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Parasitization efficacy of ***Aphytis melinus*** DeBach (Hymenoptera: Aphelinidae) as affected by host size and size distribution of ***Aonidiella aurantii*** (Maskell) (Homoptera: Diaspididae) in a lemon orchard

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Summary

Aonidiella aurantii (Maskell) (Homoptera: Diaspididae) is a major pest of citrus in the east Mediterranean region of Turkey. Among many predators and parasitoids attacking the California red scale (CRS), ***Aphytis melinus*** DeBach (Hymenoptera: Aphelinidae) is the most common natural enemy of CRS. In this study we used host size and host size distribution of ***A. aurantii*** on mature lemon trees to determine possible causes on efficacy of ***A. melinus*** observed in field. CRS density was significantly higher on fruits (1.00 CRS/cm^2) than on leaves (0.61 CRS/cm^2), twigs (0.05 CRS/cm^2) and trunks (0.01 CRS/cm^2). Virgin females tend to be larger in size on fruits, whilst size of second stage larvae was independent from tissue substrate. Significantly more CRS were parasitized by ***A. melinus*** on fruits (12.6%) and leaves (8.6%) than on twigs (1.0%); none of the individuals on trunks was parasitized. Distribution analyses of ***A. aurantii*** scale cover size showed two distinct groups of host sizes; the larval stages ranging between 0.06 - 0.30 mm^2 and the virgin females being 0.30 - 0.70 mm^2 in size. About 54.2% of the total ***A. aurantii*** population comprised of individuals smaller than 0.30 mm^2 and only 9.5% of them were parasitized. Individuals larger than 0.40 mm^2 are highly accepted for parasitization, but constituted of only 20.4 % of total population and 52.3% were parasitized by ***A. melinus***.

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Anahtar sözcükler: ***Aphytis melinus***, ***Aonidiella aurantii***, konukçu iriliği, dağılım, parazitlenme

Introduction

California red scale (CRS), ***Aonidiella aurantii*** (Maskell) (Homoptera: Diaspididae), is a most important pest of citrus in particular of lemon in the east Mediterranean region of Turkey (Eronç, 1971; Soylu and Ürel, 1977). The scale insect completes three generations a year between May and October (Karaca and Uygun, 1990). Main damages caused by CRS are dieback on young shoots and loss in marketing value due to fruit infestation.

Natural enemies are suggested to be more effective in reducing CRS population than chemical or cultural control measures. In the east Mediterranean region of Turkey several natural enemies of ***A. aurantii*** have been determined, out of which ***Chilocorus bipustulatus*** (L.), ***Lindorus lophantae*** Motsch (Coleoptera: Coccinellidae); ***Cybocephalus fodori minor*** Endrody-Younga (Coleoptera: Cybocephalidea); ***Aphytis melinus*** DeBach (Hymenoptera: Aphelinidae) and ***Comperiella bifasciata*** Howard (Hymenoptera: Encrytidae) are especially important (Eronç, 1971; Karaca and Uygun, 1990; Soylu and Ürel, 1977; Uygun, et al., 1995b). Among these ***A. melinus*** is a widespread parasitoid of CRS and parasitization rates may reach 30-40%, but still not reported to be capable to sufficiently control ***A. aurantii*** in Turkey (Soylu and Ürel, 1977; Uygun et al. 1995a). Host population density, host size, and host size distribution may all act on the overall efficacy of ***A. melinus*** in field. Therefore, this study was aimed to determine the role of these three factors on parasitization of California red scale by ***A. melinus*** on lemons.

Material and Method

A lemon orchard (cv. Kütdiken, 3 ha, 20 years old) located at the University of Çukurova, Agricultural Research Farm in Adana, Turkey, in which no insecticides have been applied for the last five years was selected as sampling site. Samples were taken two times one in September another in October when the population of CRS were most dense. Ten heavily infested trees were chosen from the center of orchard, and fruit, leaf, twing and trunk samples were taken from the periphery of each tree.

In the laboratory, an area of 1 cm^2 of each tissue substrate was examined under a stereoscopic binocular microscope to determine the population density of

A. aurantii. In total, an area of at least of 100 cm^2 of each tissue substrate was counted per sampling date. The scale and body size of CRS was estimated by measuring length x width (in mm^2) before and after removing the scale cover. Only unparasitized samples were considered for body size estimation, while those that were hosting ***A. melinus*** were used to determine the parasitization rate.

The infestation rate of CRS, the scale cover size of second stage larvae and virgin females of ***A. aurantii*** and the rate of parasitized individuals in relation to tissue substrate were analyzed by ANOVA and means separated by Bonferroni-test (P = 5%). A linear regression analysis was applied to determine the relationship between cover size and body size of ***A. aurantii***.

Result and Discussion

The population density of ***A. aurantii***, the body size of second stage larvae and virgin females, and the rate of parasitized individuals (second stage larvae plus virgin females) on different tissue substrates are given in Table 1. CRS density was highest on fruits (1.00 CRS/cm^2) and lowest on trunks (0.01 CRS/cm^2), supporting previously reported results that ***A. aurantii*** prefers fruits rather than other tissues (Atkinson, 1977; Carrol and Luck, 1984a; Jones, 1936; Şekeroğlu et al., 1989).

There was no significant difference in the size of second stage-larvae among different tissue substrates, while in contrast the size of virgin females were significantly larger on fruits than on twigs or trunks (Table 1). Similar reports were given by Luck and Podoler (1985) for grapefruit trees in California, ***A. aurantii*** being larger on fruits, intermediate on leaves and smallest on trunks.

The highest number of CRS parasitized by ***A. melinus*** occurred on fruits, followed by leaves and twigs, no parasitization was detected on trunk substrate (Table 1). It appears to be a general fact that ***A. aurantii*** on fruits and leaves are under high pressure of parasitoid attack. Atkinson (1977), Orphanides (1982), Carrol and Luck (1984 b) and Luck and Podoler (1985) also observed that parasitization rates of ***A. aurantii*** were consistently higher on these tissue substrates.

Several reasons may be used to explain the preference of ***A. melinus*** to parasitize ***A. aurantii*** on fruits and leaves: i) the parasitization rate is strongly density dependent, ii) host size available for ***A. melinus*** on fruit and leaves favours parasitization; iii) size and age distribution of the whole ***A. aurantii*** population on lemon trees, iv) expositions and colour of fruit and leaves.

Although, it appears from data that the parasitization rate is directly depended on host density (Table 1). Yu (1986) and Zhao (1990) proved that the parasitization rate of CRS was not density depended; high parasitization rate at high densities in this study might be due to the availability of suitable host size rather than high density.

Table 1. Tissue substrate depending population density of Aonidiella aurantii, scale cover size, and parasitization rate by Aphytis melinus on mature lemon trees

Plant Tissue Substrates	Density per cm^2	Scale cover size (mm^2)		Parasitization rate of second stage larvae + virgin females (%)
		2^{nd}-stage-larvae (Mean ± SD)	Virgin females (Mean ± SD)	
Fruit	1.00 ± 0.138 a	0.17 ± 0.004 a	0.46 ± 0.007 a	12.6 a
Leaf	0.61 ± 0.100 b	0.16 ± 0.003 a	0.44 ± 0.005 ab	8.6 a
Twig	0.05 ± 0.017 c	0.16 ± 0.007 a	0.42 ± 0.015 b	1.0 b
Trunk	0.01 ± 0.090 d	0.16 ± 0.004 a	0.42 ± 0.008 b	0.0 b

Means in column followed by the same letter are not significant different (Bonferroni-test, P = 5%)

A. melinus prefers host sizes larger than 0.40 mm^2 for parasitization; individuals smaller than 0.2 mm^2 are rarely accepted (Carrol and Luck, 1984 a; Opp and Luck, 1986). Analyses of frequency distribution of ***A. aurantii*** scale cover size showed that there were two distinct groups of host sizes; the larval stage ranging between 0.06 - 0.30 mm^2 and the virgin females being 0.30 - 0.70 mm^2 in size (Fig. 1). About 54.2% of the total ***A. aurantii*** population comprised of individuals that were smaller than 0.3 mm^2 and just about 9.5% (6.3 - 14.4%) of this group were parasitized (Table 2). In contrast, individuals larger than 0.40 mm^2 being highly accepted for parasitization constituted of only 20.4 % of total population, but more than half of these individuals were parasitized by ***A. melinus***. Thus, the low number of larger host sizes, suitable for parasitization, in the total CRS population may well serve as explanation for the low overall efficiency of ***A. melinus*** in citrus or at least in lemon.

The little difference determined in scale cover size of maximal 0.04 mm^2 between virgin females of ***A. aurantii*** observed on fruits and trunks do not support the argument that the higher parasitization on fruit is related to the significantly larger size of virgin females on this tissue. In addition to size some other factors such as fruit color or easy acces to host might contribute to higher parasitization rate on fruit substrate.

The effect of exposition and colour of different tissue substrate on host distribution and parasitization should, however, not be underestimated. Ecologycal studies on CRS and its natural enemies in citrus orchards indicated that both ***A. aurantii*** and its parasitoid ***A. melinus*** are attracted by yellow to light green colours (Moreno et al., 1984). Furthermore, the parasitoid was observed searching for CRS more frequently in the outer parts of citrus trees or in sparse canopies than where foliage was dense. The trees used for sampling of CRS and ***A. melinus*** in this study were about 20 years old, large in size, with a dense canopy. The appearance of lemon trees may have directly act upon size distribution of ***A. aurantii*** and occurrence of the parasitoid.

Table 2. Frequency distribution of scale cover size of Aonidiella aurantii and host size depending parasitization rate by *Aphytis melinus* on mature lemon trees

Scale cover size (mm^2)	Frequency distribution (%)	Parasitization rate (%)
0.1 - 0.2	46.2	14.4
0.2 - 0.3	8.0	6.3
Sum/Mean	54.2	9.5
0.3 - 0.4	25.4	27.0
> 0.4	20.4	52.3
Sum/Mean	45.8	37.6
Grand sum/Grand mean	100.0	18.9

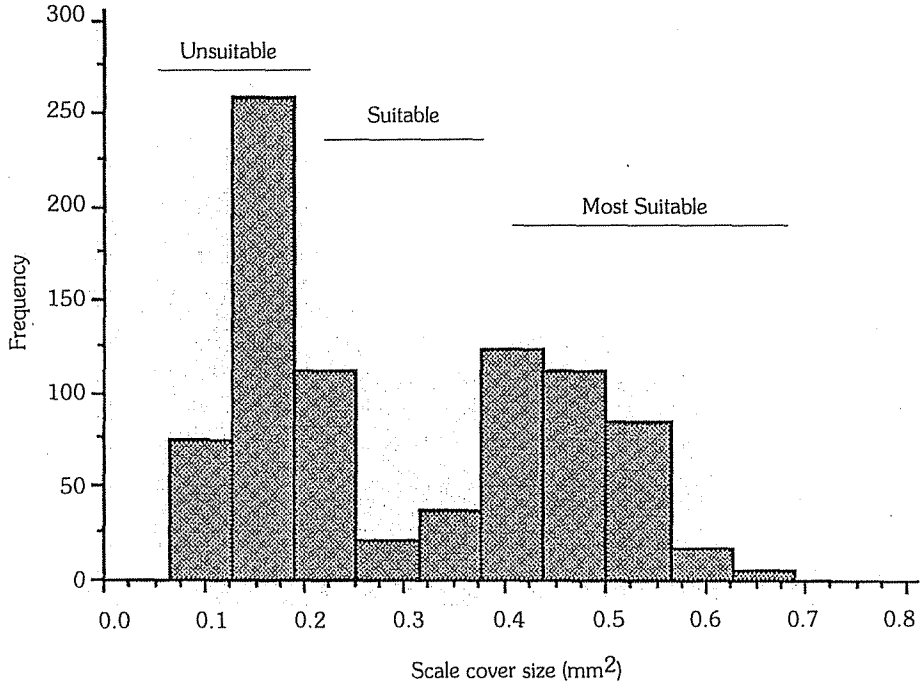

Figure1. Size distribution of second stage larvae and virgin female of Aonidiella aurantii on mature lemon trees (data pooled over all tissue substrate)

In mature lemon orchards, ***A. aurantii*** is not only more common on fruits and leaves but also the size of virgin female scales tend to be larger on these tissue substrates. The number of CRS being suitable in size for parasitization by ***A. melinus***, however, comprises only a small fraction of the total ***A. aurantii*** population. Despite low overall parasitization rate by ***A. melinus*** it still might be effective to decrease ***A. aurantii*** populations to low levels. According to DeBach (1969) the parasitization rates between 15-20 percent is appropriate to suppres the pest population. The results of this study, therefore strongly support the suggestion that half of the size frequency of CRS, is suitable for ***A. melinus*** parasitization.

Özet

Limon ağaçlarında *Aphytis melinus* **DeBach (Hymenoptera: Aphelinidae)' un parazitleme etkinliğinin konukçusu** *Aonidiella aurantii* **(Maskell) (Homoptera: Diaspididae)'nin irilik ve irilik dağılımına göre değişimi**

Kırmızı kabuklubit (***Aonidiella aurantii***), Doğu Akdeniz Bölgesi turunçgillerinin en önemli zararlılarından birisidir. Birçok doğal düşmanı olan bu zararlının baskı altına alınamasında en yaygın doğal düşmanı olan parazitoit ***Aphytis melinus***'un önemli bir yeri vardır. Bu çalışmada ***A. melinus***'un Kırmızı kabuklubit'i parazitleme etkinliğine konukçu iriliği ve irilik dağılımının etkisi incelenmiştir.

Kırmızı kabuklubit yoğunluğu en fazla meyveler üzerinde olmuş (1.00 adet /1 cm^2) bunu sırasıyla yaprak (0.61 adet /1 cm^2), sürgün (0.05adet /1 cm^2) ve gövde (0.01 adet /1 cm^2) izlemiş, aralarındaki fark istatistiki olarak önemli bulunmuştur. Bitki organlarına göre değerlendirildiğinde Kırmızı kabuklubit'in ikinci nimf dönemlerinin irilikleri arasında fark ortaya çıkmazken, çiftleşmemiş dişi dönemde en iri bireylere meyve üzerinde rastlanmıştır. Parazitleme oranları açısından da bitki organları arasında fark ortaya çıkmış olup, en fazla parazitlenme meyve üzerinde (%12.6) saptanmış bunu sırasıyla yaprak (% 8.6) ve sürgün (%1.0) izlemiş, gövde üzerinde ise parazitlenme olmamıştır. Kırmızı kabuklubit'in 2. dönem nimflerinin kabuk iriliği 0.06 - 0.30 mm^2, çiftleşmemiş dişi bireylerinki ise 0.30 - 0.70 mm^2 arasında değişmiştir. Toplam Kırmızı kabuklubit populasyonunun %54.2'si 0.30 mm^2'den küçük bireylerden oluşmuş ve bunların sadece %9.5'i parazitlenmiştir. Asalak tarafından tercih edilen 0.40 mm^2'den daha büyük olan kabuklubitlerin toplam populasyon içindeki oranı %20.4 olmasına rağmen bunların %52.3'ü parazitlenmiştir.

Literature

Atkinson, P. R. (1977) Preliminary analysis of a field population of citrus red scale, ***Aonidiella aurantii*** (Maskell), and the measurement and expression of stage duration and reproduction for life tables. **Bull. Ent. Res., 67:** 65-87.

Carrol, D.P. and Luck R.F. (1984a) Within-tree distribution of California red scale, ***Aonidiella aurantii*** (Maskell) (Homoptera: Diaspididae) and its parasitoid ***Comperiella bifasciata*** Howard (Hymenoptera: Encyrtidae) on orange trees in the San Joaquin Valley. **Environ. Entomol., 13:** 179-183.

Carrol, D.P. and R.F. Luck, 1984b. Bionomics of California red scale, ***Aonidiella aurantii*** (Maskell) (Homoptera: Diaspididae) on orange fruits, leaves and wood in California's San Joaquin Valley. **Environ. Entomol., 13:** 847-853.

DeBach, P., 1969. Biological control of diaspine scale insects on citrus in California. Proceedings first international symposium, Vol.,2. 801-815.

Eronç, H.H., 1971. Studies on species, distribution, biology, host plants and control of ***Aonidiella*** in Adana. Agricultural Research Institute Region, Ministry of Agriculture, Plant Protection and Quarantine General Directorate, Research Serial, Technical Bull. No.: 32: 103p. (in Turkish).

Jones, E. P., 1936. The bionomics and ecology of red scale- ***Aonidiella aurantii*** Mask.- in Southern Rhodesia. Mozoe Citrus Experimental Station Annual Report for 1935. The British South Africa Company Publication No.: 5: 11-52

Karaca, I. and Uygun, N., 1990. Natural enemies of ***Aonidiella aurantii*** (Maskell) (Homoptera: Diaspididae) in East Mediterranean citrus areas and their population development on different citrus varieties. Proc. 2nd Turkish National Congress of Biological Control. 4: 97-108 (in Turkish).

Luck, R. F. and Podoler, N., 1985. Competitive exclusion ***Aphytis lingnanensis*** by ***A. melinus*** potential role of host size. **Ecology, 66:** 904-913.

Moreno, D.S., W.A. Gregory and L.K. Tanigoshi, 1984. Flight response of ***Aphytis melinus*** (Hymenoptera: Aphelinidae) and ***Scirtothrips citri*** (Thysanoptera: Thripidae) to trap color, size and shape. **Environ. Entomol.,13:** 935-940.

Opp, S. B. and R.F. Luck, 1986. Effects of host size on selected fitness components of ***Aphytis melinus*** and ***A. lingnanensis*** (Hymenoptera: Aphelinidae). **Ann. Entomol. Soc. Am., 79:** 700-704.

Orphanides, G. M., 1982. Biology of the California red scale ***Aonidiella aurantii*** (Maskell) (Homoptera: Diaspididae), and its seasonal availability for parasitization by ***Aphytis*** spp. Cyprus Bull. Lab. Ent. Agrar Filippo Silv., **Portici., 39:** 203-212.

Soylu, O. Z. and N. Gürel, 1977. Investigations on parasites and predators of the pests that cause damage on citrus plantations in the south Anatolia region. **Bitki Koruma Bül., 17** (2-4): 77-112 (in Turkish).

Şekeroğlu, E., N. Uygun and I. Karaca, 1989. The effect of irrigation systems on population dynamics of California red scale (Homoptera: Diaspididae) on lemon trees in Adana, Turkey. **Turkish J. Entomol., 13:** 147-152 (in Turkish).

Uygun, N., I. Karaca and E. Şekeroğlu, 1995a. Population dynamics of ***Aonideilla aurantii*** (Maskell) (Homoptera: Dispsididae) and its natural enemies on citrus in the Mediterranean region of Turkey from 1976-1993, In: Proc. VII Int. Symposium of Scale Insects Studies, ISSIS-VII (Ascher, K. R. S. and Ben-Dov, Y. eds). **Isr. J. Ent., XXIX:** 239-246.

Uygun, N., I. Karaca, M.R. Ulusoy and N.Z. Tekeli, 1995b. Status of citrus pests and their control in Turkey. **IOBC/WPRS Bulletin, 18** (5): 171-183.

Yu, D. S., 1986. The interactions between California red scale, ***Aonidiella aurantii*** (Maskell), and its parasitoids in citrus groves of inland Southern California. Ph D. Thesis, University of California, Riverside. 105pp.

Zhao, J., 1990. An advanced study on the biology and ecology of California red scale, ***Aonidiella aurantii*** (Mask.) (Hemiptera: Diaspididae), and its natual enemy, ***Aphytis melinus*** DeBach (Hymenoptera: Aphelinidae). Contribution of the Biological Control Research Institute, Fujian Agricultural College, Special Publication No.: 3: 245 pp.