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 *C. cedri*.

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

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*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.

Materiyal 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: Parazitoid, 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-SDU Campus | 37°49'39"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 Aşık Tomb | 37°21'46"N-30°39'26"E | 838 | a, b |
| 6  | Isparta-Üğürdar-Barla | 37°55'04"N-30°44'49"E | 1182 | a, b |
| 7  | Isparta-Üğürdar | 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-Gököçay 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-Yeniserbademli            | 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-Keciborlu-1                | 37°57′29″N-30°18′03″E | 1042         | a                      |
| 20 | Isparta-Keciborlu-2                | 37°54′57″N-30°17′28″E | 1067         | a                      |
| 21 | Isparta-Keciborlu-Senir            | 37°49′17″N-30°17′24″E | 1026         | a                      |
| 22 | Isparta-SenirKent-Kapdağ          | 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-Altinayla-Kumluagıl         | 36°50′19″N-29°24′19″E | 1604         | a                      |
| 25 | Burdur-Altinayla-Tamır             | 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-Çarıkarsaraylar            | 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-Büyükçöküeli              | 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°30′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.

**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* Michelen, 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.

![Figure 1](image1.png)

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

![Figure 2](image2.png)

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

**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)           | ADEADEC      | 1               |
|                              | *Adalia fasciata* (Linnaeus, 1758)                | ADEAFAS      | 37              |
|                              | *Anatis ocellata* (Linnaeus, 1758)                | ANAOCE       | 3               |
|                              | *Brunus quadripustulatus* (Linnaeus, 1758)        | BRUQUA       | 53              |
|                              | *Chilocorus bipustulatus* (Linnaeus, 1758)        | CHIBIP       | 6               |
|                              | *Coccinella septempunctata* (Linnaeus, 1758)      | COCESEP      | 168             |
|                              | *Coccinula quatuordecimpustulata* (Linnaeus, 1758)| COCQUA       | 4               |
|                              | *Exochomus undulatus* Weise, 1878                 | EXOUND       | 1               |
|                              | *Harmonia axyridis* Pallas, 1773                  | HARAXY       | 5               |
|                              | *Harmonia quadripunctata* (Pontoppidan, 1763)     | HARQUA       | 185             |
|                              | *Hippodamia variegata* Goze, 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 pallipediformis* Günther, 1958           | SCYPAL       | 1               |
| Diptera: Syrphidae           | *Sphaerophoria scripta* (Linnaeus, 1758)          | SPHISCIP     | 5               |
|                              | *Syrphus ribesii* (Linnaeus, 1758)                | SYRRIB       | 1               |
|                              | *Syrphus vitripennis* Meigen, 1822                | SYRVIT       | 21              |
|                              | *Eupodes corollae* (Fabricius, 1794)              | EUPCOR       | 2               |
|                              | *Scaeva pyrastra* (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 |
| 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. quattardecimnotata, H. quadripunctata, H. undecimnotata, M. oblongoguttata, O. lynnea, 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 syrpheid 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. 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-Beşköy, 10.08.2016, (1) (Total 21 specimens).

*Adalia decempunctata* (Linnaeus, 1758)

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

*Adalia fasciatuspunctata 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-Şenirce, 21.06.2016, (3); Burdur-Karamanlı, 22.06.2016, (1); Burdur-Çavdır, 22.06.2016, (2); Burdur-Altunyayla-Kumluğaçı, 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-Beşköy, 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 Aşık 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 Aşık 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-Hasartepe, 02.06.2016, (5); Burdur-Çavdır, 22.06.2016, (1); Isparta-Uluborlu, 05.08.2016, (1); Isparta-Gölçük Nature 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-Çarıkşaraylar, 11.07.2016, (1); Isparta-Eğirdir-Kasnak Meleşi Nature Reserve Area, 28.09.2016, (1); Isparta-Eğirdir-Beşkuyu, 10.08.2016, (1) (Total 9 specimens).

Myzia oblongoguttata (Linnaeus, 1758)
Material examined. Isparta-Keçiborlu-2, 15.06.2016, (1) (Total 2 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 Meleşi Nature Reserve Area, 28.09.2016, 2 specimens.

Scymnus subvillious (Goeze, 1777)
Material examined. Isparta-Yalvaç City Forest, 11.07.2016, (9); Isparta-Büyükçöçü, 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 viripennis 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).

Eupodes 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-Güneyce, 31.05.2016, (1); Isparta-Gönen, 15.06.2016, (1); Isparta-Keçiborlu-2, 15.06.2016, 1 ♂ (Total 18 specimens).

Chrysoperla carnea (Stephens, 1836) (Raphidioptera: Chrysopidae)
Material examined. Isparta-SDÜ Campus, 28.05.2016, (1); Isparta-Keçiborlu-2, 22.06.2016, (1); Isparta-Keçeiborlu-2, 17.09.2016, (6); Isparta-SDÜ Campus, 02.06.2016, (17); Isparta-Gönen, 15.06.2016, (13); Isparta-Göçkçay Park, 02.06.2016, (2); Isparta-Yenişarbademli, 09.06.2016, (7); Isparta-Aksu, 09.06.2016, (1); Isparta-Keçeiborlu-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-Senire, 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- Bıyıkçıkçeli, 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). Öğuzoğlu, 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 Syrphus 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, Eşref Hacı, 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 pyrastri (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 Episyroplus balteatus (De Geer) and Meliscaeva auricollis Meigen (Diptera: Sypriphidae) 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, Çarıkşaraylar 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 nicans 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 Micheneva, 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, Völk & 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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