossypii*	450	17	3.78
	15.08.2016	*Aphis gossypii*	650	12	1.85
	23.08.2016	*Aphis gossypii*	480	15	3.13
	23.08.2016	*Aphis gossypii*	1280	38	2.97
Cucumis melo	13.07.2016	*Aphis gossypii*	270	8	2.96
	18.08.2016	*Aphis gossypii*	68	0	0
	25.08.2016	*Aphis gossypii*	750	41	5.47
	25.08.2016	*Aphis gossypii*	675	18	2.67
	31.08.2016	*Aphis gossypii*	30	1	3.33
	04.10.2016	*Aphis gossypii*	14	3	21.43

After analyzing the 2016 data, it was found that, there was a high positive correlation (r= 0.721**) between the number of total parasitized aphids and the number of total aphids. Also, there wasn't correlation between the parasitism rate and the number of total aphids. Regression analysis was performed on the data to detect the relationship between the number of total parasitized aphids and the number of total aphids and a linear relationship between them was found (Figure 2).

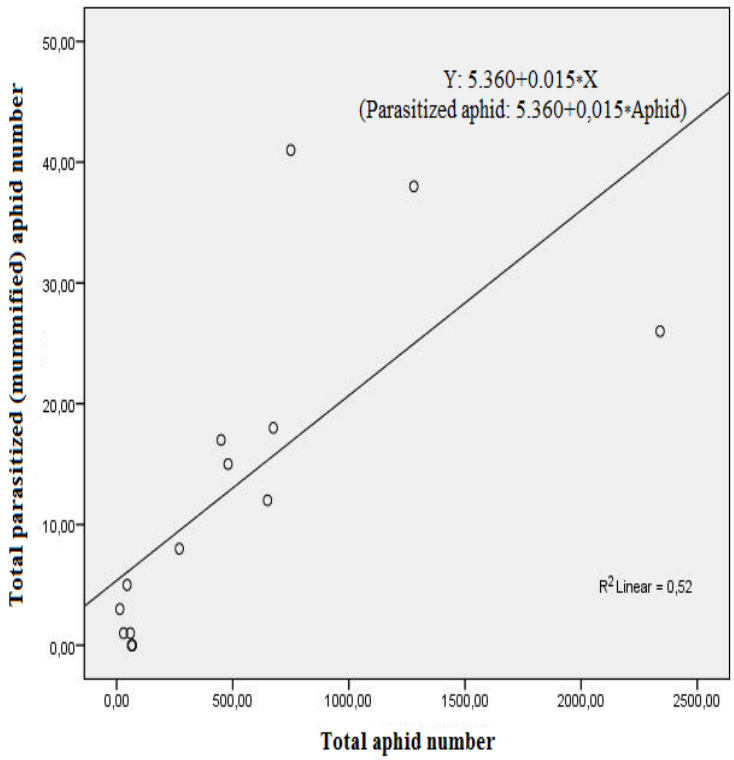

Figure 2- The relationship between the number of total parasitized (mummified) aphids and the number of total aphids in 2016

In our study, a very weak and a high positive correlation (r= 0.126-0.721) between total parasitized aphid number and total aphid number was found in both years. Additionally, not a correlation existed between parasitism rate and total aphid number in both consecutive years. Güçlü & Özbek (2002), indicated a correlation between the number of parasitoid species (*A. ervi* parasitoids of *Metopolophium dirhodum*) and the number of total aphids on *Rosa* spp. in Erzurum province in Turkey. On the other hand, Van Veen et al. (2002), determined a very strong correlation (r= 0.93) between the number of total parasitized aphids and the number of total aphids. Rakhshani et al. (2009), established that a high correlation between the number of parasitized aphids and the number of total aphids in the 5th and 6th cuts and in the 1st and 6th cuts of alfalfa respectively in 2004 (r= 0.954-0.794) and 2005 (r= 0.933-0.794). Furthermore, it has been indicated a low correlation in other periods of alfalfa. Alaserhat & Canbay (2017), conducted a study on aphid parasitoids on pepper (*Capsicum annuum* L.) in Erzincan province in Turkey in 2012-2013. They stated a very significant or a high positive correlation (r= 0.937-0.816) between the number of total parasitized

aphids and the number of total aphids, a very weak positive correlation (r= 0.163-0.064) between the rates of parasitism and the number of total aphids.

4. Conclusions

Consequently, ten aphid, seventeen predator and seven parasitoids species were determined on vegetables. Among the aphid, predator and parasitoid species were the most common species in nature respectively *A. gossypii*, *C. septempunctata* and *P. volucre*.

Aphelinus mali (Aphelinidae: Aphelininae) was recorded as a parasitoid of *L. erysimi* for the first time.

Natural parasitism rates of vegetable aphids were as 17.15% in 2015 and 4.39% in 2016. In 2015, producers did not carry out the necessary processes such as fertilization, irrigation and pesticide because their selling prices were low. Even, at the end of the season they did not harvest their vegetables and left them in the field. This led to increased parasitoid and parasitism rates.

It was found that the total aphid numbers were statistically related to the total parasitized (mummified) aphid numbers, while the total aphid numbers were not statistically related to the rate of parasitism. In 2015, the relationship between the total parasitized aphid numbers and the total aphid numbers showed variability widely. Especially, since the deviations of samples taken from at the end of the season in *C. annuum* (03.11.2015), *L. esculentum* (21.10.2015) and *S. melongena* (03.11.2015) were high, the correlation was also low. However, in 2016, the relationship between the total parasitized aphid numbers and the total aphid numbers didn't show varriabilty, so the correlation between them was found high.

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