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Functional response of ***Oenopia conglobata*** (L.) (Coleoptera: Coccinellidae) on ***Hyalopterus pruni*** (Geoffroy) (Homoptera: Aphididae) in three different size arenas

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Summary

This study was carried out to determine the functional response of ***Oenopia conglobata*** (L.) to ***Hyalopterus pruni*** (Geoffroy) in petri dishes of 6, 8 and 12 cm diameters and at 20, 40, 80, 160 and 320 prey densities. Experiments were carried out in a climate chamber set at 25±1 °C, 65±5 % RH and 16:8 (L:D) h photoperiod. Consumption by all larval instars of ***O. conglobata*** increased with increasing prey densities up to 80 in petri dishes of 6, 8 and 12 cm diameters. A further increase in prey density (to 160 and 320 aphids) did not result in higher prey consumption for all larval stages. The daily food consumption by adult females of ***O. conglobata*** in all petri dishes increased with increasing prey densities. Increasing petri dish diameters did not affect prey consumption by all larval stages and adults of ***O. conglobata***. Handling time decreased linearly as life stages developed. Handling time according to life stage was significantly different, but differences between 3rd and 4th instar larvae were not significant. Handling time did not affect by petri dish diameters. Search rate according to life stage was significantly different but no differences occurred among 2nd, 3rd and 4th instar larvae. Search rate decreased as life stage developed but increased when petri dish diameters increased.

Key words: ***Oenopia conglobata***, ***Hyalopterus pruni***, functional response, handling time, search rate

Anahtar sözcükler: ***Oenopia conglobata***, ***Hyalopterus pruni***, işlevsel tepki, yakalama süresi, arama oranı

Introduction

The mealy plum aphid, ***Hyalopterus pruni*** (Geoffroy) (Homoptera: Aphididae) is one of the most important pest of peach, plum and apricot orchards

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in Turkey and some other countries (Blackman & Eastop, 1984; Toros et al., 1996). In addition, reed (***Phragmites australis*** Cav.) serves as a secondary host for this aphid species that has a heterocious life cycle (Dixon, 1987). There are many natural enemies of ***H. pruni*** around the world and in Turkey (Hodek, 1973; Çanakçıoğlu, 1975; Uygun, 1981; Basky, 1982; Frazer, 1988; Oncüer, 1991; Iperti, 1999). Among these, ***Oenopia conglobata*** (L.) (Coleoptera: Coccinellidae) appears to be the most important natural enemies of ***H. pruni*** in Van province (Erol & Yaşar, 1996; Yaşar et al., 1999). Other coccinellids known as predators of ***H. pruni*** in Turkey are ***Adonia variegata***, ***Adalia fasciatopunctata revelierei***, ***Scymnus apetzi***, ***S. subvillosus***, ***Adalia bipunctata*** and ***Exochomus nigromaculatus*** (Yaşar & Özgökçe, 1994; Erol & Atlıhan, 1995; Kaydan & Yasar, 1999; Atlıhan et al., 1999; Özgen & Yaşar, 1999; Kasap & Yaşar, 1996; Atlıhan & Özgökçe, 2002).

Functional response has received much attention in the entomological and ecological literature (i.e.; Holling, 1959, 1966; Rogers, 1972; Luck, 1984; Wiedenmann & O'Neil, 1991; Fan & Petitt, 1994; Heimpel & Hough-Goldstein 1994; Williams & Juliano, 1996; Munyaneza & Obrycki, 1997; Gitonga et al., 2002). Functional response refers to the change in the number of prey consumption by a predator per unit time in relation to prey density.

Virtually, no research has been conducted to determine the functional response of all predatory stages (larval and adult) of ***O. conglobata*** to ***H. pruni***. So, this paper describes and compares the functional response of ***O. conglobata*** feeding with five different prey densities of ***H. pruni*** under laboratory conditions.

Material and Methods

The initial population of Mealy plum aphid, ***H. pruni***, was collected from reeds (***Phragmites australis*** Cav.) while ***O. conglobata*** (L.) was collected from plum orchards infested with the aphids in Van, Turkey. All the experiments were conducted in a climate chamber set at 25±1°C, 65±5 % RH and 16:8 (L:D) h photoperiod. Experiments were initiated after rearing one generation of ***O. conglobata*** under laboratory conditions. Before starting the experiment 20, 40, 80, 160 and 320 mealy plum aphids inhabiting reed leaves were transferred to petri dishes of three sizes (6 cm =84.78 cm^2, 8 cm =138.16 cm^2, 12 cm =282.6 cm^2) ($A=2\pi r^2+2\pi rh$). Newly emerged first instars larvae of ***O. conglobata*** were then selected at random from stock cultures and was placed in an experimental arena for each prey density and arena size. Experiments were carried out at least with 10 replications.

The number of mealy plum aphid consumed by ***O. conglobata*** was counted at the end of each 24 h period under a stereo microscope. Therefore, the consumption of mealy plum aphid by 1^{st}, 2^{nd}, 3^{rd}, 4^{th} instars and adults of ***O. conglobata*** in petri dishes of different three sizes were determined when 20, 40, 80, 160 and 320 aphids were given to the predator as prey.

Data analysis

Factorial design (5*5*3) was used to compare the effects of food levels and hunting arena size on prey consumption by immature and adult stages of ***O. conglobata.*** Means of main effects were compared at the $P < 0.05$ by Duncan's Multiple Range Test (DMRT) and means of the interaction effects such as life stages * prey density were compared with possible differences test by using SAS/GLM/LSMEANS/pdiff procedure.

The functional response of predators to different prey densities was expressed by fitting Holling's disc equation to the data (Holling, 1959):

$$Na = aTN/(1+aThN)$$

Where Na=The number of prey attacked by a predator, T= Exposure time (1 day), N=prey density per unit area, a= Search rate of a predator and Th=Handling time for each prey caught. Search rate, handling time and their standard errors were calculated from linear regression of disc equations. The means obtained from linear regression were analyzed with two-way ANOVA and compared with DMRT at $P < 0.05$ level. Confidence limits were calculated for means. All analysis was conducted by SAS statistical software (Anonymous, 1998).

Results

The daily food consumption of all larval instars increased with increasing prey densities in petri dishes of 6, 8 and 12 cm diameters. But, there were no differences among of 80, 160 and 320 prey numbers (Table 1; Figure 1; $P < 0.05$). So, it is possible to say that the daily 80 prey numbers for all larval stages of ***O. conglobata*** is enough for their feeding.

The daily food consumption in adult females of ***O. conglobata*** in all petri dishes (6, 8, 12 cm diameter) increased with the increasing prey densities. The prey numbers consumed by adult females in each petri dish diameter were significantly different from each other (Table 1; Figure 1; $P < 0.01$).

The daily food consumptions in all larval stages ($P < 0.05$) and adults ($P < 0.01$) of ***O. conglobata*** feeding on five different prey densities of ***H. pruni*** in petri dishes of three different sizes were not different among them. The increasing petri dish diameters did not affect prey consumption of all stages of ***O. conglobata***.

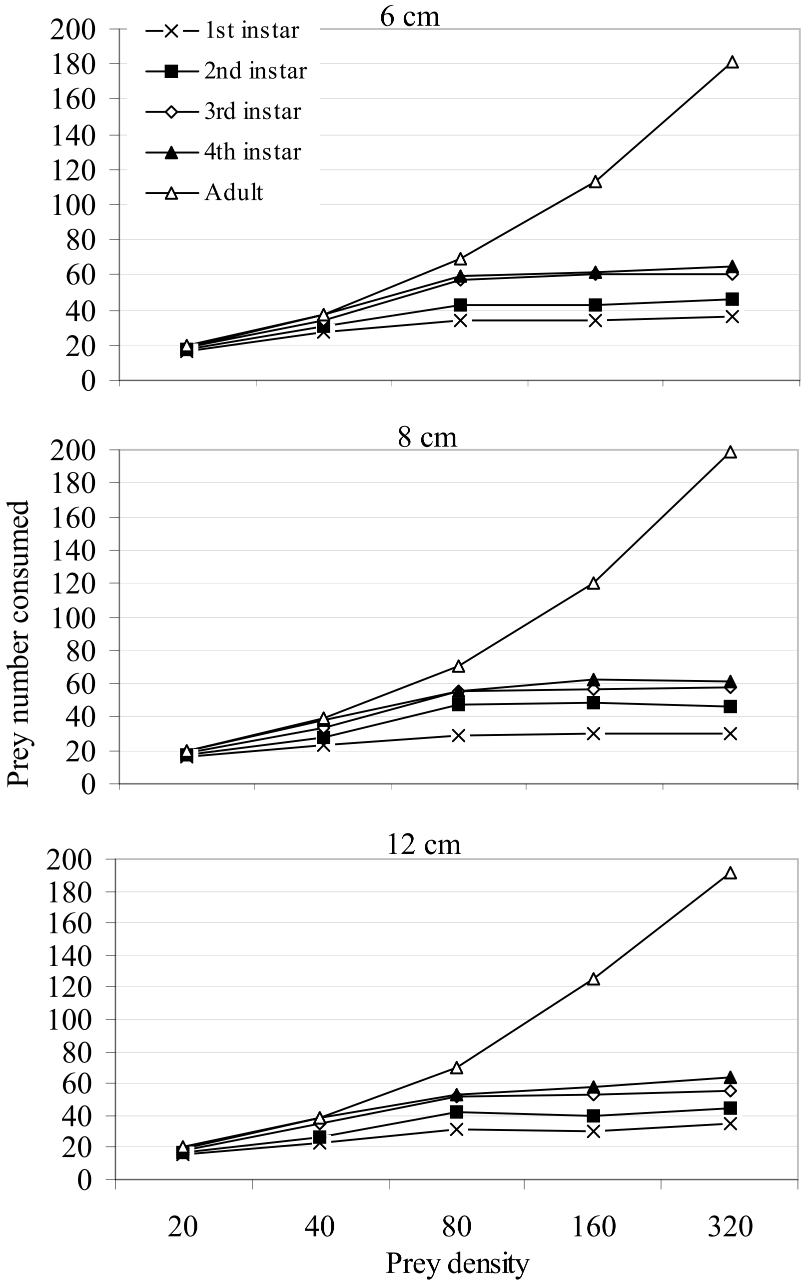

Figure 1. The daily food consumptions in larval and adult stages of ***Oenopia conglobata*** feeding with five prey densities of ***Hyalopterus pruni*** in petri dish of different three diameters.

Table 1. The comparisons according to all stages of the daily food consumptions of ***Oenopia conglobata*** feeding with five prey densities in petri dishes of three different diameters (Mean±SE) and multiple comparisons of the interaction effects (Life stages*Prey density)

Prey density	Larval stages**				Mean	Adult*
	1st instar	2nd instar	3rd instar	4th instar		
6 cm (Petri dish diameter)						
20	16.42±0.70 c	17.88±0.97 c	18.48±0.50 c	19.17±0.28 c	17.98±0.32 c	19.48±0.47 e
40	27.38±0.55 b	30.30±1.58 b	34.17±1.46 b	37.17±1.05 b	32.29±0.45 b	37.67±1.33 d
80	33.76±1.41 a	42.88±1.09 a	56.75±1.25 a	59.70±1.20 a	48.55±0.70 a	69.29±0.39 c
160	34.23±2.32 a	43.33±2.20 a	60.53±2.69 a	61.95±4.07 a	49.78±0.58 a	113.08±2.50 b
320	36.76±3.76 a	45.98±0.89 a	60.38±2.48 a	65.20±2.71 a	50.22±0.64 a	181.63±7.07 a
8 cm (Petri dish diameter)						
20	15.78±0.54 b	17.32±0.68 c	18.70±0.48 c	19.42±0.49 c	17.85±0.30 c	19.97±0.02 e
40	22.86±0.68 ab	28.11±2.13 b	33.26±2.31 b	37.73±1.00 b	31.49±0.49 b	38.98±0.19 d
80	28.83±1.27 a	47.88±2.42 a	55.50±1.50 a	55.33±2.57 a	46.80±1.05 a	70.84±1.67 c
160	29.50±2.90 a	48.25±4.54 a	56.20±3.22 a	62.38±0.72 a	48.54±1.71 a	120.50±0.33 b
320	29.95±3.96 a	46.39±0.55 a	57.88±3.40 a	61.30±4.30 a	49.91±1.89 a	198.53±1.53 a
12 cm (Petri dish diameter)						
20	16.25±1.37 c	16.79±1.28 c	18.00±0.61 c	19.16±0.28 c	17.38±0.62 c	19.96±0.02 e
40	22.79±1.78 b	26.38±1.35 b	34.67±1.16 b	38.07±1.06 b	30.27±0.69 b	38.94±0.29 d
80	31.78±2.26 a	42.03±3.82 a	51.70±2.37 a	52.76±2.82 a	44.15±1.78 a	70.33±0.33 c
160	30.16±1.58 a	40.25±1.30 a	52.58±2.56 a	58.30±4.21 a	44.74±1.12 a	125.00±0.58 b
320	34.57±4.31 a	44.63±3.08 a	55.67±3.18 a	64.00±3.06 a	49.71±0.76 a	191.31±8.56 a

*Means in a column followed by same letter do not differ statistically (DMRT; $P < 0.01$)

**Means in a column followed by same letter do not differ statistically (DMRT; $P < 0.05$)

Handling time according to the stages were significantly different, but differences between the 3rd and 4th instar larvae were not significant (Table 2; $P < 0.05$). The handling time decreased when stages developed. Differences of handling time in petri dish diameters of three different sizes were not significant (Table 2; $P < 0.05$). Handling time did not affect by petri dish diameters

Table 2. Search rate (α), handling time (T_h) and confidence limits in Holling's disc equation for ***Oenopia conglobata*** feeding on ***Hyalopterus pruni*** in petri dishes of three different diameters

Stages	T_h (day/nymph)**		95% CL		((cm2/h)*		95% CL	
			Lower	Upper			Lower	Upper
1st instar	0.625	a	0.574	0.675	244.62	a	224.33	264.92
2nd instar	0.404	b	0.353	0.454	209.50	b	189.21	229.79
3rd instar	0.277	c	0.226	0.327	206.19	b	185.90	226.48
4th instar	0.251	c	0.201	0.302	214.85	b	194.55	235.42

Adult	0.053	d	0.002	0.103	175.53	c	155.24	195.83
	SEM: 0.0219				SEM:8.801			
Petri diameter (cm)	Th(day/nymph)		95% CL		((cm2/h)*		95% CL	
			Lower	Upper			Lower	Upper
6 (84.78 cm2)	0.302	a	0.263	0.341	105.25	c	84.53	120.97
8 (138.16 cm2)	0.330	a	0.291	0.369	174.08	b	158.36	189.80
12 (282.60 cm2)	0.334	a	0.294	0.373	351.08	a	335.36	366.80
	SEM: 0.017				SEM: 6.82			

* Means in a column followed by same letter do not differ statistically (DMRT; $P < 0.01$)

** Means in a column followed by same letter do not differ statistically (DMRT; $P < 0.05$)

Search rate according to the stages was significantly different, but differences among 2nd, 3rd and 4th instar larvae were not significant (Table 2; $P < 0.01$). Search rate of adults was shorter than all larval stages. Search rate according to the petri dish diameters were significantly different from each other (Table 2). Search rate decreased when stages developed but increased when petri dish diameters increased.

Discussion

The results indicated that consumption of ***H. pruni*** by ***O. conglobata*** can increase with increasing prey densities up to 80 individuals in petri dishes and no more increase occurs in consumption if the prey density is further increased. Similar results were indicated by Zhao & Holling (1986), Ofuya & Akinbohungbe (1988), Shukla et al. (1990), and Kumar et al. (2002).

The daily food consumptions of ***O. conglobata*** adult females in all petri dish diameters increased with the increasing prey densities. Prey numbers consumed by ***O. conglobata*** adult females in each petri dish diameter were significantly different from each other. Adults of other coccinellids, ***Scymnus levaillanti*** (Uygun & Atlıhan, 2000), ***Exochomus nigromaculatus*** (Atlıhan & Özgökçe, 2002), ***Coleophora inaequalis*** (Wang & Tsai, 2001) ***Semiadalia***

undecimnotata (Yaşar et al., 2000), and ***Scymnus apetzi*** (Kaydan & Yaşar, 1999) also consumed more prey than their larvae. This study showed that the increasing petri dish diameter did not have any effect on the prey consumption by all larval stages and adults of ***O. conglobata*** feeding on five different prey densities of ***H. pruni***.

Handling time according to the stages was significantly different but differences between the 3rd and 4th instar larvae were not significant. The handling time decreased linearly when stages developed. Handling times of adult females were the shortest compared with other stages. The same result was obtained for handling time of ***Exochomus nigromaculatus*** feeding on ***H. pruni*** (Atlıhan & Özgökçe, 2002). Briefly, petri dish diameters did not affect handling times.

Search rate according to life stage and also the petri dish diameters were significantly different but differences were not significant among 2nd, 3rd and 4th instar larvae. Search rate decreased as life stages developed, but increased when petri dish diameters increased.

In conclusion, the lack of difference in food consumptions of different stages of this predator in different hunting areas could indicate that ***H. pruni*** is a suitable food (prey) for ***O. conglobata***.

Özet

Üç farklı büyüklükteki alanda *Hyalopterus pruni* **(Geoffroy) (Homoptera: Aphididae) üzerinde beslenen** *Oenopia conglobata* **(L.) (Coleoptera: Coccinellidae)'nın işlevsel tepkisi**

Bu çalışmada ***Hyalopterus pruni*** (Geoffroy)'nin 20, 40, 80, 160 ve 320 av yoğunluklarında 6,8 ve 12 cm'lik petrilerde beslenen ***Oenopia conglobata*** (L)'nın işlevsel tepkisi saptanmıştır.

Üç farklı çapta petri kaplarında beslenen avcı böceğin tüm larva dönemlerinde tükettikleri av sayıları arasında istatistiki olarak fark olmamasına karşılık, ergin dişilerde petri çapı arttıkça tüketilen av sayısı da artmıştır. Avını yakalama süresi ve arama oranı larva dönemleri arttıkça azalmış ve ergin dişide en az olmuştur. Petri çaplarına göre ise avını yakalama süreleri arasında bir fark görülmezken, alan arttıkça avını arama oranı da artmıştır.

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