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Natural Enemies of *Cinara cedri* Mimeur 1936 (Hemiptera: Aphididae) in Cedar Forests in Isparta Regional Forest Directorate

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Abstract

Aim of study: This study was performed between 2015 and 2016 with the aim of identifying natural enemies of cedar aphid (*Cinara cedri* Mimeur, 1936) (Hemiptera: Aphididae) in cedar (*Cedrus libani* A. Rich.) forests.

Area of study: Specimens were collected from 40 areas in Isparta Regional Forest Directorate cedar forests.

Material and methods: At each site, specimens were randomly collected from infested shoots. Shoots were cut and put in plastic bags and containers and were brought to the laboratory, examined with a stereomicroscope. The adults obtained were prepared and sent to specialists for identification.

Main results: Twenty eight species of insect enemies were found, most of them coccinellid and syrphid predators. *Harmonia axyridis* Pallas, 1773, *Anatis ocellata* (Linnaeus, 1758) (Coleoptera: Coccinellidae), *Asaphes vulgaris* Walker, 1834 (Hymenoptera: Pteromalidae) and *Pauesia anatolica* Michelena, Assael & Mendel, 2005 (Hymenoptera: Braconidae) were found for the first time in the study area. Moreover, 17 species were firstly determined as a natural enemy of *Cinara cedri*.

Highlights: In this study, new records were identified for study area. Moreover, 17 species were firstly determined as a natural enemy of *Cinara cedri*.

Keywords*:* Parasitoid, Predator, *Cinara cedri*, Isparta, Turkey.

Cinara cedri Mimeur 1936 (Hemiptera: Aphididae)'nin Isparta Orman Bölge Müdürlüğü Sedir Ormanlarındaki Doğal Düşmanları

Öz

Çalışmanın amacı: Bu çalışma, Güneybatı Anadolu'da 2015-2016 yıllarında 40 sedir (*Cedrus libani* A. Rich.) ormanında sedir yaprak bitinin (*Cinara cedri* Mimeur, 1936) (Hemiptera: Aphididae) doğal düşmanlarını tespit etmek amacıyla gerçekleştirilmiştir.

Çalışma alanı: Örnekler, Isparta Orman Bölge Müdürlüğü sedir ormanlarındaki 40 alandan toplanmıştır.

Materyal ve Yöntem: Örnekler her bir alandaki bulaşık sürgünlerden rastgele toplanmıştır. Sürgünler kesilmiş ve plastik kaplara konulmuş ve laboratuvara getirilerek stereomikroskop ile incelenmiştir. Erginlerin preparasyonu yapılmış ve teşhisleri için uzmanlara gönderilmiştir.

Sonuçlar: Çoğu coccinellid ve syrphid olan 28 adet doğal düşman bulunmuştur. *Harmonia axyridis* Pallas, 1773, *Anatis ocellata* (Linnaeus, 1758) (Coleoptera: Coccinellidae), *Asaphes vulgaris* Walker, 1834 (Hymenoptera: Pteromalidae) ve *Pauesia anatolica* Michelena, Assael & Mendel, 2005 (Hymenoptera: Braconidae) çalışma sahasında ilk kez tespit edilmiştir. Ayrıca 17 tür *Cinara cedri*'nin doğal düşmanı olarak ilk kez bulunmuştur.

Önemli vurgular: Çalışma sahası için yeni kayıtlar tespit edilmiştir. Ayrıca 17 türün *C. cedri*'nin doğal düşmanı olduğu ilk kez belirlenmiştir.

Anahtar kelimeler: Parazitoit, Predatör, *Cinara cedri*, Isparta, Türkiye.

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Introduction

Taurus cedar (*Cedrus libani* A. Rich.) is one of the most important forest tree species in Turkey. Taurus cedar locates naturally in the Taurus Mountains of Southern Turkey, in Western Syria and in the Lebanon Mountains. The timber of this tree has particular values for many for years, due to the exceptional durability, strength aesthetically pleasing appearance. In Turkey, *C. libani* covers a land area of 482,391 ha and is located especially in the south of Turkey (OGM, 2015).

It was identified two aphid species (*Cinara cedri* and *C. laportei*) on *Cedrus libani* in Turkey (Aslan & Uygun, 2005; Aytar, 2006). *C. cedri* differentiates from *C. laportei* in terms of the number of antenna segments (Blackman & Eastop, 2012). *C. cedri* is that the most common cedar aphid in Turkey (Çanakçıoğlu, 1975; Ünal & Özcan, 2005; Aytar, 2006; Ülgentürk et. al., 2013; Akyıldırım, Şenol, Görür & Demirtaş, 2013).

Cinara cedri Mimeur 1936 (Hemiptera: Aphididae) was first identified and described in Morocco on Atlas cedar (*Cedrus atlantica*) (Mimeur, 1935). It causes damage by sucking the sap of cedar shoots and foliage and resulting in desiccation decolourization of needles. Honeydew secreted by the aphids attracts several the other insect species to the trees, and the disease vectored by these species may further damage the trees. The growth of sooty-molds on affected foliage and shoots may reduce tree productivity in terms of both timber and seed yields (Núñez-Perez and Tizado, 1996).

C. cedri was firstly identified on *C. libani* at 1964 in Gaziantep, Turkey (Tuatay & Remaudiere, 1964) and then was found in many regions of Turkey (Çanakçıoğlu, 1975; Düzgüneş, Toros, Kılınçer & Kovancı, 1980; Usta & Keskin, 1992; Tuatay, 1999; Uygun, Toros, Ulusoy, Satar & Özdemir, 2000; Toper Kaygın, Görür & Çota, 2008; Ünal & Özcan, 2005; Aytar, 2006; Akyıldırım et. al., 2013). So far, it was determined to feed on *C. libani*, *C. deodora*, *C. atlantica*, *Cedrus* sp., *Thuja* sp. and *Pinus* sp. (Çanakçıoğlu, 1975; Ünal & Özcan, 2005; Aytar, 2006; Ülgentürk et. al., 2013; Akyıldırım et. al., 2013).

In Turkey, there is one study about natural enemies of *C. cedri* in forest. In the study, the damage to this species was observed in the plantation forests and it was identified parasitoid of *C. cedri* in the southeast of Anatolia (Aytar, 2006). In other studies, it was mainly identified natural enemies of *C. cedri* in non-forest areas such as park and gardens. Therefore, this research was conducted to identify the natural enemies associated with *C. cedri* on cedar trees in the southwest of Anatolia.

Material and Methods

Study area

The work was conducted between 2015 and 2016 in Isparta Regional Forest Directorate, which is located in the Lakes District of southwest Turkey. Lakes District is one of the important regions for Turkey. It was performed 820-1738 m altitudes, in a total of 40 areas, in both natural stands and plantations of *Cedrus libani*. Study areas comprise of pure *C. libani* stands (13), *C. libani-Pinus nigra* subsp. *pallasiana* mixed stands (25), *C. libani-Quercus vulcanica* mixed stand (1) and *C. libani-Abies cilicica* subsp. *isaurica* stand (1). Information on the study site locations and typical stand tree species composition is given in Table 1.

Table 1. Characteristics of the areas where *Cinara cedri* was sampled

No	Location	Coordinates	Altitude (m)	Dominant tree species*
1	Isparta-Center	37°46'43"N-30°32'49"E	1043	a, b
2	Isparta-SDÜ Campus	37°49'49"N-30°32'05"E	1019	a, b
3	Burdur-Bucak-Karapınar	37°21'46"N-30°22'00"E	820	a, b
4	Burdur-Bucak-Seydiköy	37°30'27"N-30°33'07"E	892	a
5	Isparta-Sağ Âşık Tomb	37°21'46"N-30°39'26"E	838	a, b
6	Isparta-Eğirdir-Barla	37°55'04"N-30°44'49"E	1182	a, b
7	Isparta-Eğirdir	37°52'24"N-30°49'36"E	976	a, b

Table 1. (Continued)

No	Location	Coordinates	Altitude (m)	Dominant tree species*
8	Isparta-Eğirdir-Beşkuyu	37°43'44"N-30°48'25"E	1738	a
9	Isparta-Güneyce	37°40'45"N-30°45'22"E	880	a, b
10	Isparta-Çobanisa	37°47'49"N-30°47'04"E	1716	a
11	Isparta-Gökçay Park	37°44'49"N-30°32'45"E	1153	a, b
12	Isparta-Hisartepe	37°43'45"N-30°31'56"E	1485	a, b
13	Isparta-Yenişarbademli	37°42'33"N-31°20'52"E	1415	a
14	Isparta-Aksu	37°43'35"N-31°12'21"E	1213	a, b
15	Isparta-Aksu-Yakaafşar	37°44'36"N-31°10'19"E	1275	a, b
16	Isparta-Aksu-Yaka	37°43'55"N-31°14'08"E	1326	a, b
17	Isparta-Atabey	37°56'45"N-30°37'14"E	1041	a, b
18	Isparta-Gönen	37°57'55"N-30°31'24"E	1086	a, b
19	Isparta-Keçiborlu-1	37°57'29"N-30°18'03"E	1042	a
20	Isparta-Keçiborlu-2	37°54'57"N-30°17'28"E	1067	a
21	Isparta-Keçiborlu-Senir	37°49'17"N-30°17'24"E	1026	a
22	Isparta-Senirkent-Kapıdağ	38°06'00"N-30°46'10"E	1507	a
23	Isparta-Senirce	37°53'03"N-30°30'06"E	1025	a
24	Burdur-Altınyayla-Kumluağıl	36°50'19"N-29°24'19"E	1604	a
25	Burdur-Altınyayla-Tamtır	36°50'48"N-29°24'23"E	1564	a
26	Burdur-Çavdır	37°09'51"N-29°42'51"E	1150	a, b
27	Burdur-Tefenni	37°20'47"N-29°48'27"E	1138	a, b
28	Burdur-Karamanlı	37°22'45"N-29°52'23"E	1121	a, b
29	Isparta-Kızıldağ National Park	38°02'22"N-31°21'52"E	1421	a
30	Isparta-Çarıksaraylar	38°07'43"N-31°25'28"E	1301	a, b
31	Isparta-Yalvaç-City Forest	38°18'58"N-31°10'36"E	1116	a, b
32	Isparta-Yalvaç-Bağkonak	38°12'31"N-31°15'57"E	1136	a, b
33	Burdur-Bucak-Katran Mountain	37°21'54"N-30°05'38"E	1136	a, c
34	Isparta-Büyükgökçeli	37°53'13"N-30°44'04"E	1047	a, b
35	Isparta-Uluborlu	38°03'58"N-30°25'09"E	1150	a
36	Isparta-Ayazmana Park	37°44'48"N-30°34'54"E	1045	a, b
37	Isparta-Eğirdir-Kasnak Oak Nature Protected Area	37°42'46"N-30°50'11"E	1192	a, d
38	Isparta-Gölcük Nature Park	37°43'45"N-30°29'05"E	1400	a, b
39	Isparta-Senirkent	38°06'12"N-30°33'27'E	1001	a, b
40	Isparta-Gelincik	37°45'36"N-30°27'59"E	1255	a, b

*a: *Cedrus libani*, b: *Pinus nigra* subsp. *pallasiana*, c: *Abies cilicica* subsp. *isaurica*, d: *Quercus vulcanica*

Collection of Insects

At each site, specimens were randomly collected on infested shoots of trees. It was sampled about 10 trees when population density of *Cinara cedri* was high, but it was sampled 1-2 trees when its population density was low. It was controlled if there were any other pests on shoots. Photos of infested shoots and damage of *Cinara cedri* were taken (Figure 1). Infested shoots were cut and put in plastic bags and containers. Adult coccinellids were collected by hand picking and the methodology described by Steiner (1962). Shoots and specimens were transferred to the laboratory and examined with a stereomicroscope. They were made preparations of the aphids and they were identified according to Blackman &Eastop (2012) (Figure 2). Specimens in their immature stage were put in different sizes of culture containers covered with a net. Containers were periodically controlled to emerge adults of parasitoids and predators. Observations were conducted on the predators' larvae to record feeding on *C. cedri*. The adults obtained were prepared and sent to specialists for identification. Adult Syrphidae were identified according to sex. After the identification, it was researched

whether they are aphidophagus or not according to the literature.

Figure 1. Damage (a, b, c) and natural enemies species (d, e) on infested shoots of *Cinara cedri*

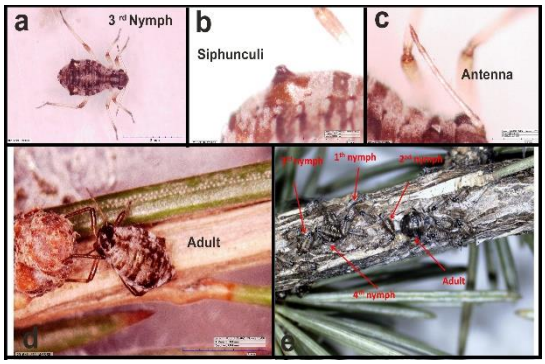

Figure 2. Some morphological characteristics (b, c) and different stages of *Cinara cedri* (a, d, e)

Results

Natural enemies were obtained from 36 of the 40 stands examined. 846 specimens were collected and a total of 28 insect natural enemy species were identified belonging to six families including 18 coccinellids (Coleoptera), 5 syrphids (Diptera), 2 braconids and 1 pteromalid (Hymenoptera), raphidiid and chrysopid (Neuroptera). These enemies included 3 parasitoids were found (Table 2, Figure 3).

Harmonia axyridis Pallas, 1773 (Coleoptera: Coccinellidae) is a new record for study area. The highest numbers of adults were for *Pauesia anatolica* Michelena, Assael & Mendel, 2005 (Hymenoptera: Braconidae), with 248, followed by *Harmonia quadripunctata* (Pontoppidan, 1763) with 185 and *Coccinella septempunctata* Linnaeus, 1758 with 168. In contrast, only single adults of *Adalia decempunctata* (Linnaeus, 1758), *Exochomus undulatus* Weise, 1878, *Scymnus pallipediformis* Günther, 1958 (Coleoptera: Coccinellidae) and *Syrphus ribesii* (Linnaeus, 1758) (Diptera: Syrphidae) were found.

Table 2. Natural enemies of *Cinara cedri* Mimeur 1936 (Hemiptera: Aphididae) in cedar forests of Isparta Forest Regional Directorate

Order: Family	Species	Species code	Specimen number
Coleoptera: Coccinellidae	*Adalia bipunctata* (Linnaeus, 1758)	ADABIP	21
	Adalia decempunctata (Linnaeus, 1758)	ADADEC	1
	Adalia fasciatopunctata revelierei Mulsant	ADAFAS	37
	Anatis ocellata (Linnaeus, 1758)	ANAOCE	3
	Brumus quadripustulatus Linnaeus, 1758	BRUQUA	53
	Chilocorus bipustulatus (Linnaeus, 1758)	CHIBIP	6
	Coccinella septempunctata Linnaeus, 1758	COCSEP	168
	Coccinula quatardecimpustulata (Linnaeus, 1758)	COCQUA	4
	Exochomus undulatus Weise, 1878	EXOUND	1
	Harmonia axyridis Pallas, 1773	HARAXY	5
	Harmonia quadripunctata (Pontoppidan, 1763)	HARQUA	185
	Hippodamia (Hippodamia) variegata Goeze, 1777	HIPVAR	5
	Hippodamia undecimnotata (Schneider, 1792)	HIPUND	2
	Myzia oblongoguttata (Linnaeus, 1758)	MYZOBL	9
	Oenopia conglobata (Linnaeus, 1758)	OENCON	5
	Oenopia lyncea (Olivier, 1808)	OENLYN	2
	Scymnus subvillious (Goeze, 1777)	SCYSUB	23
	Scymnus pallipediformis Günther, 1958	SCYPAL	1
Diptera: Syrphidae	*Sphaerophoria scripta* (Linnaeus, 1758)	SPHSCP	5
	Syrphus ribesii (Linnaeus, 1758)	SYRRIB	1
	Syrphus vitripennis Meigen, 1822	SYRVIT	21
	Eupeodes corollae (Fabricius, 1794)	EUPCOR	2
	Scaeva pyrastri (Linnaeus, 1758)	SCAPYR	18
Neuroptera: Chrysopidae	*Chrysoperla carnea* (Stephens, 1836)	CHRCAR	4

Table 2 *(continued)*

Order: Family	Species	Species code	Specimen number
Neuroptera: Raphidiidae	*Phaeostigma* (*Aegeoraphidia*) *ressli* (Aspöck & Aspöck, 1964)	PHARES	2
Hymenoptera: Braconidae	*Pauesia* (*Pauesia*) *anatolica* Michelena, Assael & Mendel, 2005	PAUANA	248
	Aphidius sp.	APHSP	2
Hymenoptera: Pteromalidae	*Asaphes vulgaris* Walker, 1834	ASAVUL	13
Total specimen number			847

Figure 3. Natural enemies species of *Cinara cedri*

The highest number of species was found in the Coccinellidae (18 species). This work is the first to demonstrate that *A. decempunctata*, *A. fasciopunctata revelierei*, *C. bipustulatus*, *E. undulatus*, *C. quatardecimpustulata*, *H. quadripunctata*, *H. undecimnotata*, *M. oblongoguttata*, *O. lyncea*, *S. pallipediformis* and *S. subvillosus* are also predators of *C. cedri*. Five species in the Syrphidae were also recorded as predators of *C. cedri* for the first time. The discovery of *Syrphus vitripennis* was the first record for study area; moreover, it was the syrphid with the highest number of individuals. From the Chrysopidae, *Chrysopa carnea* was found for the first time as a predator of *C. cedri*. 4 adults of this species were identified. One individual of *P. ressli* (Raphidiidae) was identified in each of 2 plots during sampling, the first record of this insect as a predator of *C. cedri*. The most common natural enemy found was *Pauesia anatolica* (Braconidae). Two individuals of another braconid *Aphidius* sp., were also found. *Asaphes vulgaris* (Pteromalidae) emerged from mummified of *C. cedri* during incubation in the laboratory. *A. vulgaris* and *P. anatolica* were detected the first time in the study area (Figure 3).

Natural enemies were not detected in 4 of the areas examined (Isparta-Çobanisa, Isparta-Keçiborlu-1, Burdur-Altınyayla-Tamtır and Burdur-Bucak-Seydiköy). The highest number of natural enemies, 176 individuals, was found on the Isparta-SDU Campus, Isparta-Center with 155 and Isparta-Atabey with 127. In terms of number of species, 13 were found in both Isparta-Center and on the Isparta-SDU Campus, while 11 species were found in Isparta-Gönen. Although the number of individuals was higher in Isparta-Atabey than in Isparta-Gönen, only four species were found in Isparta-Atabey. It was only found one species for each of 7 study areas (Figure 4). The numbers of species found within study areas varied between 1 and 25. *P. anatolica* was found in 25 sites, *H. quadripunctata* in 20 sites, and *C. septempunctata* in 16 sites. Nine natural enemies determined only in one area (Figure 5).

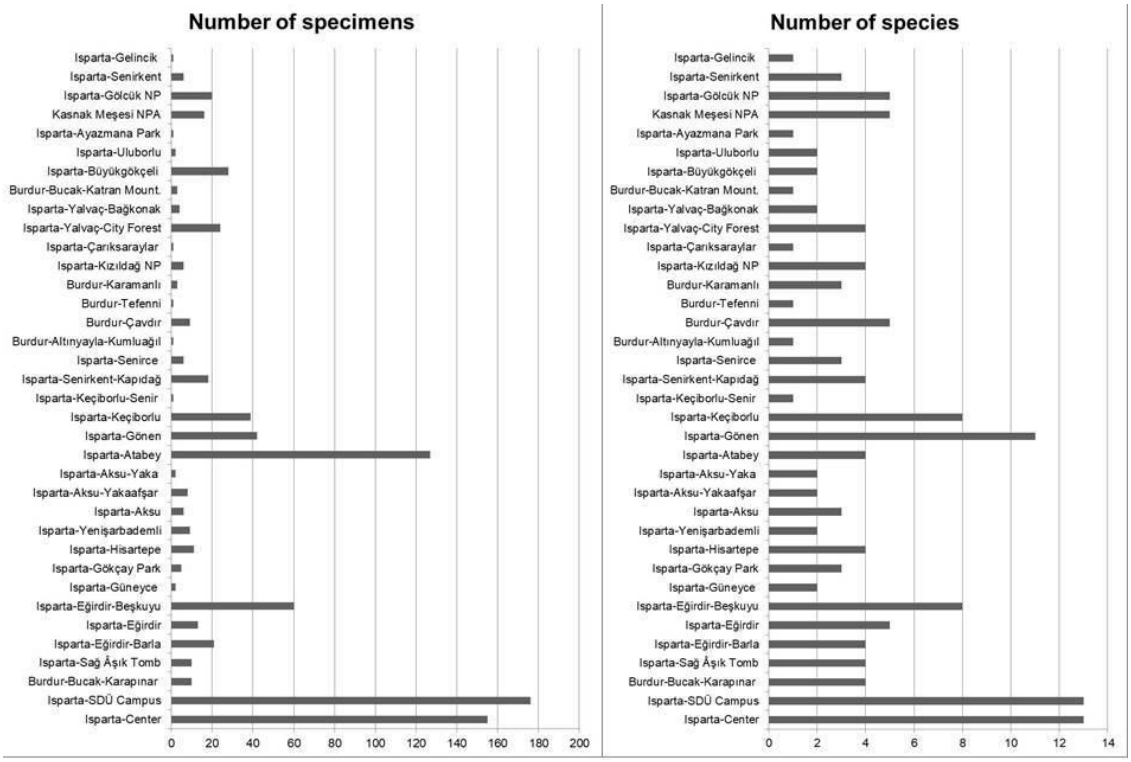

Figure 4. The number of species and specimens of *Cinara cedri* in study areas

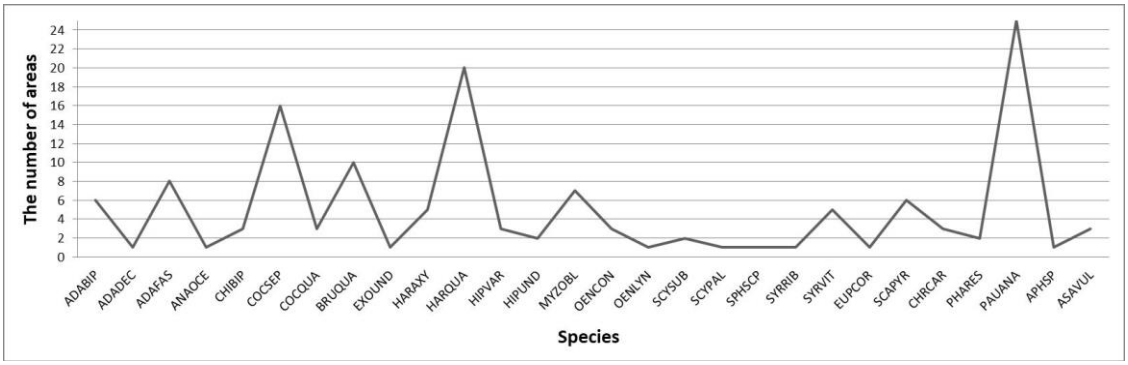

Figure 5. The number of areas where natural enemies of *Cinara cedri* were found

Locations, where the natural enemies were found during this work, along with dates of collection and numbers of individuals recovered are presented below.

Predators

***Adalia bipunctata* (Linnaeus, 1758) (Coleoptera: Coccinellidae)**

Material examined. Isparta-Center, 03.04.2016, (4); 09.04.2016, (2); Isparta-SDÜ Campus, 04.04.2016, (1); 08.04.2016, (5); 19.05.2016, (1); 20.05.2016, (1); 28.05.2016, (1); Isparta-Gökçay Park, 02.06.2016, (1); Isparta-Hisartepe, 02.06.2016, (1); Isparta-Keçiborlu-2, 15.06.2016, (3); Isparta-Eğirdir-Beşkuyu, 10.08.2016, (1) (Total 21 specimens).

***Adalia decempunctata* (Linnaeus, 1758)**

Material examined. Isparta-Center, 03.04.2016, 1 specimen.

***Adalia fasciatopunctata revelierei* Mulsant**

Material examined. Isparta-Center, 02.11.2015, (1); 03.04.2016, (8); 09.04.2016, (1); Isparta-SDÜ Campus, 04.04.2016, (4); 08.04.2016, (5); 19.05.2016, (4); 20.05.2016, (1); 28.05.2016, (3); 09.09.2016, (1); Isparta-Hisartepe, 02.06.2016, (2); Isparta-Keçiborlu-2, 15.06.2016, (2); Isparta-Gönen, 15.06.2016, (1); Isparta-Gölcük Naturel Park, 11.08.2016, (1); Isparta-Ayazmana Park, 21.08.2016, (1); Isparta-Senirkent, 12.10.2016, (2) (Total 37 specimens).

***Anatis ocellata* (Linnaeus, 1758)**

Material examined. Isparta-Gölcük Naturel Park, 15.07.2016, 3 specimens.

***Chilocorus bipustulatus* (Linnaeus, 1758)**

Material examined. Isparta-Center, 09.04.2016, (1); Isparta-Eğirdir, 29.04.2016, (3); 03.09.2016, (1); Isparta-SDÜ Campus, 18.08.2016, (1) (Total 6 specimens).

***Coccinella septempunctata* Linnaeus, 1758**

Material examined. Isparta-Atabey, 15.06.2016, (72); Isparta-Keçiborlu-2, 15.06.2016, (7); Isparta-Gönen, 15.06.2016, (6); Isparta-Senirkent-Kapıdağ, 20.06.2016, (9); Isparta-Senirce, 21.06.2016, (3); Burdur-Karamanlı, 22.06.2016, (1); Burdur-Çavdır, 22.06.2016, (2); Burdur-Altınyayla-Kumluağıl, 22.06.2016, (1); Isparta-Yalvaç-Bağkonak, 11.07.2016, (1); Isparta-Kızıldağ National Park, 11.07.2016, (1); Isparta-Yalvaç City Forest, 11.07.2016, (7); Isparta-Gelincik, 15.07.2016, (1); Isparta-Gölcük Naturel Park, 15.07.2016, (6); 11.08.2016, (3); Burdur-Bucak-Katran Mountain, 27.07.2016, (3); Isparta-Eğirdir-Beşkuyu, 10.08.2016, (34); Isparta-Eğirdir-Kasnak Meşesi Nature Reserve Area, 28.09.2016, (11) (Total 168 specimens).

***Coccinula quatardecimpustulata* (Linnaeus, 1758)**

Material examined. Isparta-Kızıldağ National Park, 11.07.2016, (1); Isparta-Gölcük Naturel Park, 11.08.2016, (2); Isparta-Eğirdir-Kasnak Meşesi Nature Reserve Area, 18.09.2016, (1) (Total 4 specimens).

***Brumus quadripustulatus* Linnaeus, 1758**

Material examined. Burdur-Bucak-Karapınar, 08.11.2015, (1); Isparta-Center, 03.04.2016, (5); 09.04.2016, (1); Isparta-SDÜ Campus, 04.04.2016, (3); 08.04.2016, (5); 19.05.2016, (3); 20.05.2016, (1); 28.05.2016, (2); Isparta-Sağ Âşık Tomb, 07.04.2016, (1); Isparta-Eğirdir-Barla, 21.04.2016, (3); Isparta-Eğirdir, 29.04.2016, (1); Isparta-Eğirdir-Beşkuyu, 31.05.2016, (1); Isparta-Atabey, 15.06.2016, (13); 07.04.2016, (1); 24.05.2016, (5); 07.05.2016, (4); Burdur-Çavdır, 22.06.2016, (2); Burdur-Karamanlı, 22.06.2016, (1) (Total 53 specimens).

***Exochomus undulatus* Weise, 1878**

Material examined. Burdur-Bucak-Karapınar, 08.11.2015, 1 specimen.

***Harmonia axyridis* Pallas, 1773**

Material examined. Isparta-Center, 09.04.2016, (1); Isparta-SDÜ Campus, 19.05.2016, (1); Isparta-Gönen, 15.06.2016, (1); Isparta-Keçiborlu-2, 15.06.2016, (1); Isparta-Uluborlu, 05.08.2016, (1) (Total 5 specimens).

***Harmonia quadripunctata* (Pontoppidan, 1763)**

Material examined. Isparta-Center, 03.04.2016, (26); 28.04.2016, (1); 07.05.2016, (9); Isparta-Eğirdir, 29.04.2016, (1); 01.05.2016, (2); Isparta-Eğirdir-Barla, 24.05.2016, (1); 17.09.2016, (1); Burdur-Bucak-Karapınar, 07.04.2016, (1); 24.05.2016, (6); Isparta-Güneyce, 31.05.2016, (1); Isparta-Sağ Âşık Tomb, 10.05.2016, (1); Isparta-SDÜ Campus, 04.04.2016, (4); 08.04.2016, (2); 12.04.2016, (1); 18.04.2016, (1); 19.05.2016, (12); 20.05.2016, (27); 28.05.2016, (19); Isparta-Eğirdir-Beşkuyu, 31.05.2016, (2); Isparta-Keçiborlu-2, 15.06.2016, (9); Isparta-Yalvaç City Forest, 11.07.2016, (1); Isparta-Atabey, 15.06.2016, (27); Isparta-Aksu, 09.06.2016, (1); Isparta-Senirce, 16.06.2016, (1); 21.06.2016, (1); Isparta-Gönen, 15.06.2016, (11); Isparta-Hisartepe, 02.06.2016, (5); Burdur-Çavdır, 22.06.2016, (1); Isparta-Uluborlu, 05.08.2016, (1); Isparta-Gölcük Naturel Park, 11.08.2016, (5); Isparta-Kızıldağ National Park, 11.07.2016, (1); Isparta-Senirkent, 12.10.2016, (3) (Total 185 specimens).

***Hippodamia (Hippodamia) variegata* Goeze, 1777**

Material examined. Isparta-Gönen, 15.06.2016, (1); Burdur-Karamanlı, 22.06.2016, (1); Isparta-Eğirdir-Beşkuyu, 10.08.2016, (3) (Total 5 specimens).

***Hippodamia undecimnotata* (Schneider, 1792)**

Material examined. Isparta-Gönen, 15.06.2016, (1); Isparta-Keçiborlu-2, 15.06.2016, (1) (Total 2 specimens).

***Myzia oblongoguttata* (Linnaeus, 1758)**

Material examined. Isparta-Hisartepe, 02.06.2016, (3); Isparta-Senir, 16.06.2016, (1); Isparta-Senirkent-Kapıdağ, 20.06.2016, (1); Isparta-SDÜ Campus, 21.06.2016, (1); Isparta-Çarıksaraylar, 11.07.2016, (1); Isparta-Eğirdir-Kasnak Meşesi Nature Reserve Area, 28.09.2016, (1); Isparta-Eğirdir-Beşkuyu, 10.08.2016, (1) (Total 9 specimens).

***Oenopia conglobata* (Linnaeus, 1758)**

Material examined. Isparta-Eğirdir, 02.05.2016, (2); Isparta-Center, 07.05.2016, (2); Isparta-SDÜ Campus, 19.05.2016, (1) (Total 5 specimens).

***Oenopia lyncea* (Olivier, 1808)**

Material examined. Isparta-Eğirdir-Kasnak Meşesi Nature Reserve Area, 28.09.2016, 2 specimens.

***Scymnus subvillious (*Goeze, 1777)**

Material examined. Isparta-Yalvaç City Forest, 11.07.2016, (9); Isparta-Büyükgökçeli, 02.08.2016, (14) (Total 23 specimens).

***Scymnus pallipediformis* Günther, 1958**

Material examined. Isparta-Eğirdir-Beşkuyu, 10.08.2016, 1 specimen.

***Sphaerophoria scripta* (Linnaeus, 1758) (Diptera: Syrphidae)**

Material examined. Isparta-Atabey, 15.06.2016, 3 ♂♂; Isparta-Gönen, 15.06.2016, 2 ♂♂ (Total 5 specimens).

***Syrphus ribesii* (Linnaeus, 1758)**

Material examined. Isparta-SDÜ Campus, 19.05.2016, 1 ♀ specimen.

***Syrphus vitripennis* Meigen, 1822**

Material examined. Isparta-Sağ Âşık Tomb,

10.05.2016, 1 ♂, 1 ♀; Isparta-Eğirdir-Barla, 24.05.2016, 5 ♂♂, 3 ♀♀; Isparta-Aksu-Yakaafşar, 09.06.2016, 3 ♂♂, 2 ♀♀; Isparta-Aksu, 09.06.2016, 2 ♂♂, 2 ♀♀; Isparta-Gönen, 15.06.2016, 2 ♂♂ (Total 21 specimens).

***Eupeodes corollae* (Fabricius, 1794)**

Material examined. Isparta-SDÜ Campus, 18.04.2016, 1 ♀, 1 ♂ (Total 2 specimens).

***Scaeva pyrastri* (Linnaeus, 1758)**

Material examined. Isparta-Center, 03.04.2016, 1 ♂; Isparta-SDÜ Campus, 19.05.2016, 2 ♂♂, 5 ♀♀; 28.05.2016, 1 ♂; 02.06.2016, 1 ♀; 19.05.2016, 2 ♀♀; Isparta-Aksu-Yaka, 09.06.2016, 1 ♂; Isparta-Yenişarbademli, 09.06.2016, 1 ♂, 1 ♀; Isparta-Gönen, 15.06.2016, 2 ♂♂; Isparta-Keçiborlu-2, 15.06.2016, 1 ♂ (Total 18 specimens).

***Chrysoperla carnea* (Stephens, 1836) (Raphidioptera: Chrysopidae)**

Material examined. Isparta-Güneyce, 31.05.2016, (1); Isparta-Gönen, 15.06.2016, (1); Isparta-Center, 03.09.2016, (1); 0.10.2016, (1) (Total 4 specimens).

***Phaeostigma (Aegeoraphidia) ressli* (Aspöck & Aspöck, 1964) (Raphidioptera: Raphidiidae)**

Material examined. Isparta-Senirkent-Kapıdağ, 20.06.2016, (1); Burdur-Çavdır, 22.06.2016, (1) (Total 2 specimens).

Parasitoids

***Pauesia (Pauesia) anatolica* Michelena, Assael & Mendel, 2005 (Hymenoptera: Braconidae)**

Material examined. Isparta-Center, 03.04.2016, (21); 23.04.2016, (9); 29.04.2016, (1); 01.05.2016, (16); 02.05.2016, (16); 07.05.2016, (11); 07.10.2016, (4); Isparta-Sağ Âşık Tomb, 07.04.2016, (6); Isparta-Barla, 21.04.2016, (1); 24.05.2016, (1); 17.09.2016, (6); Isparta-SDÜ Campus, 19.05.2016, (3); 02.06.2016, (17); 28.05.2016, (2); 02.06.2016, (16); 18.08.2016, (12); Isparta-Eğirdir, 02.05.2016, (1); 02.08.2016, (2); Burdur-Bucak-Karapınar, 24.05.2016, (1); Isparta-Eğirdir-Beşkuyu, 31.05.2016, (17); Isparta-Gönen, 15.06.2016, (13); Isparta-Gökçay Park, 02.06.2016, (2); Isparta-Yenişarbademli, 09.06.2016, (7); Isparta-Aksu, 09.06.2016, (1); Isparta-Keçiborlu-2, 15.06.2016, (15); Isparta-Aksu-Yaka, 09.06.2016, (1); Isparta-Hisartepe, 02.06.2016, (2); Isparta-Senirkent-Kapıdağ, 20.06.2016, (7); Burdur-Çavdır, 22.06.2016, (3); Burdur-Tefenni, 22.06.2016, (1); Isparta-Aksu-Yakaafşar, 09.06.2016, (3); Isparta-Senirce, 21.06.2016, (1); Isparta-Yalvaç City Forest, 11.07.2016, (7); Isparta-Kızıldağ National Park, 11.07.2016, (3); Isparta-Yalvaç-Bağkonak, 11.07.2016, (3); Isparta-Büyükgökçeli, 02.08.2016, (14); Isparta-Senirkent, 12.10.2016, (1); Isparta-Eğirdir-Kasnak Meşesi Nature Reserve Area, 05.10.2016, (1) (Total 248 specimens).

***Aphidius* sp.**

Material examined. Isparta-Center, 03.04.2016, 2 specimens.

***Asaphes vulgaris* Walker, 1834 (Hymenoptera: Pteromalidae)**

Material examined. Isparta-Center, 03.04.2016, (6); 23.04.2016, (3); Isparta-Gönen, 15.06.2016, (3); Isparta-SDÜ Campus, 28.05.2016, (1) (Total 13 specimens).

Discussion

In this work, 28 natural enemies of *C. cedri* were found in the Isparta Regional Forest Directorate, including 18 coccinellid (Coleoptera), 5 syrphid (Diptera), 2 braconid, 1 pteromalid (Hymenoptera), 1 raphidiid and 1 chrysopid (Neuroptera). The highest number of species was identified from the Coccinellidae. An invasive alien species, *H. axyridis* was newly recorded in study area, underlying the importance of this work in terms of detection and distribution of this species in Turkey.

Adalia bipunctata was already reported as a predator of *C. cedri* in previous studies (Núñez-Pérez & Tizado, 1996; Karaca et al., 2006; Glavendekić, 2012). In this study, 21 individuals of this species were recorded in 6 areas, although 6 individuals of this species had been reported in 3 areas in Isparta (Karaca et al., 2006). Oğuzoğlu, Avcı, Şenal & Karaca, (2017) reported that *A. ocellata*, a predator of *C. cedri*, as a new record for Turkish fauna. Núñez-Perez & Tizado (1996) reported that *A. ocellata* was a predator of *C. pinea* (Mordvilko, 1894), a species related to *C. cedri*. *Coccinella septempunctata* (Aslan & Uygun, 2005; Glavendekić, 2012; Mouna, 2013; Aslan, 2014), *B. quadripustulatus* (Aslan & Uygun, 2005; Mouna, 2013), *H. variegata* (Mouna, 2013; Aslan, 2014) and *O. conglobata* (Aslan & Uygun, 2005; Aslan, 2014) are also known predators of *C. cedri*. Glavendekić (2012) stated that *H. axyridis* was one of the most common natural enemies of *C. cedri* in Belgrade, Serbia.

Five species of Syrphidae as predators of *C. cedri* were found for the first time. *Syrphus vitripennis* is the first record for Isparta province and had the highest number of individuals among the other Syrphidae species found. *Sphaerophoria scripta* (Linnaeus, 1758) was reported on *Rosa damascena* in Isparta-Center, Gönen, and Keçiborlu by Demirözer & Karaca (2014), in Burdur, Isparta-Merkez, Yalvaç, Senirkent-Kapıdağ and on Isparta-Antalya road by Sarıbıyık & Hasbenli (2006). In this study, the species was found in Atabey and Gönen. Sarıbıyık & Hasbenli (2006) found *S. ribesii* in Isparta, Yalvaç-Senirkent road and Yalvaç. In this study, this species was found on the campus of Isparta-SDU. Aslan (2015) recorded that *Sryphus vitripennis* was a predator of *Dysaphis devecta* (Walker, 1849) (Hemiptera: Aphididae) in Burdur. *Eupeodes corellea* (Fabricius, 1794) was found on *Rosa damascena* in Isparta-Center, Eğirdir and Keçiborlu by Demirözer & Karaca (2014), in Burdur, Isparta-Antalya road and Yalvaç by Sarıbıyık & Hasbenli (2006), and in Burdur by Aslan (2015), whereas in the present work, the species was found on Isparta-SDU Campus. *Scaeva pyrasti* (Linnaeus, 1758) was reported in Senirkent-Kapıdağ, Gelendost, Yalvaç and Isparta-Center by Sarıbıyık & Hasbenli (2006). In contrast, shoots with *C. cedri* collected from Gelendost had no *S. pyrasti* present. Aslan (2014) stated that *Episyrphus balteatus* (De Geer) and *Meliscaeva auricollis* Meigen (Diptera: Sryphidae) were predators of *C. cedri* in Kahramanmaraş, Turkey, but these species were not found in the present work.

Canbulat (2003) reported that *Chrysopa* (=*Chrysoperla*) *carnea* was found on *C. libani* in Isparta-Senirkent, Keçiborlu-Özbahçe, Eğirdir, Isparta-Center, Çarıksaraylar and Isparta-Güneyce. *C. carnea* was found in the same sites (except Keçiborlu-Özbahçe) in the present work. Glavendekić (2012) stated that *Chrysopa* sp. was a common natural enemy of *C. cedri*. As a predator of *C. cedri*, *Hemerobius micans* Olivier, 1792 (Neuroptera: Hemerobiidae) was stated by Tosun (1975) and Usta & Keskin (1992) but was not found in this work. In our study, *Phaeostigma ressli* (Raphidiidae) was observed in two sites and recorded as a predator of *C. cedri* for the first time. Canbulat (2003) reported that this species was observed on *C. libani* and it was distributed in Burdur-Çavdır. Two samples were collected in June in the present work, whereas Canbulat (2003) found this species in April and July.

Pauesia anatolica was identified for the first time in the provinces of Isparta and Burdur, and it was the species with the highest number of individuals found in the study. This species was defined as *Pauesia cedri* in 1991 in Turkey (Mouna & Fabre, 2005). *Pauesia* sp. which is a parasitoid of *C. cedri* was recorded for the first time by Aslan, Uygun & Starý (2004) in 1999-2001 in the natural distribution area of *C. libani*. In 2002, the species obtained from the mummies of *C. cedri* was defined by Michelena, Assael & Mendel (2005) as *P. anatolica* and noted as a parasitoid of *C. cedri*. Aytar (2006) found *C. cedri* on *C. libani* in Adana, Ankara, Karaman, Mersin, Niğde, Osmaniye provinces in 2002-2006. The present study found two individuals of *Aphidius* sp. There are no studies in the literature showing that it is a parasitoid of *C. cedri*. However, it was stated previously that *Aphidius* species is a parasitoid of conifer aphids (*Cinara* spp.) (Watanabe, 1941).

Asaphes vulgaris, a parasitoid of *C. cedri*, was identified in the Isparta and Burdur for the first time in the present work. According to literature, *A. vulgaris* is hyperparasitoid of parasitoids (*Pauesia* sp.) of *Cinara* species (Müller, Völkl & Godfray, 1997).

The research is the first detailed study about natural enemies of *C. cedri* in Turkey forests. There is one only study about natural enemies of *C. cedri* in forest in the southeast of Anatolia and in this study, it was found one species, *Pauesia anatolica* (Aytar, 2006).

Conclusions

Although *C. cedri* was frequently found in this study in the cedar forests of Isparta Regional Forest Directorate, there were no signs of significant damage except to a few areas. The presence of abundant natural enemies in this area could explain the low amount of damage that was present. Natural enemies were determined in 90% of sampling sites and the richness and numbers of natural enemy species in many sites were particularly notable. It is suggested here that protection of mixed forests will increase biological diversity and efficacy of natural enemies in forests. *C. cedri* seems not to need chemical control in mixed forests due to the large amount and variety of natural enemies (Coleoptera, Diptera, Hymenoptera and Neuroptera). If the population of *C. cedri* increases, these natural enemies could be used as a biological control agency. In sites damaged by *C. cedri*, natural enemies can be transferred into the area if predatory populations are inadequate and lack diversity. Further studies related to natural enemy species and the possibilities of their usage within the scope of biological control programs should be investigated. But, chemical control (especially biopesticides) may be applied in heavily infested sites in park and gardens, in order to eliminate visual damage due to intensive honeydew secretion and sooty-mold growth.

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