INTRA- AND INTERSPECIFIC PREDATION BY *NEOSEIULUS BARKERI* AND *TYPHLODROMUS NEGEVI* (ACARI: PHYTOSEIIDAE) ON DIFFERENT LIFE STAGES: PREDATION RATES AND EFFECTS ON REPRODUCTION AND JUVENILE DEVELOPMENT

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ABSTRACT: Cannibalism and interspecific predation of adult females and immatures stages of the generalist phytoseiid mites, *Neoseiulus barkeri* and *Typhlodromus negevi* were studied under laboratory conditions. Adult females of both predators exhibited higher predation rates on larvae than on eggs and protonymphs respectively. *Neoseiulus barkeri* and *T. negevi* fed more inter- than intraspecifically. Females of *N. barkeri* were able to sustain oviposition on a conspecific prey, whereas cannibalizing females of *T. negevi* were not able to lay eggs. When females confined without food, no eggs was laid by the two predators, and *T. negevi* survived longer than the corresponding stage of *N. barkeri*. Immatures of both predators were able to reach adulthood when provided with either con- or heterospecific prey. Juvenile development was shorter and predation was higher when *N. barkeri* and *T. negevi* fed on heterospecific vs. conspecific larvae. The present study indicates that phytoseiid immatures are a suitable prey for survival, development and reproduction of polyphagous phytoseiids.

KEY WORDS: Cannibalism, generalist predators, Phytoseiidae, interspecific predation

INTRODUCTION

The two-spotted spider mite *Tetranychus urticae* Koch (Acari: Tetrnychidae) is one of the most problematic phytophagous pests in Egyptian cucumber and pepper fields (Hassan et al. 2007). Phytoseiid mites are important biological control agents because of their well-known capacity to suppress pest mite populations, mainly tetranychids in diverse cropping system (Easterbrook et al. 2001; Colfer et al. 2004). Two mite predators of the family Phytoseiidae have been found in association with the two-spotted spider mite on cucumber and pepper fields in Egypt. *Neoseiulus barkeri* (Hughes) (Acari: Phytoseiidae) is an oligophagous predatory mite. It has been mass-reared with storage mites, such as *Acarus farris* (Oudemans) (Acari: Acaridae), as a prey (Ramakers and van Lieburg 1982) to control of thrips, *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) on cucumbers and peppers in many parts of the world (Hansen 1988). It also has been reported that *N. barkeri* can reduce *T. urticae* damage on cucumbers (Karg et al. 1987). *Typhlodromus negevi* Swirski and Amitai (Acari: Phytoseiidae) is the agriculturally important predator of spider and eriophyid mites (Abou-Awad et al. 1989, 1998). Based on the diet width, *N. barkeri* and *T. negevi* can be categorized as generalist predators type 111 (McMurtry and Croft 1997), and references on their biology does not mention differences in the resources they use; this suggests that these two predators could be competitors on the cucumber and pepper plants (Abou-Awad et al. 1998; Momen 1999). Predation at various life stages may take place between different species within a guild (in-traguild predation) as well as within each species (cannibalism). Intraguild predation (IGP) is apparent when more than one species feed on the same prey and therefore may predate each other (Rosenheim et al. 1995), and is a widespread phenomenon among arthropod food webs (Polis 1981). *Neoseiulus barkeri* and *T. negevi* partly share the same habitats and have overlapping food ranges. In the periods of limited food availability they can be competitors by exploiting the same prey species, but they can also interact directly through predation on each other (Schausberger 1997, 1998a). Cannibalism and intraguild predation are expected to occur mainly when the amount of the preferred prey is low (Polis 1981; Polis et al. 1989). The intra- and interspecific predation were found to be common among generalist and specialist phytoseiid mites (e.g. Schausberger 1997, 1999b). Schausberger and Croft (2000a) indicated that the propensity to cannibalism depends on the predator and prey stages but not on a diet specialization within the family. Schausberger (1999a) raised the hypothesis that the generalist phytoseiids are able to choose between con- and heterospecificity and prefers to prey upon the latter when are given the choice. Intraguild predation may cause interference between two or more predators and the predation on a prey can decrease (Rosenheim 2001). A sizable body of knowledge has been accumulated on the prevalence of cannibalism and interspecific predation in the family Phytoseiidae (Croft and Zhang 1994; Schausberger and Croft 2000a, b; Schausberger 2003; Zannou et al. 2005). No study has been conducted on the predatory

abilities of *T. negevi*. Schausberger and Croft (2000a) have addressed both cannibalism and predation in *N. barkeri*, but never in comparison to *T. negevi*. The latter authors indicated that *N. barkeri* was highly aggressive and vigorously attacked heterospecific larvae of *Amblyseius andersoni* Chant, *Neoseiulus cucumerius* (Oudemans) and *Euseius finlandicus* (Oudemans) (all Acari: Phytoseiidae). The cannibalism and intraguild predation among immatures mainly happens in the proto- or deutonymphs eating individuals that are in a previous developmental stage and preferentially attacking larvae (e.g. Schausberger 1999a; Schausberger and Croft 2000a; Momen and Abdel-Khalek 2009a). Our preliminary investigations have shown that immatures of both phytoseiids were observed to feed on younger stage (larvae), while adult females observed to prey particularly on larvae and protonymphs and occasionally on the eggs of hetero- and conspecifics, when other food is in short supply (Momen 1995; Momen et al. 2009). The present study has two objectives: (1) to determine under the laboratory conditions the levels of intra- and interspecific predation in females of *N. barkeri* and *T. negevi* when confined with con- or heterospecifics immature stages; (2) to test whether immatures of both phytoseiids have the ability to molt to the subsequent life stages and to reach adulthood when feeding exclusively on a diet of phytoseiid developmental stages. The purpose of comparisons of prey consumption and fecundity of each mite species is to suggest their possible interaction under greenhouse conditions.

MATERIALS AND METHODS
Predator sources and rearing

Cohorts of the two phytoseiid predators used in this study originated from colonies initiated with thirty individuals of each species. *Neoseiulus barkeri* and *T. negevi* were collected in 2007 from pepper and cucumber fields in Faywam Province, Esgypt. The predatory mite, *N. barkeri* was reared at 27ºC on detached bean leaves (*Phaseolus vulgaris* L.) infested with two-spotted spider mites, *T. urticae*, while *T. negevi* was fed on pollen of *Ricinus communis* L. (Euphorbiaceae). Pollen was field collected and stored in the freezer at –15ºC. Bean leaves with *T. urticae* were added to the *N. barkeri* culture three times a week and pollen was brushed to arenas and leaves with *T. negevi* twice a week. These leaves surrounded by water-saturated tissue paper folded over the edges of leaves and arenas (sponge pad) to prevent the escaping of

mites. Eggs were collected every day to create cohorts of a known age (<24h), also arenas were checked for larvae at intervals of 12h to obtain aged larvae and protonymphs for the experiments. Preliminary tests showed that a supply of either six eggs or nine larvae or protonymphs per day is sufficient for females of both predators to survive and reproduce. A supply from 7 to 9 larvae is sufficient for juveniles of *T. negevi* and *N. barkeri* to develop to adults. Rearing unites and experimental arenas were held in environmental chambers at 28 ± 1ºC and $70 \pm 5\%$ RH and 16 h photoperiod.

Experimental procedures
Adult females preying upon con- and heterospecific eggs, larvae and protonymphs

Freshly cut, clean, inverted 3 cm diameter bean leaf discs were placed on a layer of filter sheet placed on water-saturated cotton pad in plastic Petri dishes, were used for each experimental arenas. The filter paper was kept moist during the experimental period. Stikem Special ™ was painted around each leaf disc to form a barrier to prevent escape. One male and one female (7 days old since egg hatching) of each species were added to leaf discs with an excess of food, and they were left there to mate. After 24 h, each female was transferred to a fresh arena with no food and with a 1 cm long piece of black cotton as the oviposition site. Females were left there for 24 h to standardize the level of hunger among individuals. At the end of starvation period, eggs laid by these females were removed, and only females that laid at least one egg during starvation were used for the experiments. Subsequently, 6 eggs of <24 h old (Experiment 1), 9 newly hatched larvae (Experiment 2), or 9 protonymphs (24 h. old) (Experiment 3) of either con- or heterospecific preys were added into each arena. Tested individuals and a prey were drawn from the same colonies (kin on cannibalism). Predation (number of prey individuals consumed), survival and oviposition capacity (number of eggs lay) of both predatory mite species were measured twice a day. Deflated eggs and shriveled corpses of dead immatures were taken as evidence of predation. Every 24h all eggs and immature stages were renewed, and the eggs laid by females were removed. In experiment 1, emergence of larvae occurred rarely in both species. Non-predated larvae and protonymphs were eliminated and replaced by new ones. The experimental period lasted a maximum of 8 days in experiment 1 and 14 days in experiments 2 and 3. For

control, survival of females was also measured when held without prey. Data from the first day were omitted from the calculations of the predation and oviposition capacities to reduce the influence of pre-experimental conditions. The death of the females during the experimental period was also recorded. Each treatment (con- or heterospecific prey) was replicated 13–15 times for each species.

Immatures preying upon con- and heterospecific larvae

Phytoseiid larvae of both species were held without food in leaf disc, counts were taken daily on larvae that molted to protonymphs and survival at later stages that developed up to 8 days this is considered as control.

Larvae of *T. negevi* and *N. barkeri* do not feed to reach the protonymphal stage (Bonde 1989; Momen 1997). For both species, newly emerged larvae (further regarded as predators) were transferred solely to each leaf disc with 6 conspecific or 6 heterospecific eggs, aged 24–48 h. (hatching larvae regarded as prey) (Experiment 4). A care was taken to ensure that the newly hatched larvae were available as soon as the first feeding stage of the predator emerged (protonymphal stage). Leaf discs were checked twice a day to record predation, survival and development of the predator. Prey eggs were replenished to 9 per leaf disc (to ensure availability of excess larvae as a prey throughout the whole developmental period) and to remove dead individuals. Experiments were terminated when the predator reached the adulthood, died or remained in the same stage for >8 days.

Each treatment (con- and heterospecific preys) was replicated 16 times for each species.

Statistical analysis

All experiments (1, 2, 3 and 4) were subjected to analysis of variance (ANOVA), using SPSS computer program. The mean predation and oviposition rates and survival times of predators provided with either con- or heterospecific preys were compared by using Duncan's multiple range tests. T-test for independent samples was used to analyze survival times without prey (Experiment 4). Indices of the predation and oviposition rates were calculated as a daily mean for each female and used these means for interspecies comparison. Figures were fitted the assumptions of normality, not transformed and the differences were compared among each prey species between both predators.

RESULTS

Experiment 1: Adult females feeding on con- and heterospecific eggs

Both phytoseiid species exhibited a low predation rate on conspecific eggs, although *N. barkeri* showed a higher predation rate on heterospecific ones than *T. negevi* did (Table 1). Most female of *T. negevi* were observed to leave the conspecific eggs after trying to pierce them without success (direct observation). The mean predation rate of *N. barkeri* females was significantly higher when feeding on heterospecific eggs (ANOVA: df = 3 59; F = 261.79; $P = 0.000$). Both predators were able to sustain the oviposition when fed on heterospecific eggs (Table 1). Mean survival times of *N.*

Table 1.

Predation, oviposition and survival for adult *Neoseiulus barkeri* and *Typhlodromus negevi* females when provided with con- or heterospecific eggs for 8 consecutive days

Predator	Prey	Predation[*] (eggs) (Mean ± S. E.)	Oviposition[**] (Mean ± S. E.)	Survival (days) (Mean ± S. E.)
Neoseiulus barkeri	*N. barkeri*	0.95 ± 0.07 a	0.02 ± 0.01 a	13.80 ± 0.14 ac
	T. negevi	4.60 ± 0.16 b	1.35 ± 0.07 c	14.00 ± 0.00 c
Typhlodromus negevi	*T. negevi*	0.19 ± 0.28 c	0.00 ± 0.00 a	11.20 ± 0.78 b
	N. barkeri	2.66 ± 0.16 d	0.62 ± 0.03 b	12.53 ± 0.51 ba
ANOVA				
df $_{1,2}$		3,59	3,59	3,59
F		261.793	252.275	7.411
Significance		0.000	0.000	0.000

[*] Mean number of eggs eaten / female / day
[**] Mean number of eggs deposited / female / day
Means in a column in each species followed by the same letters are not significantly different at 5% level of probability.

Table 2.

Predation, oviposition and survival for adult *Neoseiulus barkeri* and *Typhlodromus negevi* females when provided with con- or heterospecific larvae for 14 consecutive days

Predator	Prey	Predation* (larvae) (Mean ± S. E.)	Oviposition** (Mean ± S. E.)	Survival (days) (Mean ± S. E.)
Neoseiulus barkeri	*N. barkeri*	5.69 ± 0.38 a	1.78 ± 0.04 a	14.00 ± 0.00 a
	T. negevi	8.37 ± 0.33 b	2.44 ± 0.05 b	14.00 ± 0.00 a
Typhlodromus negevi	*T. negevi*	0.14 ± 0.03 c	0.00 ± 0.00 c	11.66 ± 0.59 b
	N. barkeri	4.97 ± 0.13 a	1.48 ± 0.11 d	13.46 ± 0.29 a
ANOVA				
df $_{1,2}$		3,59	3,59	3,59
F		168.213	232.341	11.298
Significance		0.000	0.000	0.000

* Mean number of larvae eaten / female / day
** Mean number of eggs deposited / female / day
Means in a column in each species followed by the same letters are not significantly different at 5% level of probability.

Table 3.

Predation, oviposition and survival for adult *Neoseiulus barkeri* and *Typhlodromus negevi* females when provided with con- or heterospecific protonymphs for 14 consecutive days

Predator	Prey	Predation* (protonymphs) (Mean ± S. E.)	Oviposition** (Mean ± S. E.)	Survival (days) (Mean ± S. E.)
Neoseiulus barkeri	*N. barkeri*	3.05 ± 0.09 a	0.66 ± 0.06 a	14.00 ± 0.0 a
	T. negevi	7.49 ± 0.15 b	1.63 ± 0.07 b	14.00 ± 0.0 a
Typhlodromus negevi	*T. negevi*	0.59 ± 0.04 c	0.00 ± 0.00 c	12.00 ± 1.06 a
	N. barkeri	3.43 ± 0.14 d	0.23 ± 0.02 d	13.50 ± 0.31 a
ANOVA				
df $_{1,2}$		3,54	3,54	3,54
F		583.523	231.528	2.832
Significance		0.000	0.000	0.047

* Mean number of protonymphs eaten / female / day
** Mean number of eggs deposited / female / day
Means in a column in each species followed by the same letters are not significantly different at 5% level of probability.

barkeri were longer irrespective of con- or heterospecific prey than *T. negevi* did.

Experiment 2: Adult females feeding on con- and heterospecific larvae

The adult females of *N. barkeri* generally consumed more larvae (irrespectively of prey species) than *T. negevi* did (Table 2). Cannibalizing *T. negevi,* resulted no female was able to sustain the oviposition. Mean predation and oviposition rates of *N. barkeri* were significantly higher, when feeding on heterospecific vs. conspecific larvae (ANOVA: F = 168.21; and F = 232.34; *p*=0.000). The adult females of *T. negevi* cannibalized only 0.1 larvae per day and ate more heterospecific individuals of *N. barkeri* (4.9 larvae). Mean survival times of *T. negevi* were longer with the heterospe-

cific vs. conspecific prey (Table 2). All *N. barkeri* females feeding on con- or heterospecific larvae were alive at the end of the experiment. Without a prey, *T. negevi* survived by 6.6 days longer than *N. barkeri* (5.5 days) (t-test: 3.771).

Experiment 3: Adult females feeding on con- and heterospecific protonymphs

Interspecific predation was greater but cannibalism was lower in *T. negevi* than in *N. barkeri* (Table 3). No significant difference was recorded in the survival times between both predators with any prey. Cannibalizing on protonymphs of *T. negevi*, resulted in no female was able to lay eggs. *Neoseiulus barkeri* consumed more than 2 times heterospecific than conspecific protonymphs (Table 3). Mean oviposition rate of *N. barkeri* was

Table 4.

Predation rate for immature *Neoseiulus barkeri* and *Typhlodromus negevi* when provided with con- or heterospecific larvae for reaching adulthood and survival without prey

Predator	Prey	Predation[*] (Mean ± S. E.)	Survival without prey[**] (days) (Mean ± S. E.)
Neoseiulus barkeri	*N. barkeri*	7.00 ± 0.59 a	2.86 ± 0.23 a
	T. negevi	8.81 ± 0.24 b	
Typhlodromus negevi	*T. negevi*	3.87 ± 0.31 c	2.36 ± 0.13 a
	N. barkeri	7.25 ± 0.41 a	
ANOVA			
df $_{1,2}$		3, 63	
F		25.161	
Significance		0.000	

[*]Mean total number of eggs 48 h age / larvae eaten / female during developmental period.
[**]Protonymphs
Means in columns followed by the same letters are not significantly different at 5 % level of probability (ANOVA) for predation; t- test for independent samples for survival; T = 3.771.

Table 5.

Developmental times (days) of *Neoseiulus barkeri* and *Typhlodromus negevi* when provided with con- or heterospecific larvae

Predator	Prey	Stages				
		Egg	Larva	Protonymph	Deutonymph	Total
Neoseiulus barkeri	*N. barkeri*	1.69 ± 0.12 a	0.81± 0.06	2.25 ± 0.14 a	2.25 ± 0.19 a	7.00 ± 0.29 a
	T. negevi	1.56 ± 0.13 a	0.84 ± 0.06	1.44 ± 0.12 b	1.37 ± 0.12 b	5.22 ± 0.23 b
Typhlodromus negevi	*T. negevi*	2.19 ± 0.10 b	0.91 ± 0.05	6.12 ± 0.38 c	4.12 ± 0.27 c	13.34 ± 0.53 c
	N. barkeri	2.25 ± 0.11b	0.87 ± 0.05	1.62 ± 0.12 ab	1.75 ± 0.17 ab	6.43 ± 0.28 a
ANOVA						
df $_{1,2}$		3,63	3,63	3,63	3,63	3,63
F		9.049	0.495	96.32	38.133	105.268
Significance		0.000	0.687	0.000	0.000	0.000

Means in columns followed by the same letters are not significantly different at 5% level of probability

significantly higher when fed on heterospecific protonymphs than *T. negevi* did (ANOVA: df = 3, 54; F =231.53, *P* = 0.000) (Table 3).

Experiment 4: Immatures feeding on con- and heterospecific larvae

Immatures of *T. negevi* and *N. barkeri* fed on higher amounts of heterospecific vs. conspecific to reach the adulthood (Table 4). The immatures of *N. barkeri* fed on a similar amount of conspecific larvae as *T. negevi* fed on heterospecific ones (ANOVA: df = 3.63; F = 25.161) (Table 4). Cannibalism was significantly lower in *T. negevi* than in *N. barkeri*. The total developmental time of *T. negevi* took one week longer than *N. barkeri* did when cannibalizing larvae. Also, the developmental times of proto- and deutonymphal stages were significantly different and that depending on the

prey offered. Proportions of immature *N. barkeri* that reached adulthood were similar in the cases of both prey species. The total developmental time of *N. barkeri* took about 2 days longer when feeding on conspecific vs. heterospecific larvae (Table 5). The mean survival rates of protonymph predators were not significantly different, when they were held without a prey (t-test, t = 1.88).

DISCUSSION

The interspecific predation and cannibalism among phytoseiid mites have been considered to occur mainly as the result of low prey densities (Yao and Chant 1989; Croft and Croft 1996; Schausberger 1997). The results clearly show that females of *N. barkeri* and *T. negevi* ate both con- and heterospecific phytoseiid eggs, larvae and

protonymphs in non-choice experiments. However, differences in the number of prey consumed and in the fecundity were observed between the two species. *Neoseiulus barkeri* females ate more *T. negevi* eggs, larvae and protonymphs than vice versa. In the present study both phytoseiid species feed more on con- and heterospecific larvae than on con- and heterospecific eggs and protonymphs. These patterns are similar to those reported for other phytoseiid species (Yao and Chant 1989; Schausberger 1997, 1999a; Schausberger and Croft 2000a; Momen and Abdel Khalek 2009b). Meszaros et al. (2007) hypothesized that intra- and interspecific predations of females was generally lower on protonymphs than on larvae assuming that a protonymph provides more food than a larvae, but this does not outweigh the energy cost for searching and handling a protonymph (because of prey defense) and piercing its more sclerotised tegument. Protonymphs appear to be more difficult for attacking than larvae, being bigger and less vulnerable (Croft et al. 1996; Schausberger 1997, 1999a, 2003). In my study, the conspecific individuals proved to be a less attractive prey for the female predators. *Neoseiulus barkeri* and *T. negevi* seem to feed more on heterospecific eggs, larvae and protonymphs than on conspecific ones, probably because generalist phytoseiids alike both studied species can discriminate the heterospecific prey from the conspecific one and feed preferentially on the heterospecific prey (Schausberger 2003). The high voracity of *N. barkeri* females preying on heterospecific immatures may definitely contribute to local suppressing or even outcompeting other phytoseiids. The oviposition of both phytoseiid species used in my study were greater on heterospecfic than on conspecific prey that certainly indicates that they gained more nutritional benefits from the former kind of prey as it was shown by the studies of Schausberger and Croft (2000b), but these differences on the hetero- and conspecific prey could be caused in part by differences in total biomass consumed prey (Zannou et al. 2005). In the present study, the nutritional benefits gained by *N. barkeri* from cannibalism (on conspecific larva or protonymph) allow the predator to reproduce and survival for longer period. In contrast, females of *T. negevi* failed to sustain oviposition when fed on conspecific individuals. A large number of mite species will benefit more from predating other phytoseiids than from cannibalism (Walzer and Schausberger 1999a) and it is likely that more nutrients will be gained from in

this way (IGP) (Walzer and Schausberger 1999b). In general, phytoseiid eggs seem to be less vulnerable for the intrguild predation than larvae because most predators have difficulties in grasping and piercing loose eggs (Schausberger and Croft 1999, 2000a). The oviposition rates of *N. barkeri* fed on the heterospecific prey were similar to the rates reported from other adequate diets at comparable environmental conditions. *Neoseiulus barkeri* female produced 1.9, 2.1, 2.3 eggs per female per day on nymphs of *T. urticae*, *T. tabaci* and two eriophyid mites *Acaria oleae* Nalepa, *Tegolophus hassani* Keifer (Acari: Eriophyidae) (Bonde 1989; Momen 1995; Metwally et al. 20005). Interestingly, *N. barkeri* was able to sustain the oviposition (1.8, 0.66 eggs / female/ day) when fed on conspecific larvae and protonymphs, which was similar to the oviposition rate on the primary prey *T. urticae* and *Aceria dioscorides* (Soliman and Abou-Awad) (Acari: Eriohyidae) reported by Momen (1995). For *T. negevi*, the oviposition rates (eggs per female per day) from 1.2 on active stages of *Aculus fockeui* (Nalepa and Trouessart) (Acari: Eriophyidae), eggs of *T. urticae* and pollen grains of *R. communis* to 0.8 on eggs of the white fly *Bemisia tabaci* Gennadius (Homoptera: Aleyrodidae) and scale insect *Insulaspis pallidula* (Green) (Homoptera: Diaspididae) have been reported by Momen (2009) and Momen et al. (2009). For adult females of some species, cannibalism on immatures (in extremis on their own progeny) may, therefore, be considered a mechanism to (re)gain the energy, which can be (re)invested into offspring production when conditions improve (Schausberger 2003). The kin cannibalism (like the present study) may provide an immature with an advantage in survivorship, development and size and this may lead to more successful foraging than its kin competitors (Schausberger 2003).

The developmental time of *N. barkeri* feeding on *T. negevi* larvae was similar to the time measured by Bonde (1989) with other adequate food source such as *T. tabaci*. Kabicek (1995) stated that *N. barkeri* was able to complete their ontogenetic development on eggs and larvae of *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseiidae). He mentioned also that the developmental period was 7 days on *P. persimilis* and the average food consumption during the life cycle was 14.8 of *P. persimilis* eggs. Most interestingly, the immatures of *N. barkeri* developed on the exclusive cannibalistic diet as fast as on their primary prey, the spider mite (Momen 1995). The developmen-

tal time of *T. negevi* with the conspecific prey (13.3 days, respectively) were longer than that with eggs and nymphs of *T. urticae* (Abou-Awad et al. 1989; Momen 1999). The research done by Schausberger and Croft (2000) as well as Momen and Abdel-khalek (2009a) indicated that the generalist predators, *A. andersoni, N. cucumeris, N. fallacis, Typhlodromips swirskii* (A. H.), *Typhlodromus athiasae* Porath et Swirski and *Euseius scutalis* (A. H.), were able to complete the juvenile development with con- and heterospecific prey.

These results were obtained in the laboratory (small-scale) and drawing of any conclusions about predation and interactions between the two species under field conditions is difficult. However, the intraguild interaction in this small scale may differ from that in the field. For example, the habitat structure, antipredatory behavior of prey (escaping) and differences in the food web complexity suggested that the IGP effect on pest population might not be so relevant in the field.

CONCLUSION

The present study has revealed IGP and cannibalism exist in the two species tested. Nevertheless, further studies are needed (i.e. functional and numerical response of each IG predator — IG prey combination) in a larger scale in order to determine recommendations for the use of these two predators together in greenhouse crops. Summarizing all the experiments indicates: (1) *N. barkeri* exhibits stronger predation on *T. negevi* than vice versa (2) *N. barkeri* benefits more from predation on *T. negevi* than from cannibalism (3) *N. barkeri* is more cannibalistic than *T. negevi* (4) heterospecific phytoseiids may be classified as an alternative food for *N. barkeri* and *T. negevi* (Overmeer 1985).

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