J. Entomol. Res. Soc., 18(3): 49-60, 2016 *ISSN:1302-0250*

Natural Enemies and Population Dynamics of the Blackmargined Aphid (*Monellia caryella* (Fitch) Aphididae, Hemiptera) on Pecan Trees in Aydın, Turkey

Fulya KAYA APAK[1] Tülin AKŞİT[2*]

[1]Department of Plant Protection, Faculty of Agriculture, University of İnönü 44210, Malatya, TURKEY, e-mail: fulyazm@gmail.com
[2*]Department of Plant Protection, Faculty of Agriculture, University of Adnan Menderes, 09100, Aydın, TURKEY, e-mail: tulinaksit@yahoo.com

ABSTRACT

Population fluctuations of blackmargined aphid, *Monellia caryella* (Fitch) (Aphididae, Hemiptera) and its predators and parasitoids were identified in an unmanaged pecan orchard in Sultanhisar district of Aydın Province. Aphids on fifty compound leaves were counted weekly between April and December. Nymphs and adults of the blackmargined aphid overwintering on pecan branches as egg were seen between the December-April. Two peaks took place in population in both years (2008, 2009) including the second half of May and in October. In research, fifteen predators, three parasitoids of *M. caryella* and two hyperparasites species were obtained. It was determined that there were numerous predators, and few in number of parasitoids. Coccinellidae and Chrysopidae families were reported as the most abundant predator groups. Chrysopid population was higher than coccinellid population. *Adalia decempunctata* (L.) and *Chrysopa viridana* (Schneider) were prominent species. Coccinellid population in spring and chrysopid population in summer and fall were higher. The percent parasitism by *Aphelinus* sp. (Hym.; Eulophidae), *Aphidius matricariae* Haliday and *Trioxys pallidus* (Haliday) (Hym.; Braconidae) was 0.85% in 2008 and 0.17% in 2009.

Key words: *Monellia caryella*, *Adalia decempunctata*, *Chrysopa viridana, Aphidius matricariae*, *Trioxys pallidus*.

INTRODUCTION

The first adaptation of pecan (*Carya illinoensis* (Wangenh.) K. Koch, Juglandaceae) in Turkey were initiated with the imported seeds from the United States in 1953 and seedling from Israel in 1969 by FAO and Turkish Ministry of Food, Agriculture and Livestock. Pecan cultivation is limited in Turkey and there is no statistical datum on the amount of cultivation. The positive results are obtained in Aegean, Mediterranean and South East Anatolia Regions in the recent years (Paköz *et al.*, 1986; Tuzcu and Yıldırım, 2000). There is only one pecan orchard in Aydın, and *Monellia caryella* (Fitch) (Hemiptera, Aphididae) was found for the first time in Aydın. It is an important pest on pecan trees.

It is a species with monocious and holocyclic life. It is reported that this pest causes yield losses more than 50% under favorable ecological conditions. It gives 16-32 generations per year. Its hosts are pecan, hickory and walnut. The aphid sucks water and plant nutrients from pecan leaf veins, so the trees infested with aphids get weak, fruit quality decreases and the leaves defoliate early. The most important damage caused by *M. caryella* is the coating of leaf surface with honeydew (Richards, 1960; Tedders, 1978; Mansour *et al*., 1988; Mansour and Harris, 1988; Petersen and Hunter, 2002; Anonymous, 2014). It is a pest causing economic losses in the countries where pecan is grown. It is recorded that it was taken under control with chemical treatments in the United States, Canada and Israel (Tedders, 1978; Bueno and Stone, 1983; Mansour, 1988, 1993; Mansour and Harris, 1988; Ellington *et al.*, 2003). There are numerous studies on its biology, ecology (Tedders, 1978; Mansour and Harris, 1988; Anonymous, 2014) and natural enemies (Bueno and Stone, 1983; Mansour *et al.,* 1988; Mansour, 1988; Mizell III, 2007).

But, only two studies have been published so far on pecan pests found in Turkey and they were determined to be related to *M. caryella*. In first study, the population fluctuation and natural enemies of *M. caryella* were identified in Antalya (Özkan and Türkyılmaz, 1987). However, this study was published as *Chromaphis juglandicola* (Kalt.) (Hemiptera, Callaphididae) due to misdiagnosis. In second study, they determined *M. caryella*'s population fluctuations in different pecan varieties in the same orchard (Özkan and Türkyılmaz, 1990).

This species was unknown in Aydın. In the present study, its population fluctuations and natural enemies were observed.

MATERIALS AND METHODS

Population fluctuations of *M. caryella* and its natural enemies were observed in an unsprayed pecan orchard consisting of about thirty five years old forty seven trees including Mahan, Western Schley, Choctaw and Wichita varieties (Sultanhisar district Aydın). Because, there is only one pecan orchard in Aydın, the population counts began by hatching nymphs (early April) from overwintered eggs and continued until the middle of December when leaves fall completely. Aphids and its natural enemies were counted on fifty compound leaves weekly. Infested leaves were collected from each of randomly selected 10 trees. And then, the number of aphids on each leaf surface (upper and lower) were recorded. Some alate adults were put in ethylalcohol (70%), which were identified by Dr. Işıl Özdemir (Directorate of Plant Protection Central Research Institute, Ankara). Aphids and natural enemies on leaves were counted with a hand-held magnifier with 10x magnification. Besides, shaking method (100x100 cm white fabric) was also used in detection of predators of *M. caryella*. The branches of each of the 10 trees were shaken five times; falling adults were killed with ethyl acetate. The obtained mummy aphids, predatory larvae and pupae were taken to the laboratory, cultivated in plastic jars and Petri dishes at rearing room (25±2°C,50±5%R.H.,16:8 h light: dark photoperiod) for adult emergence. Parasitoids and predators were identified by expert taxonomists. Temperature values were received from Sultanhisar weather station three km away from the orchard.

RESULTS

Population fluctuation of *Monellia caryella* (Fitch)

The datum obtained on population fluctuation of *M. caryella* are given in Fig. 1. The aphid overwintered in cracks and crevices on branches and trunk as egg. The first nymphs were observed on 7th May, 2008 and 8th May, 2009 (late April in 2016). The ratio of the population comprised of alate females in first and second years, were 17.73% and 19.92% respectively. In 2008, the number of *M. caryella* nymphs (23.04 nymphs/leaf) and alate parthenogenetic females (6.2 adults/leaf (compound leaf)) reached the highest level on May 22 and then the second highest point was 6.7 nymphs/leaf and 1.74 adults/leaf on October 17. In second year, the first peak was determined on May 28 (36.4 nymphs/leaf, 5.52 adults/leaf) and the second peak was found on October 9 (18.68 nymphs/leaf, 7.6 adults/leaf) (Fig. 1). The aphid population gradually increased throughout the spring and peaked in May in both years. The spring peaks were higher than autumn peaks in both years. Alate sexual males and apterous oviparae females began to be seen on the trees on October 23, 2009 and the most of males (0.54 males/leaf) and oviparae females (4.02 females/leaf) were found on November 6. Parthenogenetic or sexual females were not seen after December 4. Population in the second year was higher than that of first year. The latest live aphids on leaves were determined on December 5 in which almost all the leaves on the trees were defoliated.

The few number aphids were present from mid-June to late August (Fig. 1). *M. caryella* was determined predominantly on the lower leaf surface (88%). Fruit harvest was conducted between 15th October and 28th November.

Predators of *Monellia caryella* (Fitch)

Fifteen predators of *M. caryella* were identified during studying period. The obtained species were *Adalia decempunctata* (L.), *Oenopia* (*Synharmonia*) *conglobata* (L.), *Adalia fasciatopunctata reveierei* Mulsant, *Hippodamia* (*Adonia*) *variegata* (Goeze), *Psyllobora vigintiduopunctata* (L.), *Coccinella septempunctata* (L.), *Adalia bipunctata* (L.) (Col.; Coccinellidae), *Chrysopa viridane* (Schneider), *Chrysoperla carnea* (Stephens), *Dichochrysa prasina* (Burmeister), *Cunctochrysa baetica* (Hölzel) (Neur.; Chrysopidae), *Anystis baccarum* (L.) (Acarina; Anystidae), *Anthocoris nemoralis* (F.) (Hem.; Anthocoridae), *Nagusta goedelii* (Kolenati) (Hem.; Reduviidae) and *Episyrphus balteatus* (DeG.) (Dipt.; Syriphidae).

The numerical changes of prominent predators in the season were given in Figs. 2, 3 and 4. It was seen that the rate of coccinellids among obtained adult predators were 88.26% in 2008 and 16.52% in 2009. The others were chrysopids. However, it was determined that 91.56% of obtained predators by Shaking method were coccinellid larvae and adults. 8.44% were chrysopid larvae and few adult in 2008; 87.00% were coccinellids, 13.00% were chrysopids in 2009. It was found that 73.18% of coccinellids in 2008 and 74% in 2009 were *A. decempunctata*. In addition totally 13 individuals of *E. balteatus*, 10 *N. goedelii*, 15 *A. nemoralis* and 8 *A. baccarum* were determined in two years. Their population levels were very low.

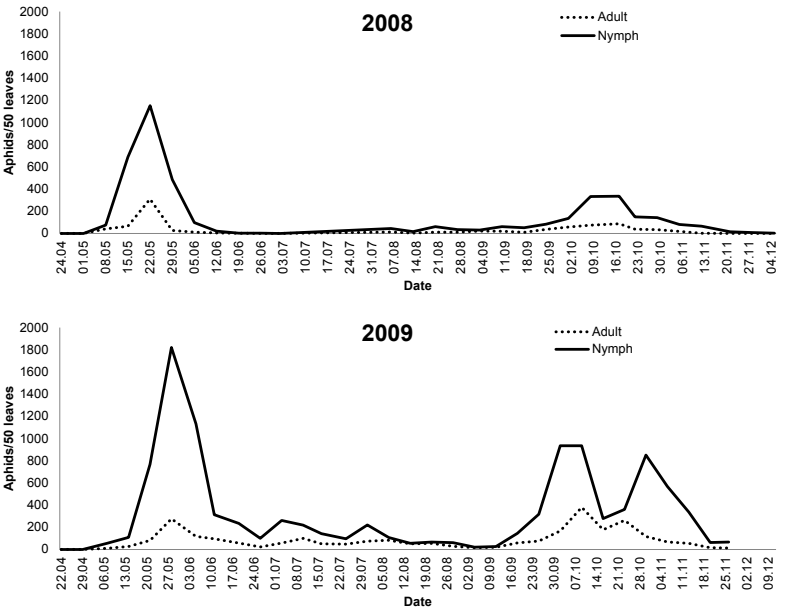

Fig. 1. Population fluctuations of *Monellia caryella* (Fitch.) in Aydın in 2008 and 2009 years.

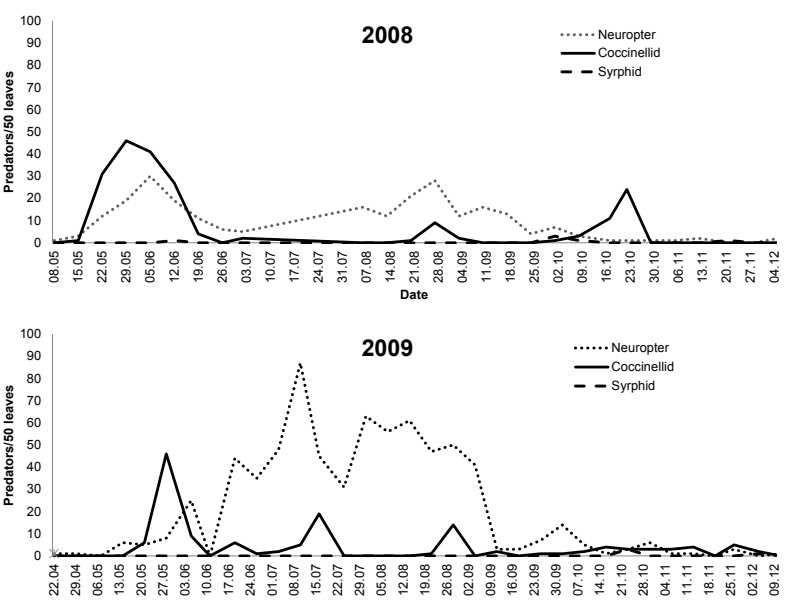

Fig. 2. Seasonal fluctuations of coccinellid, chrysopid and syrphid (egg, larva, pupa, adult) on pecan trees in Aydın in 2008 and 2009 years.

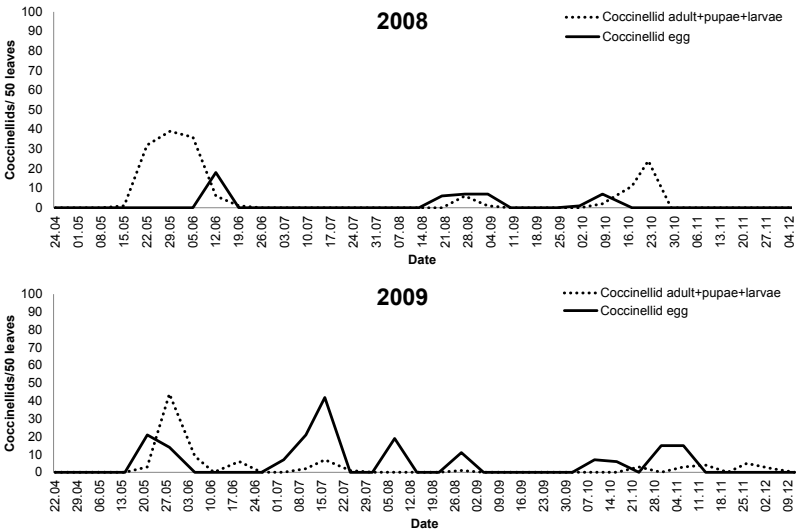

Fig. 3. Seasonal fluctuations of coccinellid (egg, larva, pupa, adult) species obtained on pecan trees in Aydın in 2008 and 2009 years.

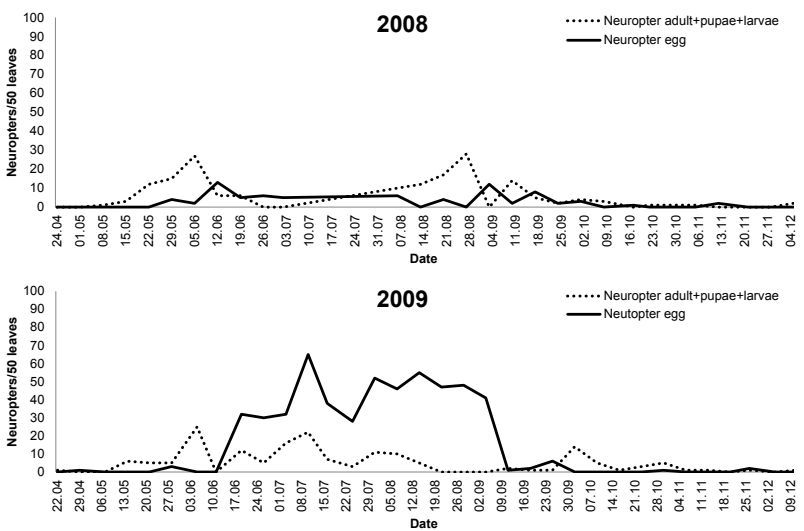

Fig. 4. Seasonal fluctuations of chrysopid (egg, larva, pupa, adult) species obtained on pecan trees in Aydın.

The number of chrysopid adults peaked on June 5 (27 adults/50 leaves) and (28 adults/50 leaves) on August 27, 2008. The highest number of egg was seen on June 12 (13 eggs/50 leaves) and on September 3 (12 eggs/50 leaves) (Fig. 4). In 2009, the number of adults peaked on June 5 (25 adults/50 leaves) and on July 10 (22 adults/50 leaves) and eggs peaked on July 10 (65 eggs/50 leaves) and on August

14 (55 eggs/50 leaves). *Chrysopids* were found in both years throughout the season. The differences in means monthly temperature and rainfall were insignificant found between two years.

Parasitoids of *Monellia caryella* (Fitch.)

During the study, the following parasitoid species were obtained: *Aphelinus* sp. (Hym.; Eulophidae), *Aphidius matricariae* Haliday and *Trioxys pallidus* (Haliday) (Hym.; Braconidae), Hyperparasitoid *Dendrocerus* sp. (Hym.; Megaspilidae), chrysopid egg parasitoid, *Telenomus chrysopae* Ashmead (Hym.; Scelionidae), pupal parasitoid, *Baryscapus impedius* (Nees) (Hym.; Eulophidae).

Parasitization ratio was determined as 0.85% in 2008 and 0.17% in 2009. In the first year, the maximum parasitized nymph was found on May 15 (10 mummies/50 leaves) and parthenogenetic female was seen on May 22 (8 mummies/50 leaves). In the second year, parasitized female was not observed, but the maximum number of parasitized nymphs were determined on July 3 and August 14 (4 mummies/50 leaves) (Fig. 5). Parasitization rate in the first year was higher than in the second year. It was observed that the parasitization rates in both years were very low. Total three hyperparasitoid individuals were obtained from *Dendrocerus* genus.

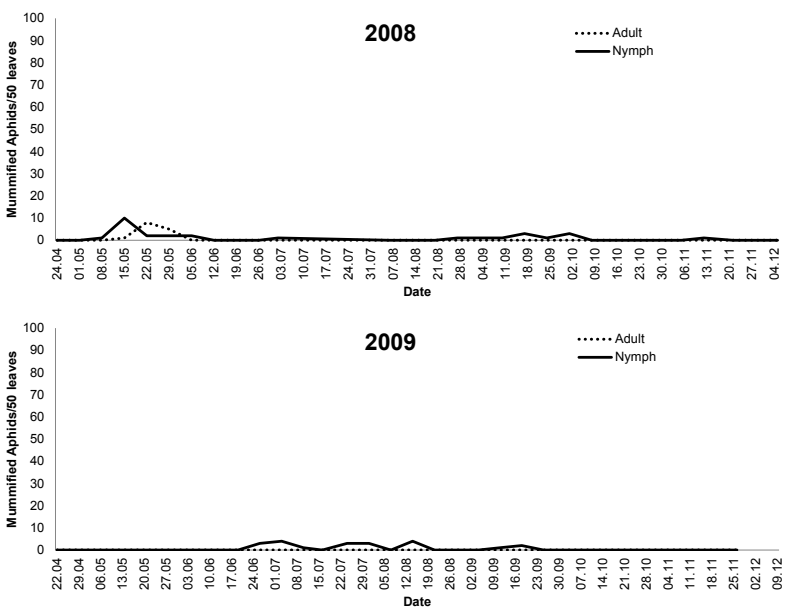

Fig. 5. Parasitization rates in *Monellia caryella* (Fitch.) in Aydın in 2008 and 2009 years.

CONCLUSIONS AND DISCUSSION

Only *M. caryella* was found on pecan trees in Antalya (Özkan and Türkyılmaz, 1990) and the same species was also noted in the present study conducted in

Aydın. However, it is known that more than one aphid species were found as mixed populations in pecan trees in United States and Canada (Tedders, 1978; Petersen and Hunter, 2002; Mizell III, 2007). It was found that 88% of *M. caryella* individuals were settled on the lower surface of the leaves, this finding is consistent with Tedders (1978) and Paulsen *et al.* (2012). Many aphid species generally settle on the lower surface of leaf to be protected from rain, wind, sun ray, dropped honeydew from other leaves and some natural enemies. Also, *M. caryella* prefers feeding on the lower surface of pecan leaves. Tedders (1978) showed that adults and fourth stage nymphs of *M. caryella* preferred large primary veins while the smaller nymphs preferred secondary veins.

As reported from the United States, Canada and Israel (Tedders, 1978; Mansour and Harris, 1988), in Aydın too, the aphid overwintered egg stage in a similar manner; the first nymphs were observed in early May in 2008-2009 years and late April in 2016. The hatching dates in different countries and locations differ due to temperature differences in the spring. Leser (1981) reported the developmental lower threshold to be 8.2°C and optimal threshold to be 23.9°C. In Aydın, the minimum daily temperature degrees increased above of the lower threshold in April, the hatchings started in April or May depending on the climatic conditions. It was recorded that the first nymphs appeared in mid-April in Antalya and between March to mid-April in United States (Tedders, 1978; Leser, 1981; Özkan and Türkyılmaz, 1987, 1990) and from the beginning of April to the beginning of May were changed based on years and temperatures in Israel (Mansour and Harris, 1988).

Findings in the present study indicated having the bimodal (two peaks) population fluctuations of *M. caryella* each year in Aydın. The first peak occurred in the second half of May and second peak in October. The spring peak was higher than fall. The climate of Aydın is dry and hot in summers. Therefore, the aphids appear commonly in spring and autumn. Also, *M. caryella* nymphs and adults appeared from mid-April to late-November in Aydın. It is know that there is an optimum temperature for development and reproduction of aphid species, and above or below this temperature the rate of development and fecundity decreases (Campbell *et al*., 1974). An earlier study by Leser and Huber (1977) was found that *M. caryella* nymph survival reduced by temperatures above or below 23.9°C and nymph mortality increased sharply above 32.2°C and below 8.2°C. Tedders (1978) also obtained similar results. According to Tedders (1978) and Leser (1981), high temperatures were a key factor in reducing the *M. caryella* populations during July and August. Similarly, Leser (1981), Mansour and Harris (1988) and Alverson and English (1990) suggested that the temperature had a significant effect in population development, especially in determining the rate of population change. In Aydın, the highest average daily temperatures in both years did not exceed 30.9°C in June, July and August. But, daily maximum temperature degrees (2008-2009 years), especially in June (40.9-38.4°C), July (41.5-40.1°C) and August (41.8-38.7°C) months were quite high. Therefore, in Aydın, *M. caryella* population was very low between June-August. Later, the population again increased due to decrease of the temperature from September to November. The freezing degrees were seen in December, January, February and March, and aphid was not

found during these months. Besides, Tedders (1978) suggested that pecan leaves after being exposed to heavy feeding (30-100 individuals/compound leaf) by *M. caryella* became a poor substrate for further development of population of this aphid. This is again confirmed by Leser (1981). These authors explained which condition was an important factor for regulating the population dynamics of *M. caryella.* Similar situation was also observed in Aydın.

Likewise in Antalya, population reached to the highest point in May but the second highest point occurred dissimilarly in August (Özkan and Türkyılmaz, 1987, 1990). It was also reported by Liao and Harris (1985) and Honaker (2007) that two peaks took place during May-June and August-September in Texas and spring peaks were higher as Antalya and Aydın. Otherwise, in Florida and Louisiana, these two peaks occurred in May-June and August-October (Mizell III, 2007). In Texas, Tedders (1978) and Bueno and Stone (1983) also recorded the two peaks in Stuart cultivar at the end of June-beginning of July and in 'Schley' cultivar in September-October.

M. caryella reproduced parthenogenetically throughout spring, summer and early autumn. The number of *M. caryella* nymphs and alate parthenogenetic females reached the highest levels in May and October in both years. Alate sexual males and apterous oviparae females began to be seen at the mid-October. The most males and oviparae females were found in early November. Similarly, in Israel and the United States, Tedders (1978) and Mansour and Harris, (1988) demonstrated that alate parthenogenetic females were found from June until the mid-November and apterous oviparae females and alate males were seen from mid-October until the mid-December. It was reported that populations of *M. caryella* was visibly reduced in June and increased from mid-July until mid-August in Texas (Bueno and Stone, 1983). In Israel the highest peak changed according to locality or year, but mostly the rate of increase of *M. caryella* was highest in fall (Mansour and Harris, 1988; Mansour, 1993).

It is seen that *M. caryella* population peaks in different locations occur in only spring, fall or both depending on various environmental factors.

Fifteen predator species of *M. caryella* were identified during working period moreover three parazitoids, one hyperparasitoid and two chrysopid egg parasitoids were obtained. The most abundant natural enemies were the general predators belong to Coccinellidae and Chrysopidae. It was determined that prominent species were *Adalia decempunctata* (L.) and *Chrysopa viridane* (Schneider). The chrysopid population has been higher than coccinellid population in both years. Coccinellid population in two years, particularly at the end of May and beginning of June, reached to the highest level. The coccinellid intensity gradually decreased throughout the summer. It is known that overwintered adult coccinellids firstly reproduce on trees in the spring and, then some of them migrate to seconder host plants. Coccinellids found abundant when abundant aphid was on pecan trees in spring, and then they passed to other plants due to decrease aphids.

Besides, plenty of *C. septempunctata* and a few *A. bipunctata* were obtained on the branches of trees touching the ground in the orchard where study was done.

Despite the presence of weeds under trees during the season, the weeds dried after June because regular watering was not done. Thus, they were unsuitable host for the other aphid species being food of coccinellids at the rest of the season. It was determined by Thompson (1988) that coccinellid population on legume cover crops in pecan orchards in United States was high, but population on trees was not affected from this situation.

Although coccinellid population was occasionally interrupted, chrysopid population continued uninterrupted between May and October. It was noted when one of coccinellid and chrysopid populations increased, the other one reduced. Syrphid population was very low. Similarly, the number of chrysopids in Israel increased towards at the end of the season (Mansour, 1993), dissimilarly at the beginning of the season in Texas (Liao *et al.,* 1985). In Israel, the chrysopids were effective on pest population, but coccinellids were very few (Mansour, 1993). However, it was also mentioned in both studies that mainly chrysopid eggs were seen on leaves but its larvae were not found. Differently, in Aydın, eggs, larvae and adults on leaves were abundant and the count of pupae were low.

The adult chrysopids feed with pollen and the aphid's honeydew. Honeydew as nutrient requires for egg producing of adults (Neuenschwander *et al.*, 1975). Therefore, chrysopid oviposition depends on the number of *M. caryella*. Decreasing temperatures and short day photoperiod in early autumn induce diapause of chrysopid. These conditions were more favorable for the *M. caryella*. Thus, the aphid population increased in late September. These findings agreed closely with Nowell (1983). Although between May-October, the chrysopid egg number was very high, larva number was less. It may have been caused by the larvae migrate to another hosts.

The number of neuropter obtained by shaking method was less than number of coccinellid. This may have been resulted from flying away of neuropter adults during shaking.

According to obtained results, the temperature is the most important factor affected the population fluctuations of aphid. Predators can also have a limiting effect on aphid populations. Similarly, Bueno and Stone (1983) and Liao and Harris (1985) reported that predators were especially effective in the orchards with low intensity of pests. Distinctly, Tedders (1978) stated that the natural enemies were not a limiting factor for *M. caryella* population. In Aydın, the aphid and chrysopid populations in 2009 were higher than 2008. But the coccinellid population was lower.

In Antalya, 25 common predators were identified in a pecan orchard. *Orius minutus* (L.) (Anthocoridae) and *Campyloneura virgula* (Herrich-Schaeffer) (Miridae), *Chrysoperla carnea* (Stephens) (Chrysopidae), *Synharmonia conglobata* (L.)*, Scymnus rupromaculatus* (Goeze) and *S. levaillanti* (Mulsant) were the most commonly predators. It was found to be abundant coccinellids (Özkan and Türkyılmaz, 1987). In studies conducted in Texas, Arizona, Florida, spider species were observed as effective predators of *M. caryella,* however coccinellid and chrysopid species were also very intensive and widespread (Tedders, 1978; Bumroongsook *et al.,* 1992; Mizell III,

2007; Ellington *et al*., 2003; Honaker, 2007). The spider predator of *M. caryella* was not determined in Aydın. It was reported that spiders and neuropters were reduced aphid population in Israel; but the number of coccinellids was very low (Mansour, 1993). *Harmonia axridis* (Pallas) (Col.: Coccinellidae) adult and larva numbers at the end of the season in North Florida were high (Mizell III, 2007).

In Aydın, in coccinellids, the number of larva and adult were higher than the number of eggs during the months of May-June, contrary to this the number of eggs in the next months were higher. This showed that the larvae dispersed to the other hosts. Mizell III (2007) reported that, in contrast to the situation, *H. axridis* adult population was seen on the trees infested with another pecan aphid called *Lagerstroemia indica* L. in Northern Florida throughout the year and the population increased at the mid and the end of the season.

The parasitization rates were very low in both years (0.85% in 2008 and 0.17% in 2009). As compared with Aydın, different parasitoid species were found in Antalya (*Trioxys angelicae* (Hal.) and *Diaeretiella rapae* (Mint.) (Hym.: Aphidiinae)), but parasitization rates were changed between 18-20% in Antalya. *T. angelica* was more effective (Özkan and Türkyılmaz, 1987). *T. pallidus* was also identified in Israel, the highest parasitization rate was found to be 25.6%; and averaged 13.46%. It was stated that this rates in Israel changed according to orchards and months and had an effect on aphid population (Mansour, 1988). Bueno and Stone (1983) reported that parasitization rate of *Aphelinus perpallidus* (Gahan) (Hym.: Aphelinidae) on *M. caryella* was chanced between 3.7-17% in Western Texas. This effective parasitoid was reared and released after importing from United States to Israel, but it was seen that *M. caryella* was not suppressed enough and did not settle in the region (Mansour *et al.,* 1988). In Aydın, the hyperparasitoids were ineffective on *M. caryella*. In Texas and Israel, the hyperparasitoids had very few affect on *A. perpallidus* and *M. caryella* population (Bueno and Stone, 1983; Mansour, 1988).

In conclusion, it was determined that *M. caryella* formed high population in pecan orchard. *M. caryella* population peaked two times during the season and spring peak was higher than fall. The temperature was the most effective factor on aphid population. The most important and effective natural enemies of *M. caryella* were the species from coccinellidae and chrysopidae families, and parasitization rate was very low. Coccinellid population in spring and neuroptera population in summer and early fall was high.

ACKNOWLEDGEMENTS

We thank Dr. Işıl Özdemir (Directorate of Plant Protection Central Research Institute, Ankara), Prof. Dr. Nedim Uygun (Çukurova University, Faculty of Agriculture, Department of Plant Protection, Adana), Petr Starý Dr. Sc. (Institute of Entomology, Academy of Sciences of the Czech Republic, Ceske Budejovice, Czech Republic), Assoc. Prof. Meral Fent (Trakya University, Faculty of Science, Edirne), Prof. Dr. Savaş Canbulat (Kastamonu University, Engineering and Architecture Faculty, Department of

Environmental Engineering, Kastamonu) and Prof. Dr. Alireza Saboori (Department of Plant Protection, College of Agriculture, Tehran University, Karaj) who have determined *M. caryella* and its predators and parasitoids, and anonymous reviewers for helpful comments on earlier drafts of the manuscript.

REFERENCES

Alverson, D. R., English, W. R.,1990, Dynamics of pecan aphids, *Monelliopsis pecanis* and *Monellia caryella*, on field-isolated single leaves of pecan. *Journal of Agricultural Entomology*, 7: 29-38.

Anonymous, 2014, Blackmargined aphid. Oklahoma State University Entomology & Plant Pathology. http://www.209.85.135.104/Monellia caryella (23.03.2014).

Bueno, R., Stone, J. D., 1983, Phenology of a parasite of the blackmargined aphid in west Texas. *The Southwestern Entomologist*, 8(1): 73-79.

Bumroongsook, S., Harris, M. K., Dean, D. A.,1992, Predation on blackmargined aphids (Homoptera: Aphididae) by spiders on pecan. *Biological Control*, 2(1): 15-18.

Campbell, A., Frazer, B. D., Gilbert, N., Gutierrez, A. P., Mackauer, M., 1974, Temperature requirements of: some aphids and their parasites. *Journal of Applied Ecology*, 11: 4-37.

Ellington, J., Carrillo, T., Drake, J., 2003, Pecan integrated biological control. *Southwestern Entomologist,* 27: 45-56.

Honaker, J. M., 2007, Quantification of Blackmargined Aphid of *Monellia caryella* (Fitch) Honeydew Production in Pecan (*Carya illinoinensisi* (Koch)) in Texas. Texas A & M University, Master of Science Thesis, 40 pp.

Leser, J. M.,1981, Effects of temperature and host-insect interaction on the population dynamics of the blackmargined aphid, *Monellia caryella* (Fitch) (Homoptera: Aphididae). The University of Arizona. http://hdl.handle.net/10150/282053 (27.03.2016).

Leser, J. F., Huber. R. T., 1977, Some important interactions concerning yellow aphids, weather and pecan trees. *Proceedings Western Pecan Conference*, El Paso, Texas. 1: 39-46.

Liao, H. T., Harris, M. K.,1985, Population growth of the blackmargined aphid on pecan in the field. *Agriculture*, *Ecosystems and Environment*, 12(3): 253-261.

Liao, H. T., Harris, M. K., Gilstrap, F. E., Mansour, F.,1985, Impact of natural enemies on the blackmargined pecan aphid, *Monellia caryella* (Homoptera: Aphididae). *Environmental Entomology*, 14: 122-126.

Mansour, F., 1988, Parasites of *Monellia caryella* (Hom.: Aphididae) phenology and effect on the aphid population in pecan orchards in Israel. *Entomophaga*, 33(3): 371-375.

Mansour, F., 1993, Natural enemies and seasonal abundance of the blackmargined aphid (*Monellia caryella*) in pecan orchards in Israel. *Phytoparasitica*, 21(4): 329-332.

Mansour, F., Harris, M. K.,1988, Biology and phenology of the blackmargined aphid (*Monellia caryella* Fitch.), a new pest of pecan in Israel. *The Southwestern Entomologist*, 13(1): 19-29.

Mansour, F., Harris, M. K., Stone, J. D.,Bueno, R., 1988, Releases in Israel of *Aphelinus perpallidus*, a recently introduced parasite of the pecan the blackmargined aphid, *Monellia caryella. Phytoparasitica*, 16(2): 171-174.

Mizell III, R. F., 2007, Impact of *Harmonia axyridis* (Coleoptera: Coccinellidae) on native arthropod predators in pecan and crape myrtle. *Florida Entomologist*, 90: 524-536.

Neuenschwander, P., Hagen, K. S., Smith, R. F.,1975, Predation on aphids in California's alfalfa fields. *Hilgardia*, 43: 53-78.

Nowell, C. E.,1983, Seasonal population trends of blackmargined aphid (*Monellia caryella*) and Green lacewing (*Chrysopa carnea*) on Aldicarb treated and untreated pecan trees in Southeastern Arizona. The University of Arizona. http://hdl.handle.net/10150/274915 (16.04.2016).

Özkan, A., Türkyılmaz, N., 1987, Investigations on the determination of population fluctuation of the Walnut aphid (*Chromaphis juglandicola* Kalt.) (Hom.: Callaphididae) which is harmful for pecan trees and its natural enemies in Antalya province. *Proceedings of the First Turkish National Congress of Entomology* (13-16 October 1987, İzmir), 99-107. (in Turkish)

Özkan, A., Türkyılmaz, N., 1990, Investigations on the preferences of Yellow aphid (*Monellia caryella* (Fitch) (Hom.: Aphididae) on pecan varieties in Antalya province. *Journal of Batı Akdeniz Agricultural Research Institute,* 7(4): 147-149. (in Turkish)

Paköz, M., Faraçlar, E., Aybak, H. Ç., 1986, The ecological factors to benoted on pecan growing. *Derim*, 3(1): 16-27. (in Turkish)

Paulsen, C. M., Cotrell, T. M., Ruberson, J. R., 2012, Distribution of the Black pecan aphid, *Melanocallis caryaefoliae,* on the upper and lower surface of pecan foliage. *Entomologia Experimentalis et Applicata*, 146: 252-260.

Petersen, M. K., Hunter, M. S., 2002, Ovipositional preference and larval-early adult performance of two generalist lacewing predators of aphids in pecans. *Biological Control*, 25(2): 101-109.

Richards, W. R., 1960, A new species of *Monellia* Oestlund, with a synopsis of the aphids attacking hickory and walnut in Canada. *The Canadian Entomologist*, 221-226.

Tedders, W. L., 1978, Important biological and morphological characteristics of the foliar-feeding aphids of pecan. *United States Department of Agriculture*, *Technical Bulletin*, 1579: 5-78.

Thompson, J. N., 1988, Evolutionary ecology of the relationship between oviposition preference and performance of offspring in phytophagous insect. *Entomologia Experimentalis et Applicata*, 47: 3-14.

Tuzcu, Ö., Yıldırım, B., 2000, Pecan (*Carya illinoinensis* Koch) and breeding. *The Scientific and Technological Research Council of Turkey*, Ankara, 29. (in Turkish)

Received: September 10, 2015 *Accepted: June 27, 2016*