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*Original article (Orijinal araştırma)*

# Response of some beneficial insect species to colored sticky traps in citrus

Turunçgilde faydalı böceklerin yapışkan renkli tuzaklara tepkileri

**Ekrem ATAKAN[1*] Serkan PEHLİVAN[1] Serdar SATAR[1]**

## Summary

Colored sticky traps have been commonly used for the sampling of detrimental insect species worldwide. However, there is no information about the catches of non-target insects such as predaceous and pollinating insects by colored traps. In this study, trials with colored sticky traps (white, yellow, blue and green) in mandarin cv Okitsu (Satsuma) trees were carried out during 2011 and 2012 in Adana Province, Turkey. Colored plates were hung, at about 1.7 m above ground level, from the exterior canopy of the selected trees and were positioned to the four cardinal directions. A total of 15 beneficial insect species were captured on various colored plates. Yellow and green traps were more attractive to the coccinellid, *Oenopia conglobata* (L., 1758), than the other colored traps. Significantly more of the predaceous hoverfly, *Episyrphus balteatus* (De Geer, 1776) and the honey bee, *Apis mellifera* L., 1758 were obtained on white traps. Green and blue traps were the least attractive to *A. mellifera*. The yellow, blue and green traps hung on the west side of the trees captured significantly more beneficial insects, but white traps hung on the south sides of outer branches trapped considerable numbers of *E. balteatus* and *O. conglobata*. White and yellow sticky traps may provide more ecological data for beneficial insects.

**Keywords:** *Apis mellifera*, citrus, *Episyrphus balteatus*, *Oenopia conglobata,* sticky traps

## Özet

Renkli yapışkan tuzaklar dünyada zararlı böcekleri örneklemek için yaygın bir şekilde kullanılmaktadır. Bununla birlikte renkli tuzakların avcı ve polinatör böcek gibi hedef dışı böcekleri yakalamasıyla ilgili bilgiler bulunmamaktadır. Renkli yapışkan tuzak (beyaz, sarı, mavi ve yeşil) denemeleri 2011-2012 yıllarında Adana ilinde Okitsu (Satsuma) mandalinada yürütülmüştür. Renkli plakalar seçilen ağaçların dış dallarına yerden 1.7 m yüksekliğe ve dört ana yöne doğru asılmıştır. Tuzaklarda toplam 15 faydalı böcek türü yakalanmıştır. Sarı ve yeşil tuzaklar coccinellid *Oenopia conglobata* (L., 1758)'ya diğer tuzaklardan daha çekici olmuşlardır. Beyaz tuzaklar avcı çiçek sineği *Episyrphus balteatus* (De Geer, 1776) ve balarısı *Apis mellifera* L., 1758' nı önemli ölçüde yakalamıştır. Mavi ve yeşil tuzaklar *A. mellifera* için en az derecede çekici olmuştur. Sarı, mavi ve yeşil tuzaklar ağaçların batı tarafına asıldığında daha fazla sayıda faydalı böcek yakalamıştır, fakat beyaz tuzaklar güneydeki dış dallara asıldığında dikkate değer sayıda *E. balteatus* ve *O. conglobata* yakalamışlardır. Beyaz ve sarı yapışkan tuzaklar faydalı böcekler için daha fazla ekolojik veri sağlayabilirler.

**Anahtar sözcükler:** *Apis mellifera*, turunçgil, *Episyrphus balteatus*, *Oenopia conglobata,* yapışkan tuzaklar

[1] Çukurova University, Faculty of Agriculture, Plant Protection Department, Adana, Turkey
* Corresponding author (Sorumlu yazar) e-mail: eatakan@mail.cu.edu.tr
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## Introduction

Citrus are one of the fruit crops grown in the temperate Mediterranean, Aegean and Black Sea Regions of Turkey. In 2015, 987,000 t of citrus fruit were produced in Adana Province, in the eastern Mediterranean Region of Turkey (TUİK, 2015).

In Turkey, various problems are encountered in citrus cultivation, including management of pest insects and acarines colonizing citrus trees. Citrus growers commonly use chemical pesticides against pest species. Controlling pests by using pesticides is often considered a unique the only option for pest management of citrus orchards. However, the use of pesticides has negative impacts on the natural balance by eliminating natural enemies of harmful insects and non-targeted organisms, and causing secondary pest outbreaks, pollution of the environment, and development of resistance to pesticides. Integrated pest management (IPM) strategies including trapping to properly estimate pest insect densities may help reduce the adverse effects of pesticide use.

Sticky traps have commonly been used to sample harmful and beneficial insects in wild and cultivated plants worldwide. Colored sticky traps are a simple and low-cost method for determining the abundance of pest insects and their natural enemies in orchards (Wallis & Shaw, 2008). Yellow sticky traps, as a sampling tool, were used to monitor the abundance of pest insects, such as thrips and leafhoppers, visiting citrus trees in Adana Province, Turkey (Başpınar & Uygun, 1994). Yellow sticky traps combined with lures have also been recommended for capturing the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann, 1824) (Diptera: Tephritidae), in citrus orchards in this region. Colored traps have been applied more commonly in integrated pest management programs of various crops because of the response of insects to colors (Gerling & Horowitz, 1984; Chandler, 1985; Meyerdirk & Oldfield, 1985; Elekçioğlu, 2013). The efficacy of sticky traps may depend on when the traps are installed relative to crop phenology (Ladd et al., 1984; Meyerdirk & Moreno, 1984; Chandler, 1985; Bryne et al., 1986).

Surveys of harmful and beneficial insect species and their population dynamics and prey-predator relationships in IPM programs of citrus in Turkey have been well documented (Uygun & Şekeroğlu, 1984). In Turkey, biological control is the principal component of integrated control of citrus pests, and it has been successfully applied in field practices (Soylu & Ürel, 1977; Kansu & Uygun, 1980). Studies associated with citrus in the region show that the citrus orchards in the Mediterranean Region of Turkey have a rich fauna of beneficial insects (Uygun & Şekeroğlu, 1984; Yiğit & Canhilal, 2005). In these studies, various methods, such as visual observation of trees, tapping of shoots or branches, removing plant parts, such as flowers and leaves, and use of baited and pheromone traps, have been commonly used to detect citrus pests.

Despite the use of colored traps for capturing detrimental insect species, capturing of non-target insects, such as predators and pollinating insects, have been ignored. Data of color attractiveness to predators or pollinators may be helpful in selecting trap color and placement in fruit orchards in the region. In this study, we determined the efficacy of 4 colors of traps for trapping three common beneficial insect species on citrus mandarin cv Okitsu (Satsuma) between blooming and the first formation of young fruits. We also investigated efficacy of cardinal directions for each trap color and interaction between trap color and cardinal directions. Marmalade hoverfly, *Episyrphus balteatus* (De Geer, 1776) (Diptera: Syrphidae), is one of the most common and distinctive hoverflies in the UK and throughout the Palearctic ecozone , which includes Europe, North Asia, and North Africa. Marmalade hoverfly larvae normally feed on aphids (Schneider, 1969). *Oenopia* (*Synharmonia) conglobata* (L.,1758) (Coleoptera: Coccinellidae) is an inhabitant of fruit orchards and well-known as a common and effective predator of aphids and coccids in Turkey (Uygun, 1981). The honey bee*, Apis mellifera* (L., 1758) (Hymenoptera: Apidae), is the most important beneficial hymenopteran species because it pollinates many crops and wild plants, and is well known as honey makers worldwide (Robinson et al., 1989). Determined data may be useful for evaluation in IPM program in citrus orchards of Turkey or other countries sharing similar ecological areas.

## Materials and Methods

### Experimental design

The study was conducted in the Research and Practice Area of the Plant Protection Department, Faculty of Agriculture, Çukurova University, Adana Province, Turkey, in 2011 and 2012. Trials were established during the blossoming period of mandarin when pollinators were more active. The experimental mandarin cv. Okitsu (Satsuma) area covered almost 0.04 ha with trees of nearly 6 years old planted at 5 × 5 m. There were a total of 10 rows and each row had 14 trees. Two middle rows were selected for the experiment. Colored sticky traps (15 × 20 × 0.3 cm) with four colors were hung on the two middle trees 10 m apart in each row. Sixteen traps (four each of white, yellow, blue and green plexiglas plates) coated with the commercial adhesive, Stickem Special (Kapar Organik Tarım, Ankara, Turkey) were installed on the exterior of the canopy of otherwise untreated trees at about 1.7 m above ground. One trap of each color was positioned at each the four cardinal directions in each tree. Therefore each combination of color and cardinal direction was replicated four times.

### Sampling of insects on traps

Sampling was conducted during the blooming stage of trees from 6 March to 19 April 2011 (14 consecutive sampling dates) and from 2 March to 30 April 2012 (15 sampling dates). Traps were replaced with new ones every 3-4 days at about 09:50 h. The traps were taken to the laboratory for processing. Insects on the traps were removed with kerosene, washed with ethanol (96%) and kept until the specimens cleared.

Harmful and beneficial insects were also examined from one inflorescence or young shoot from each cardinal directions and phenological status of trees recorded during the sampling period. During the two years of the study, no plant protection products were applied to control harmful organisms.

### Insect identification

Genitalia preparations of predatory bugs of the genus *Orius* were made, and the specimens were identified by a key (Péricart, 1972). The predatory big-eyed bug, *Piocoris luridus* Fieb., was identified by using the key to predatory Hemiptera (Lygaeidae; Geocorinae) by Çakır & Önder (1990). Hoverflies (syrphids) were identified by Prof. Dr. A. Faruk Özgür (Adana Province, Turkey), and coccinellid predators were identified by Prof. Dr. Nedim Uygun (Adana Province, Turkey). Predatory thrips were identified by the first author. All identified specimens were lodged in the collection of the Industrial Plant Pests Laboratory, Plant Protection Department, University of Çukurova, Adana, Turkey.

### Data analysis

ANOVA was performed at a significance level of $P < 0.05$ by using the SPSS statistical package (SPSS, 2006). A general linear model (GLM-ANOVA) procedure was used to measure the effects of color, cardinal direction, and interactions between color and cardinal direction. Data were pooled over sampling dates because of low numbers of insects in each taxon on the traps for some sampling dates. Comparison of means was done by Tukey's Honestly Significant Difference (HSD) test.

We did not evaluate the numbers of winged aphids captured on the traps, because too few of them were caught on the colored traps in either year.

## Results

### Catch of beneficial insect species on colored traps

Fifteen beneficial insect species were identified in both years (Table 1). In general, white and yellow traps were more attractive to beneficial insects. Traps of these two colors caught both higher numbers of common insect species and numbers of insect species. A small numbers tiny wasps on the yellow sticky traps but these were not identified.

*Oenopia conglobata*, *E. balteatus,* and *A. mellifera* were regularly captured on the traps of all colors in both years. Most of the other coccinellids were trapped by yellow traps and to a lesser extent by green traps. Other identified generalist predators, such as *Chrysoperla carnea* (Stephens), were infrequently captured on the traps. Overall, white traps captured 48.4 and 41.7% of a total adult population in 2011 and 2012, respectively. Yellow traps were second, accounting for 21.3 and 27.5% in 2011 and 2012, respectively.

**Monthly abundance of beneficial insects on traps**

No individual adults of *A. mellifera* and *E. balteatus* were captured on any colored trap in April 2011 (Table 2). Only *O. conglobata* was captured on traps in April 2011. Densities of *A. mellifera* and *E. balteatus* on white traps were higher than on the other traps in May 2011. Numbers *of O. conglobata* on white traps were less than the numbers of the other two beneficial insects in May. Mean densities of *O. conglobata* were consistently greater on yellow and green traps in 2011. Few *A. mellifera* and *E. balteatus* were captured on yellow or blue traps in April 2012. Mean numbers of *A. mellifera* and *E. balteatus* in May 2012 were greater, with means of 2.43 ± 0.61 and 2.06 ± 0.64 individuals per trap, compared to data of the previous year. High numbers of *O. conglobata*, with a mean of 2.12 ± 0.77 individuals per trap, were captured on green traps in 2012.

**Response of three beneficial insects to trap color**

Seasonal mean numbers of the three beneficial insect species captured on the different colored traps are given in Figure 1. Trap color was a significant factor in catches of these three predators in both years (Table 3). Significantly greater numbers of *A. mellifera* with a mean of 4.25 ± 0.52 insects per trap in 2011 ($F = 13.606$, df = 3, 60; $P < 0.0001$) and of 1.37 ± 0.19 in 2012 ($F = 37.391$, df = 3, 124; $P < 0.0001$) were caught on white traps compared to yellow, green and blue traps in both years (Figure 1a, b). Mean densities of *E. balteatus* on white and blue traps were similar but significantly greater than for other colored traps in 2011 and 2012 (in 2011: $F = 4.186$, df = 3, 60; $P = 0.009$; in 2012: $F = 6.446$, df = 3, 124; $P < 0.0001$; Figure 1a, b). Yellow was the least attractive to *E. balteatus* adults in both years. Mean numbers of *O. conglobata* captured by blue and white traps were significantly fewer than those captured by yellow and green traps in 2011 and 2012 (in 2011: $F = 4.793$, df = 3, 60; $P = 0.005$; in 2012: $F = 5.929$, df = 3, 124; $P = 0.001$, respectively; Figure 1a, b).

**Effect of cardinal direction on catches of three beneficial insects**

Cardinal direction and cardinal direction by color were important components for catch of the three beneficial insect species in both years (Table 3). The effects of cardinal direction on the catches of seasonal mean numbers of the three beneficial insect species are given in Figure 2.

The effect of cardinal direction on the catches of *A. mellifera* was significantly different on yellow traps facing east ($F = 81.000$, df = 3, 12; $P < 0.0001$) in 2011 (Figure 2a). White traps facing east or south had significantly greater numbers of *A. mellifera* in 2011 ($F = 7.40$, df = 3, 12; $P = 0.005$). Yellow and blue traps for each direction caught generally similar numbers of this insect. Similar results were also obtained in 2012. Cardinal direction did not have a significant effect on *A. mellifera* numbers by trap color, except for white traps, in 2012. White traps facing south had a significant mean number of *A. mellifera*, with 2.12 ± 0.35 adults per trap ($F = 4.808$, df =3, 28; $P = 0.008$) in 2012. Yellow, blue and green traps facing west caught significantly more *E. balteatus* individuals ($F = 9.566$, df = 3, 12; $P = 0.002$; $F = 16.342$, df = 3, 12; $P < 0.0001$; $F = 8.120$, df = 3, 12; $P = 0.005$, respectively; Figure 2b) in 2011.

Table 1. Beneficial insects captured on various colored sticky traps suspended in mandarin trees during 2011 - 2012 in Adana Province, Turkey

| | 2011 | | | | | 2012 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Order / Family<br>Species | W | Y | B | G | Total | W | Y | B | G | Total |
| Coleoptera / Coccinellidae | | | | | | | | | | |
| *Chilocorus bipustulatus* (L., 1758) | 6 | 6 | 2 | 0 | 14 | 0 | 5 | 0 | 1 | 6 |
| *Oenopia (Synharmonia) conglobata* (L., 1758) | 9 | 19 | 3 | 20 | 51 | 15 | 24 | 5 | 35 | 79 |
| *Scymnus subvillosus* (Goeze, 1777) | 0 | 0 | 0 | 0 | 0 | 11 | 28 | 0 | 12 | 51 |
| *Stethorus gilvifrons* (Mulsant, 1850) | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Diptera / Syrphidae | | | | | | | | | | |
| *Episyrphus balteatus* (De Geer, 1776) | 69 | 33 | 51 | 15 | 168 | 33 | 15 | 32 | 5 | 85 |
| *Eristalis* (*Eristalomia*) *tenax* (L., 1758) | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Metasyrphus corollae* (Fabricius, 1794 | 4 | 1 | 2 | 0 | 7 | 0 | 1 | 0 | 1 | 2 |
| *Spaerophoria scripta* (L, 1758) | 8 | 1 | 0 | 0 | 9 | 4 | 0 | 0 | 0 | 4 |
| *Volucella* sp. | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| Hemiptera / Lygaeidae | | | | | | | | | | |
| *Piocoris luridus* (Fieber, 1844) | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Hemiptera / Miridae | | | | | | | | | | |
| *Orius niger* Wolff, 1811 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 |
| Hymenoptera / Apidae | | | | | | | | | | |
| *Apis mellifera* L., 1758 | 68 | 9 | 3 | 3 | 83 | 45 | 5 | 1 | 2 | 53 |
| Neuroptera /Chrysopidae | | | | | | | | | | |
| *Chrysoperla carnea* (Stephens, 1836) | 1 | 1 | 5 | 1 | 8 | 4 | 9 | 3 | 8 | 24 |
| Thysanoptera /Aeolothripidae | | | | | | | | | | |
| *Aeolothrips* spp. *(Aeolothrips collaris* Priesner, 1919 + *Aeolothrips intermedius* Bagnall, 1934) | 0 | 0 | 0 | 0 | 0 | 32 | 7 | 0 | 1 | 40 |
| Total | 168 | 74 | 66 | 39 | 347 | 144 | 95 | 41 | 65 | 345 |
| % | 48.4 | 21.3 | 19.0 | 11.2 | 100 | 41.7 | 27.5 | 11.8 | 18.8 | 100 |

W: White, Y: Yellow, B: Blue, G: Green

Table 2. Monthly numbers of three beneficial insect species captured on the colored sticky traps suspended in mandarin trees during 2011 - 2012 in Adana Province, Turkey

| | | | April | | May | |
|---|---|---|---|---|---|---|
| Year | Insect species | Trap color | Total no | Per sample | Total no | Per sample |
| 2011 | *Apis mellifera* | White | 0 | 0.00 ± 0.00 | 68 | 4.25 ± 0.78 |
| | | Yellow | 0 | 0.00 ± 0.00 | 9 | 0.56 ± 0.40 |
| | | Blue | 0 | 0.00 ± 0.00 | 3 | 0.18 ± 0.13 |
| | | Green | 0 | 0.00 ± 0.00 | 3 | 0.18 ± 0.13 |
| | *Episyrphus balteatus* | White | 0 | 0.00 ± 0.00 | 69 | 4.31 ± 0.97 |
| | | Yellow | 0 | 0.00 ± 0.00 | 33 | 2.06 ± 0.62 |
| | | Blue | 0 | 0.00 ± 0.00 | 51 | 3.18 ± 0.74 |
| | | Green | 0 | 0.00 ± 0.00 | 15 | 0.93 ± 0.35 |
| | *Oenopia conglobata* | White | 0 | 0.00 ± 0.00 | 9 | 0.56 ± 0.24 |
| | | Yellow | 0 | 0.00 ± 0.00 | 17 | 1.06 ± 0.24 |
| | | Blue | 0 | 0.00 ± 0.00 | 3 | 0.18 ± 0.10 |
| | | Green | 3 | 0.18 ± 0.18 | 17 | 1.06 ± 0.33 |
| 2012 | *Apis mellifera* | White | 6 | 0.37 ± 0.22 | 39 | 2.43 ± 0.61 |
| | | Yellow | 1 | 0.06 ± 0.06 | 4 | 0.25 ± 0.19 |
| | | Blue | 0 | 0.00 ± 0.00 | 1 | 0.06 ± 0.06 |
| | | Green | 0 | 0.00 ± 0.00 | 2 | 0.12 ± 0.08 |
| | *Episyrphus balteatus* | White | 0 | 0.00 ± 0.00 | 33 | 2.06 ± 0.64 |
| | | Yellow | 0 | 0.00 ± 0.00 | 15 | 0.93 ± 0.29 |
| | | Blue | 0 | 0.12 ± 0.85 | 30 | 1.87 ± 0.63 |
| | | Green | 0 | 0.00 ± 0.00 | 5 | 0.31 ± 0.15 |
| | *Oenopia conglobata* | White | 13 | 0.81 ± 0.27 | 2 | 0.12 ± 0.12 |
| | | Yellow | 16 | 1.00 ± 0.38 | 10 | 0.62 ± 0.27 |
| | | Blue | 4 | 0.25 ± 0.11 | 1 | 0.06 ± 0.06 |
| | | Green | 34 | 2.12 ± 0.77 | 1 | 0.06 ± 0.06 |

Table 3. Effects of color, cardinal direction and their interaction on catches of insects on colored traps in mandarin trees during 2011 - 2012 in Adana Province, Turkey

| | 2011 | | | | 2012 | | | |
|---|---|---|---|---|---|---|---|---|
| Sources | df | MS | F | P | df | MS | F | P |
| *Apis mellifera* | | | | | | | | |
| Color | 3 | 62.516 | 94.512 | 0.000 | 3 | 13.437 | 49.752 | 0.000 |
| Direction | 3 | 5.266 | 7.961 | 0.000 | 3 | 0.771 | 2.854 | 0.040 |
| Color x direction | 9 | 4.918 | 7.436 | 0.000 | 9 | 1.333 | 4.937 | 0.000 |
| Error | 48 | | | | 112 | | | |
| *Episyrphus balteatus* | | | | | | | | |
| Color | 3 | 33.750 | 6.750 | 0.001 | 3 | 5.799 | 7.982 | 0.000 |
| Direction | 3 | 25.588 | 5.157 | 0.004 | 3 | 2.716 | 3.758 | 0.013 |
| Color x direction | 9 | 18.556 | 3.771 | 0.001 | 9 | 1.737 | 2.391 | 0.016 |
| Error | 48 | | | | 112 | | | |
| *Oenopia conglobata* | | | | | | | | |
| Color | 3 | 2.896 | *6.178* | 0.001 | 3 | 5.112 | 7.400 | 0.000 |
| Direction | 3 | 0.437 | *0.933* | 0.432 | 3 | 1.008 | 1.459 | 0.230 |
| Color x direction | 9 | 1.382 | *2.948* | 0.007 | 9 | 2.945 | 4.263 | 0.000 |
| Error | 48 | | | | 112 | | | |

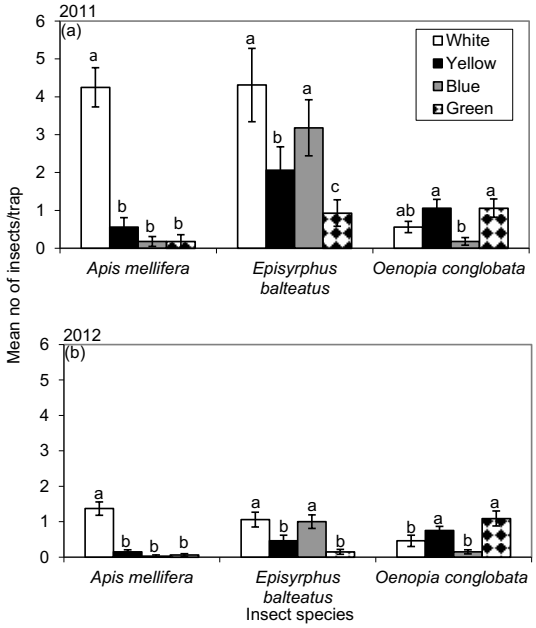


Figure 1. Seasonal mean numbers (± SEM) of three beneficial insect species captured on variously colored sticky traps suspended in mandarin trees during (a) 2011 and (b) 2012 in Adana Province, Turkey. Same letters on the bars are not statistically different according to Tukey's HSD test ($P < 0.05$).

White traps facing south trapped significant numbers of *E. balteatus* adults in 2011 (F = 12.250, df = 3, 12; P = 0.001). White traps facing east and south trapped significantly more *E. balteatus* adults (F = 4.591, df = 3, 28; P = 0.010) in 2012. White traps facing south and green facing north had significant numbers of *O. conglobate* (F = 4.636, df = 3, 12; P = 0.022; F = 5.560, df = 3, 12; P = 0.013; respectively; Figure 2c) in 2011. White traps facing south and green facing north had significant numbers of *O. conglobata* (F = 4.636, df = 3, 12; P = 0.022; F = 5.560, df = 3, 12; P = 0.013; respectively; Figure 2c) in 2011. The effect of cardinal direction on the capture of this predatory insect was not significantly different for other colors in 2012. Green traps facing the west side of trees captured more numbers of *O. conglobata* adults, with a mean of 2.25 ± 0.36 in 2012 (F = 7.279, df = 3, 28; P = 0.001; Figure 2c). The effect of cardinal direction on the capture of this predatory insect was not significantly different for other colors in 2012.

## Discussion

In spring, mostly predatory coccinellids and syrphids were detected on the colored traps. Other insects identified were captured sporadically on the traps and their numbers were few during the trials in both years. We investigated efficacy of the colored traps in catching of beneficial insects during a limited period (in two spring months), we can postulate that beneficial species numbers captured on the different colored traps would also be high if a study was conducted for the whole season in this region. Rich beneficial insect fauna in citrus ecosystem in the Mediterranean region of Turkey have been reported by the researchers (Uygun et al., 2001; Uygun & Satar, 2007).

Adults of *E. balteatus* were not caught on the colored traps placed in trees during the blossoming period. Syrphid adults caught on the traps when the young outer fresh shoots and leaves were infested by the aphids, suggesting that syrphid females lay eggs on leaves infested with the aphid colonies (*Aphis gossypii* Glov. and *Aphis spiraecola* Patch). Larval syrphids are often recognized as beneficial, preying on aphids, lepidopterous larvae and insects in the Aleyrodidae, Psyllidae, and Coccidae families (Clausen, 1972; Resendiz-Ruiz, 1993). We also noted that predacious syrphid larvae were feeding on aphids. *Oenopia conglobata* was the first predatory insect captured on the traps. Relatively high abundance of this predaceous insect is likely to relate to the dense colonization of the aphid species on the trees from late April to early May in both years. *Oenopia conglobata* is one of the most common aphid feeders in citrus orchards in the region. However, few larval coccinellids were preying on aphids on the plant during the trapping period in this study.

Population densities of the hoverflies and the honey bees captured on the traps were lower in 2012 (Table 3). The reason for no or few syrphids and honey bees on traps during the blooming period may have been that dense numbers of thrips belonging to *Thrips tabaci* Lindeman, 1889 and *Thrips major* Uzel, 1895 (Thysanoptera: Thripidae) were on the surfaces of the traps; thus, the thrips might have prevented catches of these large beneficial insect adults in April.

Blue and green traps captured fewer honey bees, but white traps were the most attractive to them. Rodriguez-Saona et al. (2012) similarly reported that honey bees were trapped mostly by the white traps, and were less attracted to or repelled by green, yellow and red sticky traps hung in cranberry marshes. In the current study, the greater numbers of honey bees caught by the white traps may related to flower color of the citrus (white), which is more attractive to the honey bees and the other insects visiting blooms (Lunau & Maier, 1995). We found fewer honey bees on the green and blue traps. Knight & Miliczky (2003) reported similar results: green and red colored sticky traps captured the lowest numbers, and white was the most attractive to honey bees. Perhaps, the bees recognize that the white flowers are crucial sources of pollen and nectar.

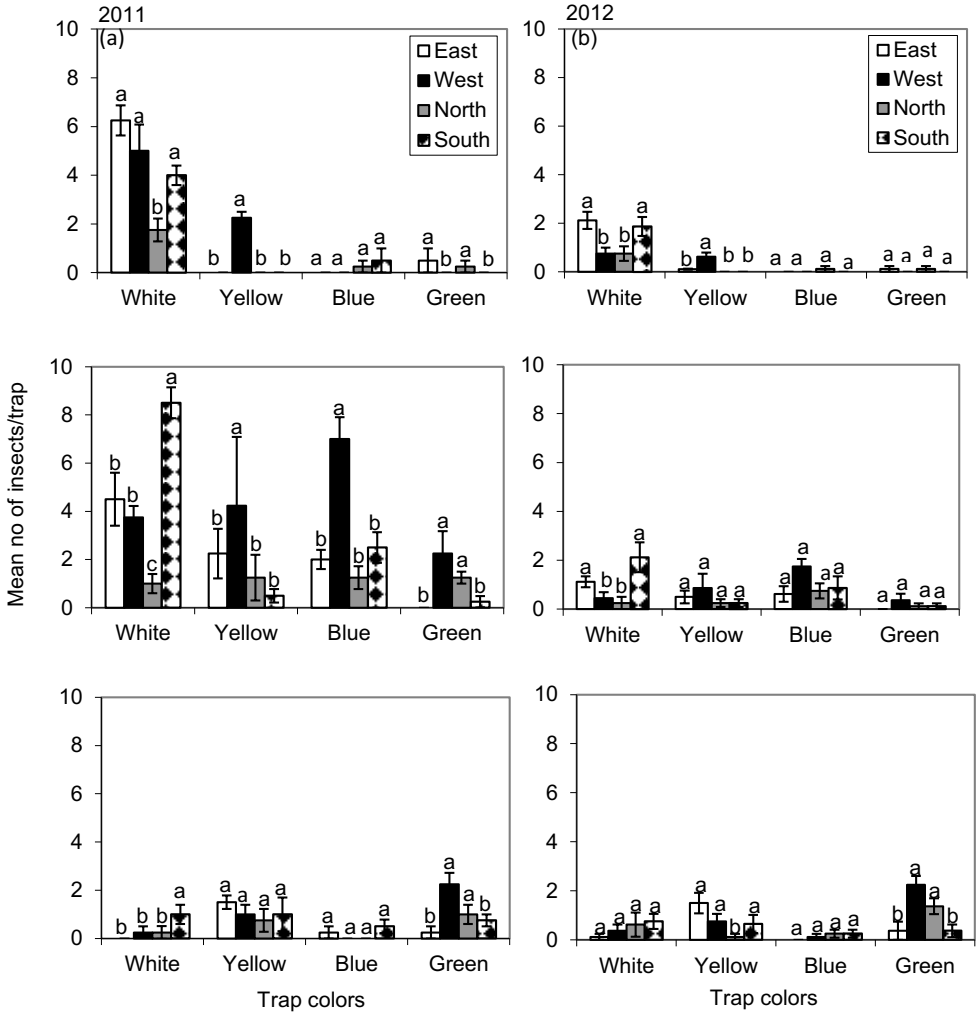


Figure 2. Effects of cardinal directions on catches of mean numbers (± SEM) of 3 beneficial insect species (a) *Apis mellifera*, (b) *Episyrphus balteatus*; (c) *Oenopia conglobata* by colored sticky traps suspended in citrus trees during 2011-2012. Same letters on the bars are not statistically different according to Tukey's HSD test ($P < 0.05$).

The hoverflies were more active mainly when infestation of the aphids occurred in the orchard during May, and the hoverflies were often detected on white and blue traps in both years. Green was less attractive to the hoverfly adults. A hoverfly species, *Toxomerus marginatus* (Say), was more common during the flowering period, and blue traps were the most attractive to the adults, followed by white traps, in cranberry marshes in New Jersey, USA (Rodriguez-Saona et al., 2012). The study of Hoback et al. (1999) also revealed that blue sticky traps captured greater numbers of the hoverfly, *Allograpta obliqua* (Say), in broccoli fields in Maricopa, USA. Similar results were obtained in a laboratory study using blue, yellow and white sticky cards for *A. obliqua* (Chen et al., 2004).

The reflectance (%) of the four colors in current study was not measured; a higher reflectance of white when compared with yellow, blue or green wavelengths (Teulon & Penman 1992; Hoddle et al., 2002) may affect the attractiveness of the white traps to syrphids and honey bee adults. Rodriguez-Saona et al. (2012) found that hoverflies and honey bees were the most attracted to blue and white traps; these colors are commonly for flowers and are often attractive to bees and other flower visitors (Lunau & Maier, 1995). These insects might recognize that blue and white floral colors are associated with nectar and pollen sources during their searching, and consequently were not attracted to other colors, such as green and red. The use of white traps, which catch considerable numbers of syrphid and honey bee adults,

would be appropriate for sampling. Yellow traps which were less attractive to both beneficial insect species may be used to monitor some sucking-pest insects, such as aphids and thrips, especially during April, the flowering period of citrus in this region. Yellow is known to be strongly attractive, especially to sucking pests worldwide.

Green and yellow traps were more attractive to the predaceous coccinellid, *O. conglobata,* than were other colored traps. Although the coccinellid species trapped were different, our results agree with the findings of previous studies of coccinellids sampled by variously colored traps. For example, Rodriguez-Saona et al. (2012) revealed that lady beetles identified as *Coleomegilla maculata* (De Geer, 1775), *Coccinella septempunctata* (L., 1758) and *Hippodamia convergens* Guérin-Méneville, 1842 were trapped mostly on yellow traps in cranberry marshes in New Jersey, USA. Maredia et al. (1992) reported that *C. septempunctata* was strongly attracted to yellow traps. We frequently observed fewer alate aphids on yellow traps on most sampling dates in both years. Therefore, yellow traps can be used to investigate prey-predator associations between coccinellids and citrus aphids in spring time in this region.

The effect of cardinal direction on the capture of beneficial insects was statistically important. Honey bees were caught mostly on white traps facing east and south (Figure 2). This may indicate that honey bees visit commonly sides of the trees becoming warmer and sunnier. White traps positioned to the south captured more syrphids, but yellow, blue and green traps facing west trapped greater numbers of individuals in 2011 (Figure 2). This might be because the spectral reflectance of the colors used in this study (Teulon & Penman, 1992; Hoddle et al., 2002); spectral reflectance of the different colored trap affects the attraction of diurnal insect species (Childers & Brecht, 1996). Sunlight on the southern sides of the trees in spring might have greater reflectance with white traps than for other colors, resulting in high numbers of syrphid adults. The effect of cardinal direction on the capture of the three beneficial insect species by the colored traps was unclear in 2012 (Figure 2). This may be due to lower abundance of the captured and identified insect species, compared with the abundance in 2011 (Figures 1 and 2).

The use of white and blue traps for the syrphids, and yellow traps for coccinellids, may provide more ecological knowledge on these beneficial insects in citrus orchards in this region and also in other geographical areas having similar ecological conditions. Catches on white traps could especially be a valuable indicator of the activities of pollinating insects in citrus.

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