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Original article (Orijinal araştırma)

Distribution and seasonal abundance of predatory bugs, *Orius* spp. (Hemiptera: Anthocoridae) in Adana Province, Turkey[1]

Adana ilinde avcı *Orius* spp. (Hemiptera: Anthocoridae)'nin dağılımı ve mevsimsel yoğunlukları

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Abstract

Orius species are considered effective biological control agents of thrips both in fields and greenhouses worldwide. The seasonal abundance and distributions of *Orius* and thrips species were determined from different arable crops and weeds in Adana Province in 2015-2016. In this study, a total of six species of genus *Orius* namely, *Orius albidipennis* (Reuter,1884), *Orius horvathi* (Reuter,1884), *Orius laevigatus* (Fieber, 1860), *Orius minutus* (L., 1758), *Orius niger* (Wolff, 1881) and *Orius vicinus* (Ribaut, 1923) (Hemiptera: Anthocoridae) were identified. *Orius niger* was the most common predatory Anthocorid species with 1944 specimens, and followed by *O. laevigatus* with 447 specimens. While, *O. laevigatus* and *O. niger* were found to be active throughout the year, *O. vicinus* was only active in spring and summer, and the other *Orius* spp. were collected in summer. The predatory bugs were mostly found with the pestiferous thrips, *Frankliniella occidentalis* Pergande, 1895 and *Thrips hawaiiensis* (Morgan, 1913) (Thysanoptera: Thripidae) in diverse agricultural areas. Alfalfa, faba bean and sunflower were determined as a crucial host plant for *Orius* spp. Also, sesame could be potential companion (trap or banker) plant to support the predatory bugs in augmentative and conservative biological control strategies. Of the weeds sampled, *Glebionis segetum* Fourr. and *Sinapis arvensis* L. were the most colonized by *Orius* spp. From results it is concluded that *O. niger* and *O. laevigatus* are well adapted to the geographical conditions and plant biodiversity in Adana Province. Therefore, these predatory bugs could be crucial biological control agents of thrips species in field crops.

Keywords: Abundance, biological control, host plants, *Orius* spp., thrips

Öz

Orius türleri dünyada hem açık alanda hem de seralarda thripslerin önemli biyolojik mücadele ajanı olarak bilinmektedirler. *Orius* ve avları olan thrips türlerinin mevsimsel yoğunlukları ve dağılımları Adana İli'nde 2015-2016 yıllarında belirlenmiştir. Bu çalışma ile *Orius* cinsine bağlı altı tür saptanmış olup, bunlar *Orius albidipennis* (Reuter, 1884), *Orius horvathi* (Reuter, 1884), *Orius laevigatus* (Fieber, 1860), *Orius minutus* (L., 1758), *Orius niger* (Wolff, 1881) ve *Orius vicinus* (Ribaut, 1923) (Hemiptera: Anthocoridae) türleridir. *Orius niger* 1944 adet ile en yaygın avcı tür olurken, *O. laevigatus* 447 adet ile onu izlemiştir. *Orius laevigatus* ve *O. niger* yıl boyunca aktif olarak belirlenirken, *O. vicinus* ilkbahar ve yaz periyodunda, diğer türler ise sadece yaz periyodunda belirlenmişlerdir. Avcı böcekler daha çok tarımsal alanlarda önemli zararlı thripsler olan, *Frankliniella occidentalis* Pergande 1895 ve *Thrips hawaiiensis* (Morgan, 1913) (Thysanoptera: Thripidae) ile birlikte örneklenmiştir. Yonca, bakla ve ayçiçeği *Orius* türleri için önemli konukçular olarak bulunmuştur. Bunun yanında, susamın doğal düşmanların korunması açısından potansiyel tuzak ya da banker bitki olabileceği düşünülmektedir. Yabancı otlardan. *Glebionis segetum* Fourr. ve *Sinapis arvensis* L. üzerinde *Orius* türleri daha çok toplanmıştır. Bu sonuçlar ile *O. niger* ve *O. laevigatus*'un Adana ilinin hem coğrafik koşullarına hem de bitki biyoçeşitliliğine iyi uyum sağladığı belirlenmiştir. Bu nedenle, bu avcı türler, açık alanda yetiştirilen kültür bitkilerinde thripslerin biyolojik mücadele ajanı olarak değerlendirilebilir.

Anahtar sözcükler: Bolluk, biyolojik mücadele, konukçu bitki, *Orius* spp., thrips

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Introduction

Chemical control is the most commonly used method for controlling pest organisms that cause economic damage to agricultural products (De Waard et al., 1993; Tyler, 2002). However, intensive and uncontrolled use of pesticides has potentially undesirable effects on ecosystems and human health (Pimentel et al., 1993). Nowadays, the protection of the environment, human health and biological diversity has come into prominence. Consequently, integrated pest management (IPM), including biological control, becomes crucial in controlling of important pest species in agroecosystems. In this context, the importance of predatory bugs belonging to the Anthocoridae family, which feed on many destructive pest Arthropoda species, is increasing in many cultivated areas (Lattin, 1999). Biological control can be described as the utilize of natural enemies to reduce the population density of pest organism than would occur in their absence (Stern et al., 1959; DeBach, 1964).

Conservation biological control is one of the main branches of biological control that can be applied by reducing the use of pesticides or using of selective pesticides with correct application methods and time (DeBach & Rosen, 1991). Thus, using of less toxic methods could preserve natural enemy biodiversity (El-Wakeil et al., 2017). Also, monocultures, reducing the non-crop areas and loss of native habitats, could cause a sharp decline in agroecosystem biodiversity (Wade et al., 2008). The natural enemies may need to utilize alternative plants as pollens-nectars source, oviposition sites or hibernation areas during non-crop periods (Wäckers et al., 2005). Preservation of natural enemies might be achieved by supporting habitat and food resources (i.e., nectar and pollen sources) (Fiedler et al., 2008). Also, winter crops (e.g., alfalfa and faba bean) and weeds usually provide shelter for natural enemies to overwinter. Managing and preventing of these plants or other food sources for natural enemies should be conducted with knowledge of the biology and behavior of the natural enemies and the pests (Bianchi & Wäckers, 2008; Wäckers & van Rijn, 2012). In this way, determination of predatory *Orius* spp. which is considered important biological control agents of many detrimental pest species such as thrips, whiteflies, aphids, and spider mites would be basic study for IPM programs.

In Turkey, *Orius* spp. have been recorded along with various insect pests and mite species in different habitats on cultivated and uncultivated plants (Önder, 1982; Karaat et al., 1986; Göven & Özgür, 1990; Atakan & Uygur, 2004; Büyük, 2008; Bahşi, 2011). Although many studies have been conducted on *Orius* spp., there is no specific information about distribution, seasonal prevalence, habitats, prey (thrips) of *Orius* spp. on the Adana Plain. For this aim, the survey studies have been conducted to determine *Orius* and thrips species from March 2015 to September 2016 in Adana Province.

Materials and Methods

Insect sampling

The abundance and prevalence of *Orius* and thrips species were determined from March 2015 to-September 2016 in Adana Province, Turkey. The survey area was divided into 4 subregions (Region I, Seyhan, Yüreğir, İmamoğlu and Kozan; Region II, Ceyhan, Yumurtalık and Karataş; Region III, Karaisalı and Tarsus; Region IV, Feke, Saimbeyli and Tufanbeyli) as their geographical characteristics and crop biodiversity. The survey areas were visited biweekly, and different cultivated crops (vegetables, orchards and crop fields) and wild plants around these crops sampled (Figure 1). In the sampling areas, there was a wide variety of agricultural practices in which both monoculture and polyculture production were performed as well as irrigated and non-irrigated production systems. Eight to ten randomly chosen plants representing each plant species were tapped into the white trap (34×23×7 cm) for 5-10 s during the flowering period of the crops (Atakan, 2008). *Orius* and thrips species were placed into the plastic tubes (2 ml) containing 70% ethanol using a fine brush. Also, a few of the potential prey of *Orius* spp., such as aphids and leafhoppers, were encountered but these insects were not evaluated in this study. The *Orius*

nymphs collected were reared to obtain adult stages in climatic chambers at 25°C, 60% RH and 16:8 h L:D photoperiod with sterilized *Ephestia kuehniella* Zeller, 1879 (Lepidoptera: Pyralidae) eggs and pollen of *Typha latifolia* L. (Typhaceae) provided as food. The samples collected were transferred to Petri dishes (5 cm diameter) and separated as *Orius* spp. and thrips. Thrips species were placed in AGA (9 parts 70% ethanol+1 part glycerin+1 part glacial acetic acid) solution for 2 d to ensure discoloration (Lewis, 1973) and then transferred to plastic tubes (2 ml) containing 70% ethyl alcohol for storage.

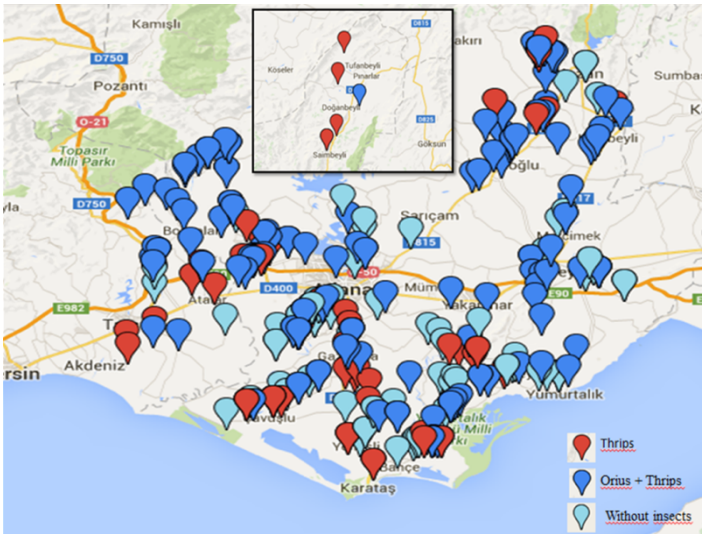

Figure 1. Survey areas of *Orius* and thrips species in Adana Province (Anonymous, 2019).

Insect identification

Microscopic slides of *Orius* spp. were made according to Silveira et al. (2003) and *Orius* adults were identified to species by comparing, the copulatory tube of females and the genital clasper of males according to the key of Péricart (1972). Thrips species were mounted on slides under a stereomicroscope and identified by the second author. These microscope slides were in the collection of the Entomology Laboratory (Department of Plant Protection, Agricultural Faculty, Çukurova University, Adana, Turkey).

Results and Discussion

Distribution of *Orius* species

A total of 2418 specimens of predatory *Orius* were collected. With the survey studies, *Orius albidipennis* (Reuter, 1884), *Orius horvathi* (Reuter, 1884), *Orius laevigatus* (Fieber, 1860), *Orius minutus* (L., 1758), *Orius niger* (Wolff,1881) and *Orius vicinus* (Ribaut, 1923) (Hemiptera: Anthocoridae) were identified. *Orius niger* was the predominant predatory Anthocoridae species (1944 specimens), while it constituted 80.4% of the total *Orius* adults. *Orius laevigatus* was the second most prevalent species with 447 specimens and accounting for 18.5% of the total individuals. Also, small proportions of *O. vicinus* (15 specimens), *O. horvathi* (8 specimens), *O. albidipennis* (3 specimens) and *O. minutus* (1 specimen) were determined (Table 1). *Orius* spp. were mostly collected from Regions I and III where field and horticultural crops are commonly cultivated. *Orius niger* was found mostly from Region I, while *O. laevigatus* was generally determined from the Region III (Table 1). This could be related to the rich crop biodiversity and adaption of both *Orius* spp. to the climatic conditions. Region IV was the highest (average 1000 m) of the areas sampled and only *O. niger* (45 specimens) were determined (Table 1). Region IV has the relatively low plant diversity, cultivating mostly horticultural crops such as stone fruits. *Orius* spp. were collected both in field crops and vegetables in this area. This finding indicates that *O. niger* is better adapted the high-altitude areas.

Table 1. Numbers of *Orius* spp. in Adana Province during 2015 and 2016

Sampling area*	*Orius niger*	*Orius laevigatus*	*Orius vicinus*	*Orius albidipennis*	*Orius horvathi*	*Orius minutus*	Total
Region I	791	107	13	2	3	0	916
Region II	413	62	0	1	5	1	482
Region III	695	278	2	0	0	0	975
Region IV	45	0	0	0	0	0	45
Total	1944	447	15	3	8	1	2418

* Region I: Seyhan, Yüreğir, İmamoğlu and Kozan; Region II: Ceyhan, Yumurtalık, Karataş; Region III: Karaisalı and Tarsus; Region IV: Feke, Saimbeyli and Tufanbeyli.

Orius spp. are considered one of the most effective biological control agents of thrips species both in fields and greenhouses (Lattin, 1999; Funderburk et al., 2000). These results showed that *O. niger* and *O. laevigatus* were the most common Anthocoridae species in Adana Province. These predatory bugs were predominant in vegetables (Zeren & Düzgüneş, 1983; Atakan, 2008), alfalfa (Atakan, 2004), faba bean (Atakan, 2010) and strawberry fields (Atakan, 2011) on the Adana Plain. Moreover, Önder (1982) reported that *O. niger* was widely distributed in all parts of Turkey, while *O. laevigatus* was found generally in the Mediterranean Region of Turkey.

Orius niger and *O. laevigatus* not only identified from cultivated crops but also found on weeds by in these surveys. Atakan & Tunç (2010) informed that *O. laevigatus*, *O. niger* and *Orius majusculus* (Reuter, 1879) (Hemiptera: Anthocoridae) were common Hemipteran predatory species of thrips in weeds in the eastern Mediterranean Region, Turkey. Also, Bahşi (2011) reported that *O. laevigatus* and *O. niger* were predominant species collected in different cultivated and uncultivated plants in the central Mediterranean Region (Antalya). These predatory bugs are widely distributed Anthocorid species in other Mediterranean countries such as Greece (Lykouressis & Perdikis, 1997), Italy (Tommasini, 2004; Bosco & Tavella, 2008) and Spain (Riudavets & Castane, 1994). However, other *Orius* spp., *O. albidipennis*, *O. horvathi*, *O. minutus*, and *O. vicinus* were rarely collected during the survey. These results agree with other studies which conducted in the Mediterranean Basin (Riudavets & Castane, 1994; Lykouressis & Perdikis, 1997; Tommasini, 2004; Bosco & Tavella, 2008; Bahşi, 2011). These results indicate the wide adaptation of *O. niger* and *O. laevigatus* to the ecological conditions and plant biodiversity of the Mediterranean Basin.

Seasonal abundance of *Orius* species

The seasonal abundance of the *Orius* species collected from the survey area are given in Table 2. *Orius niger* and *O. laevigatus* were collected throughout the whole year, while *O. vicinus* was only collected in spring and summer. In contrast, *O. albidipennis, O. horvathi*, and *O. minutus* were only collected in summer.

Table 2. Seasonal abundance of *Orius* species collected from various plants in Adana Province during 2015 and 2016

Seasons	*Orius niger*		*Orius laevigatus*		*Orius vicinus*		*Orius albidipennis*		*Orius horvathi*		*Orius minutus*	
	S.N*	I.N	S.N	I.N	S.N	I.N	S.N	I.N	S.N	I.N	S.N	I.N
Spring	76	335	20	41	2	3	-	-	-	-	-	-
Summer	201	1281	81	381	11	12	2	3	7	8	1	1
Autumn	28	68	2	4	-	-	-	-	-	-	-	-
Winter	40	260	14	21	-	-	-	-	-	-	-	-
Total	345	1944	117	447	13	15	2	3	7	8	1	1

* S.N: Sample number, I.N: Individual number. The dash indicates that no individuals were collected.

Many Anthocorid species are well adapted to different climatic conditions to synchronize their life cycle with favorable environmental conditions over a whole year (Tommasini & van Lenteren, 2003). Therefore, some predatory *Orius* spp. can be active throughout the year (Van de Veire & Degheele, 1992; Bahşi & Tunç, 2008), while the others undergo reproductive diapause (Ruberson et al., 1991, van den Meiracker, 1994; Ito & Nakata, 1998). The results of the present study indicate that *O. laevigatus* and *O. niger* which were the most prevalent predatory bugs, were found year-round. Also, *O. vicinus* was collected in spring and summer. Other *Orius* spp. were collected only in the summer in Adana Province. These results are consistent with the findings of previous studies indicating *O. laevigatus* and *O. niger* are active throughout the whole year on alfalfa in Adana (Atakan, 2004) and on certain weeds in the eastern Mediterranean Region (Atakan & Tunç, 2010). Bahşi (2011) reported that these predatory bugs were found on cultivated and uncultivated crops throughout the year in Antalya Province. Also, *O. horvathi* and *O. minutus* were collected during the summer, whereas *O. vicinus* was collected only in the winter. In Italy, *O. laevigatus* and *O. niger* did not enter overwintering reproductive diapause during the whole year (Tavella et al., 1996; Bosco & Tavella, 2013). During the summer, favorable climatic conditions and plant biodiversity may positively affect the number of *Orius* spp. collected. Some important pollen-rich plants, such as cotton, sesame and sunflower, may be important for *Orius* species, attracting *Orius* prey, such as thrips, and providing alternative food sources (nectar and pollen for *Orius* species) in summer in Adana. Considerable numbers of *Orius* spp. mainly *O. niger* were also collected in the hard winter conditions of Adana. Faba bean which is generally grown during the winter, appeared to be important for providing food, shelter, and ovipositon areas for predatory bugs in this region.

Plant species on which *Orius* were collected

The plant species on which *Orius* spp. were collected and the numbers of the *Orius* are shown in Table 3. The predatory *Orius* spp. was collected from mostly sunflower (*Helianthus annuus* L.; 1251 specimens). Otherwise, most predatory Anthocorids were collected from an important winter host, faba bean (*Vicia faba* L.; 339 specimens), and from evergreen alfalfa (*Medicago sativa* L.; 336 specimens). Besides, *Orius* spp. were collected in relatively high numbers from cotton (*Gossypium hirsutum* L.; 175 specimens), sesame (*Sesamum indicum* L.; 113 specimens) and pepper (*Capsicum annum* L.; 36 specimens). In addition, a few *Orius* spp. were collected from field crops, such as soybean (*Glycine max* L.; 9 specimens), okra (*Abelmoschus esculentus* L.; 8 specimens), peanut (*Arachis hypogaea* L.; 6 specimens), vetch (*Vicia sativa* L.; 4 specimens), maize (*Zea mays* L.; 4 specimens), cowpea (*Vigna sinensis* L.; 1 specimen) and on some vegetables like cucumber (*Cucumis sativus* L.; 5 specimens), potato (*Solanum tuberosum* L.; 3 specimens), bean (*Phaseolus vulgaris* L.; 2 specimens) and eggplant (*Solanum melongena* L., 1 specimen). However, in the fruit orchards, there was only two predatory bugs were collected, both from apple (*Malus domestica* Borkh). *Glebionis segetum* Fourr. (40 specimens) and *Sinapis arvensis* L. (25 specimens) supported relatively high numbers of *Orius* spp. Also, some *Orius* spp. were also found on *Anthemis arvensis* L. (19 specimens), *Ochtodium aegyptiacum* DC. (15 specimens) and *Daucus carota* L. (11 specimens).

Table 3. Abundance and composition of *Orius* spp. on different plants in Adana Province, Turkey during 2015 and 2016

Family / Species Name	*Orius niger*		*Orius laevigatus*		*Orius vicinus*		*Orius albidipennis*		*Orius horvathi*		*Orius minutus*	
	S.N*	I.N	S.N	I.N	S.N	I.N	S.N	I.N	S.N	I.N	S.N	I.N
Asteraceae												
***Anthemis arvensis* L.**	4	19	-	-	-	-	-	-	-	-	-	-
****Glebionis segetum* Fourr.**	11	39	1	1	-	-	-	-	-	-	-	-
Helianthus annuus L.	110	914	64	335	2	2	-	-	-	-	-	-
Apiaceae												
****Dacus carota* L.**	7	11	-	-	-	-	-	-	-	-	-	-
Brassicaceae												
****Ochtodium aegyptiacum***	5	14	1	1	-	-	-	-	-	-	-	-
****Sinapis arvensis* L.**	11	22	2	3	-	-	-	-	-	-	-	-
Cucurbitaceae												
Cucumis sativus L.	1	5	-	-	-	-	-	-	-	-	-	-
Cucurbita pepo L.	1	1	-	-	1	1	-	-	-	-	-	-
Fabaceae												
Arachis hypogaea L.	4	4	1	2	-	-	-	-	-	-	-	-
Glycine max L.	7	9	-	-	-	-	-	-	-	-	-	-
Medicago sativa L.	28	278	14	56	2	2	-	-	-	-	-	-
Phaseolus vulgaris L.	2	2	-	-	-	-	-	-	-	-	-	-
Vicia faba L.	63	319	13	20	-	-	-	-	-	-	-	-
Vicia sativa L.	1	4	-	-	-	-	-	-	-	-	-	-
Vigna sinensis L.	1	1	-	-	-	-	-	-	-	-	-	-
Malvaceae												
Abelmoschus esculentus L.	1	7	1	1	-	-	-	-	-	-	-	-
Gossypium hirsitum L.	36	159	10	14	3	3	-	-	-	-	-	-
Pedaliaceae												
Sesamum indicum L.	35	85	6	10	5	7	2	3	7	8	1	1
Poaceae												
Malus domestica Borkh	1	1	1	1	-	-	-	-	-	-	-	-
Zea mays L.	4	6	4	4	-	-	-	-	-	-	-	-
Solanaceae												
Capsicum annuum L.	11	35	1	1	-	-	-	-	-	-	-	-
Solanum melongena L.	1	1	-	-	-	-	-	-	-	-	-	-
Solanum tuberosum L.	1	3	-	-	-	-	-	-	-	-	-	-
Total	345	1944	117	447	13	15	2	3	7	8	1	1

* S.N: Sample number, I.N: Individual number.
** These plant species are weeds. The dash indicates that no individuals were collected.

Plant diversity can affect the distribution of the predatory bugs directly and indirectly (Russell, 1989; Moreira et al., 2016). The present results show that sunflower was the most attractive plant to *Orius* spp. The sunflower is known as an excellent plant to attract beneficial insects including important predators or parasitoids of agricultural insect pests (e.g., minute pirate bugs, ladybird beetles, lacewings, and several parasitoids) (Jones & Gillett, 2005). In this study, faba bean and alfalfa were the important plants bearing relatively high numbers of the predatory bugs, and also providing food source (nectars, pollens), shelter, mating and oviposition sites especially during the winter period. These results agree with findings of previous studies on faba bean and alfalfa in Mediterranean Region (Atakan & Tunç, 2004; Atakan, 2010; Atakan & Malik, 2018; Bahşi, 2011). Also, faba bean have been utilized as a cover crop in vineyard areas to protect the beneficial insects during winter times in the Northern Italy (Burgio et al., 2016). In the USA, when faba bean was grown with the other plants (alyssum, buckwheat, phacelia, and chamomile), it was the more preferred as an oviposition site for *Orius insidiosus* (Say, 1832) (Hemiptera: Anthocoridae) females (Pumariño et al., 2012). Atakan & Tunç (2004) reported that *O. niger* and *O. laevigatus* were the most common on alfalfa in Adana. Ban et al. (2010) suggested that alfalfa plants could help to create a natural balance between predators and pests inside a crop and in the surrounding area of greenhouses from June to mid-August in northern Hungary. On the Adana Plain, sesame, cotton, pepper, strawberry and rapeseed were also alternative host for *Orius* spp. (Atakan, 2010, 2011, 2017; Atakan et al., 2009; Atakan & Bayram, 2011). In the current study, all *Orius* spp. were collected from sesame plants. Sesame plants may be considered to be more attractive to *Orius* spp. in the agroecosystems. Biondi et al. (2016) suggested that sesame could be used for *Nesidiocoris tenuis* (Reuter, 1895) (Hemiptera: Miridae) in augmentative and conservative biological control strategies in tomato crops as a companion (trap or banker) plants. Also, many other studies reported that nectars of sesame greatly improved longevity, fecundity and handling time of parasitoids (Lou et al., 2014; Lu et al., 2015) and predatory mirids (Zhu et al., 2013). In the light of these studies, this plant may have a potential for enhancing the beneficial insect diversity in agroecosystems.

On the weedy flora, *O. niger was* the most prevalent species followed by *O. laevigatus*. *Orius albidipennis*, *O. horvathi*, *O. minutus* and *O. vicinus* were seldom recorded from the uncultivated plants during the survey. This may be related to adaptation of *Orius* spp. to different ecological conditions and differences in habits of predatory bug species. Some researchers indicated that *O. niger* and *O. laevigatus* were commonly found anthocorids in weeds in the Mediterranean Region of Turkey (Atakan & Uygur, 2004; Atakan & Tunç, 2010; Bahşi, 2011). Also, in Italy, this was the most common species found. Also, *O. majusculus*, *O. minutus* and *O. laevigatus* were collected from some weeds (Tommasini, 2004; Bosco & Tavella, 2008). Therefore, some weed species may be important as alternative plants providing food sources, oviposition substrates, hibernation sites, shelter, and refugia for *Orius* spp.

Orius species collected together with thrips species

In the present survey a total of 6725 pest thrips were collected. *Frankliniella occidentalis* Pergande, 1895 (Thysanoptera: Thripidae) was the most prevalent species followed by *Thrips hawaiiensis* (Morgan, 1913) (Thysanoptera: Thripidae). Predatory thrips species *Aeolothrips* spp., and phytophagous thrips species such as *Haplothrips* spp., *Melanthrips* spp. and *Thrips tabaci* Lindeman, 1889 (Thysanoptera: Thripidae) were also collected. Most thrips were collected from Region I where most field and horticultural crops are grown (Table 4). This could be related to rich plant biodiversity and well adaptation of the thrips species to the ecological conditions of this region. Fewer thrips were collected in Region IV which had the highest altitude and mostly only horticultural crops are grown (Table 4).

Table 4. Numbers of commonly collected thrips species in survey areas of Adana Province, Turkey during 2015 and 2016

Sampling area*	*Frankliniella occidentalis*	*Thrips hawaiiensis*	*Thrips tabaci*	*Haplothrips* spp.	*Melanthrips* spp.	*Aeolothrips* spp.	Other thrips species	Total
Region I	2170	557	112	230	138	231	25	3463
Region II	891	77	33	85	88	65	5	1244
Region III	1129	194	68	67	193	182	38	1871
Region IV	12	6	30	37	41	21	0	147
Total	4202	834	243	419	460	499	68	6725

* Region I: Seyhan, Yüreğir, İmamoğlu and Kozan; Region II: Ceyhan, Yumurtalık, Karataş; Region III: Karaisalı and Tarsus; Region IV: Feke, Saimbeyli and Tufanbeyli.

Orius spp. collected with thrips during the survey are shown Table 5. Although the *Orius* spp. are considered as the generalist predators, it is well known that they mostly fed upon thrips (Riudavets & Castane, 1998; Baez et al., 2004). *Orius niger*, which was the most common during the survey, was mostly collected with *F. occidentalis* (1598 specimens) but also with thrips, such as *T. hawaiiensis* and *Aeolothrips collaris* (Priesner, 1919) (Thysanoptera: Aeolothripidae) (594 and 570 specimens, respectively). The second most common species, *O. laevigatus*, was collected with *F. occidentalis* (414 specimens), *T. hawaiiensis* (171 specimens) and *A. collaris* (167 specimens). The other predatory bugs, *O. vicinus*, *O. horvathi* and *O. albidipennis,* were mostly collected with *F. occidentalis*. *Frankliniella occidentalis* and *T. hawaiiensis* were the most common pest thrips species and were collected with all predatory bugs (Table 5).

Occurrence of *Orius* spp. with thrips species may be important in management of pest thrips species in field crops and weeds (Bosco & Tavella, 2013). In this study, *F. occidentalis* and *T. hawaiiensis* were the common pest thrips species found with predatory bugs. In many studies, *F. occidentalis* was found to be widespread across the USA (Kirk & Terry, 2003; Morse & Hoddle, 2006), Europe (zur Strassen, 1986; Tommasini, 2003), and Turkey (Tunc & Gocmen, 1995; Atakan, 2003; Tunç & Hastenpflug-Vesmanis, 2016). However, *T. hawaiiensis* was the first reported in 2015 and spread over the eastern Mediterranean Region of Turkey within one year (Atakan et al., 2015). Atakan & Özgür (2001) reported that *O. niger* was one of the prevalent predatory bugs in cotton fields on the Adana Plain, and it appeared before the population increase of *F. occidentalis* during flowering and then the thrips population declined sharply after the peak in the *O. niger* population. Also, Funderburk et al. (2000) reported that *O. insidious* was an effective predator of *Frankliniella* spp. during the spring when thrips were rapidly colonizing pepper flowers in the field.

Bahşi (2011) found that populations of *O. niger* and *O. laevigatus* were related to *F. occidentalis,* but were collected with the other thrips species, such as *A. collaris*, *Aeolothrips intermedius* Bagnall, 1934 (Thysanoptera: Aeolothripidae), *Thrips major* Uzel, 1895 (Thysanoptera: Thripidae) and *T. tabaci*. Collecting *Orius* spp. with the predatory thrips such as *A. collaris* on the same plants could be explained by the competition of predators for the same food source (phytophagous thrips). In this situation, predatory bugs may have negative effects on the densities of *Aeolothrips* spp. due to intraguild predation. Fathi et al. (2008) reported that at low density of *T. tabaci*, the intraguild predation of *O. niger* on *A. intermedius* occurred when these predators were used in combination against this pest thrips.

Table 5. *Orius* spp. collected together with thrips in survey areas of Adana province, Turkey during 2015 and 2016

Thysanoptera species	*Orius niger*		*Orius laevigatus*		*Orius vicinus*		*Orius albidipennis*		*Orius horvathi*		*Orius minutus*	
	S.N*	I.N	S.N	I.N	S.N	I.N	S.N	I.N	S.N	I.N	S.N	I.N
Aeolothripidae												
Aeolothrips collaris Priesner	90	572	38	167	2	2	1	1	1	1	-	-
Aeolothrips ericae Bagnall	3	28	1	9	-	-	-	-	-	-	-	-
Aeolothrips fasciatus (L.)	2	3	-	-	-	-	-	-	-	-	-	-
Aeolothrips intermedius Bagnall	4	8	2	2	-	-	-	-	-	-	-	-
Aeolothrips propinquus Bagnall	1	1	1	1	-	-	-	-	-	-	-	-
Melanthrips fuscus (Sulzer)	47	229	10	14	1	1	-	-	1	1	-	-
Melanthrips pallidior Priesner	-	-	-	-	-	-	1	1	-	-	-	-
Phlaeothripidae												
Haplothrips aculeatus (Fabricius)	13	45	4	11	-	-	1	1	-	-	-	-
Haplothris distinguendus (Uzel)	8	66	3	8	-	-	-	-	-	-	-	-
Haplothrips gowdeyi (Franklin)	11	64	3	8	1	2	-	-	-	-	-	-
Haplothrips reuteri (Karny)	63	402	28	146	1	1	-	-	-	-	-	-
Thripidae												
Anaphothrips sudanensis Trybom	1	20	1	9	-	-	-	-	-	-	-	-
Chirothrips africanus Priesner	1	1	-	-	-	-	-	-	1	1	-	-
Frankliniella occidentalis (Pergande)	295	1598	103	414	13	15	2	3	6	8	1	1
Limothrips ceralium Haliday	3	4	1	1	-	-	-	-	-	-	-	-
Rhipidothrips gratiosus Uzel	4	24	-	-	-	-	-	-	-	-	-	-
Tenothrips frici (Uzel)	1	5	1	8	-	-	-	-	-	-	-	-
Thrips hawaiiensis (Morgan)	111	594	41	171	5	7	2	3	1	2	1	1
Thrips meridionalis (Preisner)	8	48	3	8	-	-	-	-	-	-	-	-
Thrips pillichi Priesner	1	13	0	0	-	-	-	-	-	-	-	-
Thrips tabaci Lindeman	51	347	21	99	-	-	-	-	-	-	-	-
Thrips trehernei Priesner	1	34	1	1	1	1	-	-	-	-	-	-

* S.N: Sample number, I.N: Individual number. The dash indicates that no individuals were collected.

In conclusion, *O. niger* and *O. laevigatus* were the predominant species in different cultivated and weedy plants in Adana Province. These predatory Anthocorids were collected mostly with the pest thrips, *F. occidentalis* and *T. hawaiiensis* in diverse agricultural habitats. Although *O. niger* is one of the most common species in the survey area, it is known that rearing of *O. niger* under laboratory conditions is not efficient (Bahşi & Tunç, 2008). However, *O. laevigatus* has been commercially used to control *F. occidentalis* in European greenhouses (van Lenteren, 2012) as well as in Turkey. Alfalfa, faba bean and sunflower were determined as important host plants supporting both *Orius* and thrips species. Also, sesame

may be an important companion plant to promote predatory bugs for augmentative and conservative biological control strategies in agroecosystems. The protection of natural populations of predatory bugs is crucial to create a balance between pest and beneficial insects in agricultural areas. Presence of *Orius* spp. in agroecosystems may be a key factor for maintenance of the suitable IPM programs.

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