

Prey consumption capacity and functional response of *Phytoseiulus persimilis* (Acari: Phytoseiidae) feeding on *Tetranychus urticae* (Acari: Tetranychidae) on different cotton varieties

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Original research

ABSTRACT

This study aimed to determine the predatory performance of *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseiidae) against *Tetranychus urticae* Koch (Acari: Tetranychidae) on six different cotton varieties (Gloria, Lima, Carla, DP-396, Edessa, ST-468) with different leaf characteristics. The eggs and the protonymph stages of the prey with six prey densities (5, 10, 20, 40, 80 and 160) were separately offered to a single female predator to determine its predation and oviposition rates for 24h. The results showed that *P. persimilis* exhibited a Type II functional response to both egg and protonymphal stages of *T. urticae* irrespective of cotton varieties. The highest attack rates (α) were 0.045 h⁻¹ and 0.085 h⁻¹ when the predator fed on eggs and protonymphs of *T. urticae* on Gloria (low trichome density) variety, respectively. There was a great similarity between the handling times (Th) of *P. persimilis* feeding on *T. urticae* eggs and protonymphs among different cotton varieties. No significant difference was found in terms of food consumption of *P. persimilis* fed on *T. urticae* eggs in different cotton varieties. In contrast, food consumptions of *P. persimilis* in all protonymph densities (except 160) were significantly higher on varieties with lower trichome density (Gloria and Lima) compared to the varieties with higher trichome density (Edessa and ST-468). The current study showed that the leaf trichome density of the cotton plant affected the prey consumption capacity of *P. persimilis* on *T. urticae* protonymphs. However, more studies are needed to address the issue from a wider perspective, especially to observe the performance and biological control potential of *P. persimilis* on cotton varieties under field conditions.

Keywords two-spotted spider mite; morphological structure; leaf hairiness; predatory mite; prey density; consumption rate

Introduction

Cotton (*Gossypium hirsutum* L.) is one of the most important industrial fiber crops. It is cultivated in nearly 100 countries with temperate and tropical climates in the world (Tokel

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2021). India, China, and the United States of America are the top producers and Türkiye ranks 8th. Annual production of this valuable cultural plant can reach 25.733 billion tons (ICAC 2023).

Cotton plants are vulnerable to attacks from various pests. Tetranychid mites such as *Tetranychus urticae* Koch and *T. turkestanii* (Ugarov & Nikolski) (Acari: Tetranychidae), puncture and feed on plant cells using their suctorial mouthparts on the undersides of leaves. The feeding activity on plant leaves greatly affects plant growth and subsequent cotton yield (Yüksel 2023). Cotton plants can employ different mechanical and chemical strategies to hinder pest activity. For example, different cotton varieties can exhibit varying trichome densities on their leaves and stems. Trichome, unicellular and multicellular extensions that grow out of the epidermis on various plant organs, can play important roles in plant defense (Wang *et al.* 2021). Such pubescence phenotypes can be described as smooth (no hairy), hairy (medium hairy), or pilose (high hairy) (Wright *et al.* 1999). Hairiness can increase resistance to pests especially mites by producing toxic chemicals and physical deterrent effects. Trichomes affect the feeding, growth, and survival of mites (Nawab *et al.* 2011). Sulek and Cakmak (2022) demonstrated that cotton varieties with higher trichome density negatively affected the development, reproduction and population parameters of *T. urticae*.

Different levels of leaf hairiness might affect natural enemies of spider mites (Skirvin and De Courcy Williams 1999). *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseiidae) is a predatory mite widely used for the control of *Tetranychus* spp. mites on important cultivated plants such as strawberries, cucumbers, peppers and tomatoes under greenhouse conditions. The performance of this predatory mite can be negatively affected by temperature, prey type, the host plant and plant defenses, pesticides, etc. (Cakmak *et al.* 2005, 2009). This mite may occur in cotton fields in Aydin province where acaricides are widely used (at least 5-6 sprays are made against *T. urticae*). Under greenhouse conditions, *P. persimilis* is highly effective against *T. urticae* on cucumber plants but fail to control spider mites on eggplants due to the presence of hairy leaves. Likewise, *P. persimilis* performance is low on tomato varieties with leaves with dense trichomes (Helle and Sabelis 1985). No study has thus far assessed the effectiveness of *P. persimilis* against *T. urticae* in different cotton varieties. This study aimed to determine the effects of leaf characteristics of different cotton varieties on the performance of the predatory mite *P. persimilis*.

Material and methods

Cotton varieties

Common cotton (*Gossypium hirsutum* L.) varieties (Gloria, Lima, Carla, DP-396, Edessa, ST-468) from Türkiye were used for the experiments. According to Sulek and Cakmak (2022), the trichome densities on leaves of these cotton varieties were high for ST-468 and Edessa; medium for DP-396 and Carla; and low for Lima and Gloria. These cotton varieties were grown in pots (12 × 10 cm) with forest soil mixed with perlite (2:1 ratio) and incubated at 25 ± 2 °C, 16L/8D h photoperiod and 65 ± 10% RH in a climate chamber.

Mite Rearing

Spider mites and predatory mites were sampled from cotton fields in Germencik, Aydin and have been kept in the laboratory since 2017 in separate climate chambers at 25 ± 1°C, 16L/8D h photoperiod, and 70 ± 10% relative humidity. *Tetranychus urticae* (green form) were maintained on clean *Phaseolus vulgaris* (cv. 'Barbunia') plants. They were grown in pots (12 × 10 cm) in a climate room at 25 ± 2 °C, 65 ± 10% RH and 16L/8D h photoperiod (PG34 – 3 Digitech Ltd., Ankara, Türkiye) (Cakmak *et al.* 2005, 2009).

Phytoseiulus persimilis was reared and maintained on tetranychid infested bean leaves on inverted pots in two interlocking trays covered with plexiglass box (Kustutan and Cakmak

2009; Kamburgil and Cakmak 2014). Trays were filled with tap water to prevent predatory mite from escaping; infested leaves were added to the predatory mite culture thrice a week.

Functional response and egg production of *Phytoseiulus persimilis* on six cotton varieties

Experiments on functional response and egg production of *P. persimilis* on six cotton varieties were conducted using 9 cm plastic Petri dishes. Firstly, cotton leaves (6 cm Ø) were placed with lower surface up on moist cotton (6 cm Ø) in Petri dishes (one leaf/dish); the space between leaf edges and Petri sides was inundated to prevent predator mite from escaping.

To obtain a cohort of *T. urticae* individuals at the same age for the experiments, 50 gravid *T. urticae* females were transferred with a fine brush to each leaf and allowed to lay eggs for 24 hours. After egg laying, the adults removed from the test units. Thus, only eggs were left in each Petri dish. In this way, eggs and protonymphs of the same age of *T. urticae* were obtained.

To starve the predatory mites, females were individually transferred from stock cultures to new Petri dishes (9 cm) which were placed on water-saturated cotton wool in higher-sized plastic cups. The predators starved for one hour before being used in the experiments. One starved female was transferred to an experimental arena with six prey densities of (5, 10, 20, 40, 80 and 160 eggs or protonymphs) of *T. urticae*. In the study, 20 replications were used for each prey density. After 24 hours, the number of prey items and the number of eggs consumed and produced by the predatory mite were determined. The number of prey consumed by the predatory mite depending on the prey density was used to determine the functional response and its parameters. All experiments were carried out at 25 ± 1 °C, $65 \pm 5\%$ RH and 16L/8D h photoperiod in a climate room (PG34–3 Digitech Ltd., Ankara).

Statistical analyses

The functional responses of *P. persimilis* depending on the different biological stages (egg and protonymph) and density of *T. urticae* were analyzed using a two-step data analysis in SAS portable version 9.4 (Juliano 2001). In this regard, functional response type was ascertained using the logistic regression of the prey density (N_a/N_0) consumed by the predator depending on the initial prey density (N_0) (Juliano 2001). The formula below (1) was used to calculate the functional response type of the predatory mite, and P_0 , P_1 , P_2 and P_3 given in the equation indicate constant, linear, quadratic and cubic coefficients, respectively. Accordingly, significantly negative linear P_1 parameter indicates that the predator exhibits a Type II functional response regardless of cotton varieties.

$$(1) \frac{N_a}{N_0} = \frac{\exp(P_0 + P_1 N_0 + P_2 N_0^2 + P_3 N_0^3)}{1 + \exp(P_0 + P_1 N_0 + P_2 N_0^2 + P_3 N_0^3)}$$

In the second step, the predator's handling time (T_h) and attack rate (α) were calculated using the random predator equation (formula 2) as suggested by Rogers (1972);

$$(2) N_a = N_0[1 - \exp(-\alpha(T_h * N_a - T))]$$

where N_a is the number of prey consumed; T is the experimental period (hour); N_0 is the initial number of preys offered to the predator; α indicates the attack rate and T_h indicates the handling time of the predator.

The number of prey items consumed and the number of eggs laid by the predatory mite were separately analyzed using General Linear Model (GLM) factorial analyses. The six cotton varieties, the two biological stages of the prey, and the six prey densities were considered as three factors, and their interactions were determined. Because the interactions are significant in all cases, the data regarding prey consumption was subjected to One-way ANOVA, and the differences among cotton varieties were determined by using Student–Newman–Keuls test. In addition, differences among two prey stages within the same prey density were determined

by using independent samples T-test. Prior to data analysis, normality and homogeneity of variances were confirmed by using Shapiro–Wilk and Levene’s test, respectively. Because the interactions among the cotton varieties, prey stage, and densities are not significant in all cases, no further analyses were conducted with regard to egg production data. In addition, numerical responses of the predator were calculated by using the formula suggested by Omkar and Pervez (2004) and Fathipour *et al.* (2020). However, very low R^2 values were obtained when egg production and efficiency of conversion of ingested food (ECI) versus initial prey density were fitted using linear regression. Therefore, the results regarding numerical response were not included to paper. All analyses were performed in SPSS (version 25.0 Chicago IL, USA).

Results

Estimated linear coefficients (P_1 values) by the logistic regression in relation to initial *T. urticae* egg and protonymph densities on different cotton varieties were significantly negative (Table 1). In addition, the prey consumption rates of *P. persimilis* decreased with increasing prey densities in six different cotton varieties (Figures 1 and 2). Therefore, *P. persimilis* exhibited a Type II functional response against *T. urticae* eggs and protonymphs regardless of cotton varieties. The highest attack rates (α) are 0.045 h^{-1} and 0.085 h^{-1} when the predator fed on eggs and protonymphs of *T. urticae* on Gloria (low trichome density) variety, respectively (Tables 2 and 3). In contrast, the lowest attack rates are 0.040 h^{-1} and 0.047 h^{-1} when the predator fed on eggs and protonymphs of *T. urticae* on ST-468 (high trichome density) variety, respectively. The handling times (T_h) obtained on six cotton varieties ranged between 0.344–0.353 h and 0.373–0.426 h when the predator fed on eggs and protonymphs of *T. urticae*.

A factorial analysis within GLM on prey consumption of the predator revealed that there

Table 1 Estimated coefficients by logistic regression of proportion of prey consumption adult female *Phytoseiulus persimilis* in relation to initial *Tetranychus urticae* eggs and protonymphs density on different cotton varieties in 24 hours

Varieties	Parameters ¹	Eggs			Protonymphs		
		Estimates±S.E.	χ^2	P value	Estimates±S.E.	χ^2	P value
Gloria (Low) ²	P_0	2.2661±0.203	124.34	<0.0001	2.2303±0.218	104.46	<0.0001
	P_1	−0.1066±0.012	83.30	<0.0001	−0.0676±0.123	30.22	<0.0001
	P_2	0.0013±0.0002	60.83	<0.0001	0.0007±0.0002	15.53	<0.0001
Lima (Low)	P_0	1.9678±0.0195	102.03	<0.0001	2.1459±0.216	99.14	<0.0001
	P_1	−0.0911±0.011	64.70	<0.0001	−0.0625±0.012	26.26	<0.0001
	P_2	0.0011±0.0002	43.99	<0.0001	0.0006±0.0002	12.21	<0.001
Carla (Medium)	P_0	1.5473±0.0185	70.22	<0.0001	2.0438±0.199	105.49	<0.0001
	P_1	−0.0689±0.011	39.96	<0.0001	−0.0887±0.011	59.79	<0.0001
	P_2	0.0007±0.0002	21.29	<0.0001	0.0011±0.0002	42.90	<0.0001
DP-396 (Medium)	P_0	1.5502±0.0184	71.15	<0.0001	2.1372±0.199	114.79	<0.0001
	P_1	−0.0738±0.011	46.06	<0.0001	−0.1003±0.012	75.94	<0.0001
	P_2	0.0009±0.0002	30.14	<0.0001	0.0013±0.0002	59.09	<0.0001
Edessa (High)	P_0	1.7512±0.0188	86.40	<0.0001	1.2312±0.178	47.95	<0.0001
	P_1	−0.0837±0.011	57.21	<0.0001	−0.0564±0.011	28.26	<0.0001
	P_2	0.0010±0.0002	38.85	<0.0001	0.0007±0.0002	18.98	<0.0001
ST-468 (High)	P_0	1.9051±0.0192	98.14	<0.0001	1.2611±0.178	49.73	<0.0001
	P_1	−0.0911±0.011	65.78	<0.0001	−0.0552±0.011	26.88	<0.0001
	P_2	0.0011±0.0002	44.96	<0.0001	0.0007±0.0002	16.96	<0.0001

¹Coefficients: P_0 , P_1 and P_2 are constant, linear and quadratic, respectively.

²Trichome density

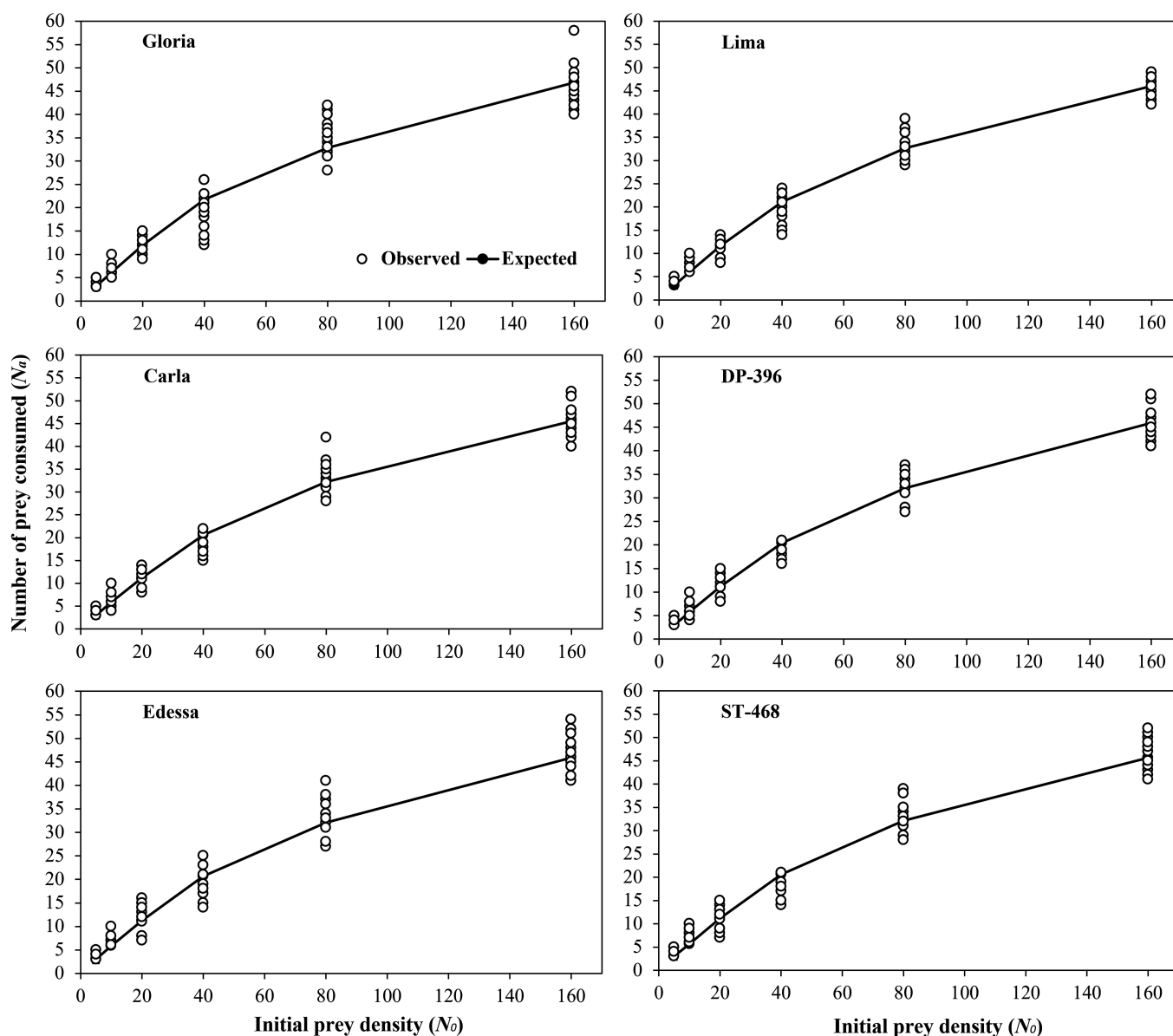


Figure 1 Functional response curves of *Phytoseiulus persimilis* to different egg densities of *Tetranychus urticae* on different cotton varieties

were significant interactions between host plant variety $\times$ prey stage ($F=10.387$; $P<0.001$), prey density $\times$ prey stage ($F=39.952$; $P<0.001$), host plant variety $\times$ prey density ($F=2.780$; $P<0.001$) as well as the interactions of the three factors ($F=2.007$; $P<0.001$).

Although no significant difference was determined regarding food consumption of *P. persimilis* fed on *T. urticae* eggs on different cotton varieties, numerically higher values were obtained on the Gloria (low trichome density) variety in general (Table 4). In contrast, food consumptions of *P. persimilis* in all protonymph densities (except 160) were significantly higher on varieties with lower trichome density (Gloria and Lima) compared to varieties with higher trichome density (Edessa and ST-468). Independent sample T-test on egg and protonymph consumptions of the predator revealed that it consumed more protonymphs compared to eggs at 20, 40, and 80 densities on Gloria and Lima varieties, and at 20 and 80 prey densities on Carla and DP-396 varieties (P two-tailed <0.001). In contrast, egg consumption of the predator

compared to protonymph consumption were significantly higher at 5, 10 and 80 prey densities on Edessa and ST-468 varieties (P two-tailed <0.001). Furthermore, the number of prey items consumed by the predatory mite increased with increasing prey densities for both biological stages of the prey.

A factorial analysis within GLM on egg production of the predator revealed that there were no significant interactions between host plant variety $\times$ prey stage ($F=0.586$; $P=0.711$), prey density $\times$ prey stage ($F=0.515$; $P=0.765$), host plant variety $\times$ prey density ($F=0.439$; $P=0.993$) as well as the interactions of the three factors ($F=0.286$; $P=1.00$). Although there was no significant difference between the numbers of eggs produced by the predatory mite among different cotton varieties, egg production was also increased in response to increasing prey densities (Table 5).

Discussion

Aydin is a province located in the western part of Türkiye. It has suitable climatic conditions and fertile plains and has long been a production center of cotton plants. Population outbreaks of *T. urticae* and failures in controlling this mite probably due to resistance problems have been reported in cotton fields in the region (Sulek and Cakmak 2022). Despite the heavy insecticide and acaricide applications in cotton fields, *P. persimilis* unexpectedly is the most abundant predator associated with *T. urticae* in the region. This predatory mite is one of the most comprehensively studied species as a specialized on *T. urticae*. This is the first study assessing its foraging behavior on different cotton varieties with varying degrees of leaf hairiness. Therefore, this study documents the functional response and egg production of *P. persimilis* fed on *T. urticae* on six cotton varieties for the first time.

According to the results, *P. persimilis* exhibited a Type II functional response to both egg and protonymph stages of *T. urticae* irrespective of cotton varieties. This result was not surprising since a series of studies reported a Type II functional response for phytoseiid mites

Table 2 Attack rate (α), handling time (T_h) and confidence limits of the Rogers's Random Predator Equation for *Phytoseiulus persimilis* preying on *Tetranychus urticae* eggs on different cotton varieties

Varieties	Trichome density	$\alpha \pm \text{SE}$ (h^{-1})	95% CL		$T_h \pm \text{SE}$ (h)	95% CL		R^2
			Lower	Upper		Lower	Upper	
Gloria	Low	0.045 $\pm$ 0.002	0.040	0.051	0.353 $\pm$ 0.015	0.323	0.383	0.905
Lima	Low	0.043 $\pm$ 0.001	0.040	0.047	0.354 $\pm$ 0.010	0.332	0.376	0.932
Carla	Medium	0.041 $\pm$ 0.001	0.037	0.045	0.349 $\pm$ 0.012	0.326	0.373	0.930
DP-396	Medium	0.040 $\pm$ 0.001	0.037	0.043	0.343 $\pm$ 0.011	0.321	0.365	0.936
Edessa	High	0.041 $\pm$ 0.002	0.037	0.045	0.344 $\pm$ 0.011	0.316	0.373	0.921
ST-468	High	0.040 $\pm$ 0.001	0.037	0.044	0.344 $\pm$ 0.012	0.320	0.368	0.935

Table 3 Attack rate (α), handling time (T_h) and confidence limits of the Rogers's Random Predator Equation for *Phytoseiulus persimilis* preying on *Tetranychus urticae* protonymphs on different cotton varieties

Varieties	Trichome density	$\alpha \pm \text{SE}$ (h^{-1})	95% CL		$T_h \pm \text{SE}$ (h)	95% CL		R^2
			Lower	Upper		Lower	Upper	
Gloria	Low	0.085 $\pm$ 0.005	0.075	0.096	0.426 $\pm$ 0.010	0.405	0.446	0.825
Lima	Low	0.084 $\pm$ 0.005	0.076	0.093	0.431 $\pm$ 0.009	0.413	0.449	0.833
Carla	Medium	0.056 $\pm$ 0.003	0.050	0.062	0.392 $\pm$ 0.011	0.369	0.415	0.879
DP-396	Medium	0.055 $\pm$ 0.003	0.048	0.062	0.404 $\pm$ 0.014	0.376	0.433	0.859
Edessa	High	0.047 $\pm$ 0.002	0.042	0.052	0.372 $\pm$ 0.012	0.347	0.397	0.895
ST-468	High	0.047 $\pm$ 0.003	0.042	0.053	0.373 $\pm$ 0.013	0.347	0.399	0.893

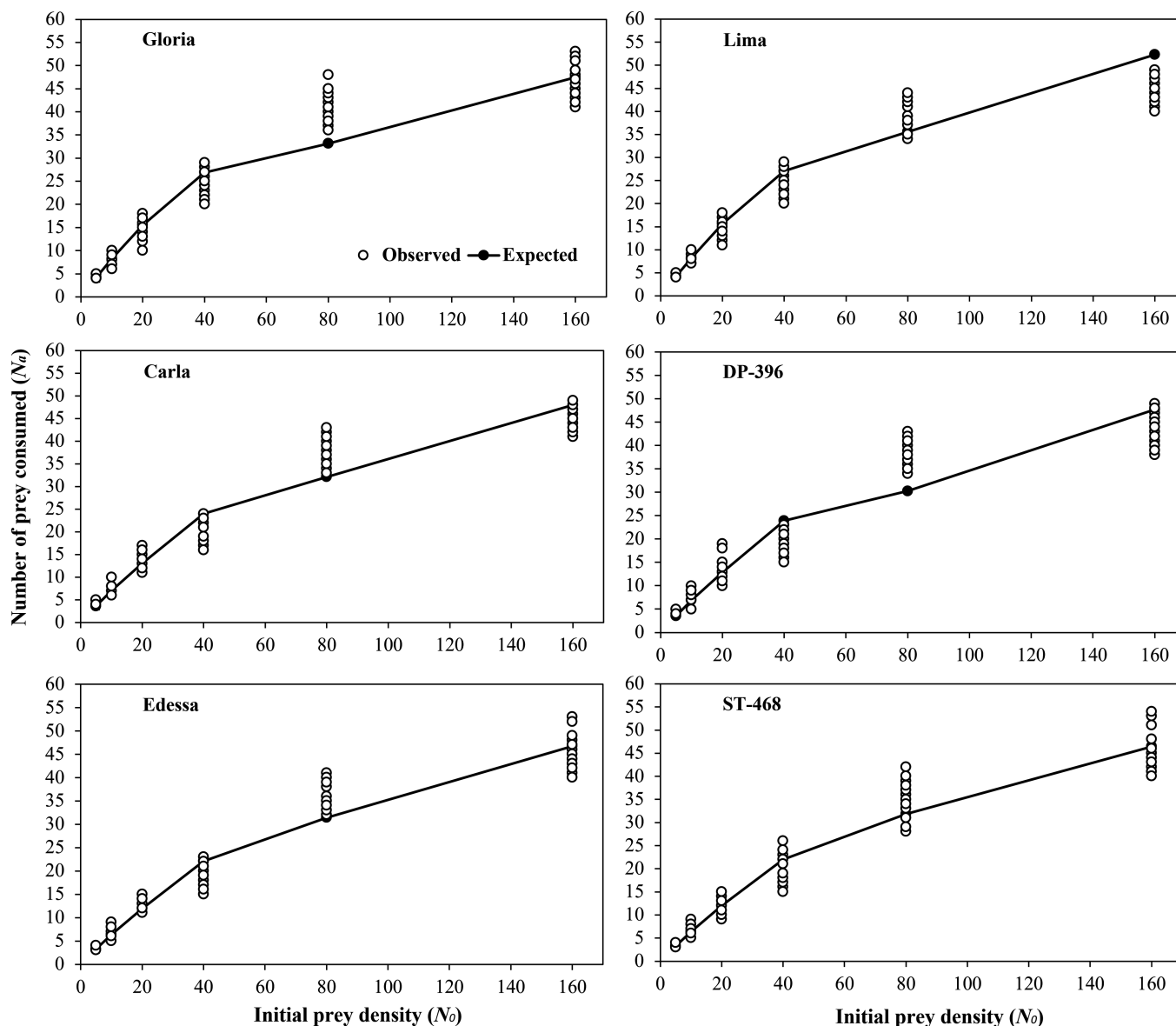


Figure 2 Functional response curves of *Phytoseiulus persimilis* to different protonymph densities of *Tetranychus urticae* on different cotton varieties

under a variety of factors including temperature, humidity, host plant, insecticide applications, age, and rearing history of the predator (Castagnoli and Simoni 1999; Poletti *et al.* 2007; Kustutan and Cakmak 2009; Ahn *et al.* 2010; Döker *et al.* 2016; Fathipour *et al.* 2018; Sugawara *et al.* 2018).

In general, no significant difference was detected among the attack rates of the predator except on Gloria and Lima varieties – these have low trichome densities – when feeding on protonymphs. Similarly, Krips *et al.* (1999) reported low searching efficiency of *P. persimilis* on gerbera varieties that had higher trichome density. Jafarian *et al.* (2022) found that the attack rates of protonymphs of another phytoseiid mite *Typhlodromus bagdasarjani* Wainstein & Arutunjan fed *Eotetranychus frosti* (McGregor) (Acari: Tetranychidae) varied on different apple varieties. The authors reported more than two times higher attack rate on a low hairy cultivar (Kohanz Golab) compared to a high hairy cultivar (Granny Smith). Koveos and Broufas

(2000) also reported a substantially lower attack rate for *Amblyseius andersoni* (Chant) and *Euseius finlandicus* (Oudemans) on apple leaves compared to peaches. In general, our results also showed that the attack rates obtained on protonymphs were higher than those obtained on eggs. This result can be explained by the size of prey, and the predator may spend less time finding a protonymph than finding an egg (Li and Zhang 2020; Döker *et al.* 2021).

In contrast to attack rates, there was a great similarity in the handling times of *P. persimilis*

Table 4 Average daily number of *Tetranychus urticae* eggs and protonymphs consumed by *Phytoseiulus persimilis* at different prey densities and cotton varieties (Mean±SE)

		Prey density ¹		Cotton varieties			
		Gloria (Low) ²	Lima (Low)	Carla (Medium)	DP-396 (Medium)	Edessa (High)	ST-468 (High)
Egg ³	5	4.5±0.2	4.4±0.1	4.1±0.2	4.1±0.2	4.0±0.2*	4.1±0.2*
	10	8.5±0.4	8.1±0.3	7.2±0.4	7.2±0.4	7.7±0.4*	8.0±0.3*
	20	11.6±0.4*	11.4±0.4*	11.8±0.4*	11.2±0.5*	11.6±0.6	11.2±0.5
	40	19.2±0.9*	19.3±0.6*	18.8±0.5	18.7±0.4	18.4±0.7	18.3±0.4
	80	35.1±0.9*	33.8±0.7*	33.1±0.8*	33.2±0.6*	33.5±0.8*	33.2±0.6*
	160	46.3±1.0	45.8±0.5	45.5±0.7	45.7±0.6	45.8±0.9	45.8±0.8
Protonymph ⁴	5	4.5±0.1 a	4.4±0.1 a	4.3±0.1 a	4.4±0.1 a	3.4±0.1 b	3.6±0.1 b
	10	8.3±0.3 ab	8.5±0.3 a	7.5±0.3 bc	7.4±0.3 bc	6.6±0.3 b	6.8±0.2 b
	20	14.9±0.5 a	14.7±0.5 a	13.8±0.4 ab	13.5±0.6 ab	12.7±0.3 b	12.4±0.4 b
	40	25.1±0.7 a	25.2±0.7 a	19.8±0.6 b	18.7±0.6 b	18.5±0.5 b	19.2±0.7 b
	80	40.8±0.8 a	40.1±0.7 ab	37.9±0.7 bc	38.1±0.6 bc	36.0±0.7 b	35.6±0.8 b
	160	45.8±0.9 a	45.4±0.6 a	45.0±0.6 a	43.4±0.8 a	44.7±0.9 a	44.8±0.9 a

¹ Provided daily number of the *Tetranychus urticae* eggs and protonymphs as prey for one adult female *Phytoseiulus persimilis*

² Trichome density

³ Means within same row are not significantly different between varieties according to Student–Newman–Keuls Test ($P < 0.05$)

⁴ Means within same row with different letters indicated statistical differences according to Student–Newman–Keuls Test ($P < 0.05$)

*Denotes significant differences between two prey stages within same prey density according to independent samples T-test (P two-tailed < 0.05)

Table 5 Average daily number of eggs laid by *Phytoseiulus persimilis* feeding on *Tetranychus urticae* eggs and protonymphs at different prey densities and cotton varieties (Mean±SE).

		Prey density ¹		Cotton varieties			
		Gloria (Low) ²	Lima (Low)	Carla (Medium)	DP-396 (Medium)	Edessa (High)	ST-468 (High)
Egg	5	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0
	10	0.4±0.1	0.5±0.1	0.4±0.1	0.5±0.1	0.5±0.1	0.5±0.1
	20	0.6±0.1	0.6±0.1	0.4±0.1	0.5±0.1	0.5±0.1	0.5±0.1
	40	0.7±0.1	0.6±0.1	0.5±0.1	0.5±0.1	0.5±0.1	0.6±0.1
	80	1.6±0.1	1.5±0.1	1.4±0.1	1.3±0.2	1.3±0.2	1.4±0.1
	160	2.5±0.1	2.4±0.2	2.4±0.1	2.3±0.1	2.3±0.1	2.4±0.1
Protonymph	5	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0
	10	0.4±0.1	0.6±0.1	0.4±0.1	0.3±0.1	0.3±0.1	0.4±0.1
	20	0.7±0.1	0.7±0.1	0.5±0.1	0.6±0.1	0.5±0.1	0.5±0.1
	40	0.7±0.1	0.7±0.1	0.5±0.1	0.6±0.1	0.5±0.1	0.5±0.1
	80	1.5±0.1	1.6±0.1	1.3±0.1	1.3±0.1	1.5±0.1	1.5±0.1
	160	2.5±0.1	2.5±0.1	2.3±0.1	2.4±0.1	2.4±0.1	2.2±0.1

¹ Provided daily number of the *Tetranychus urticae* eggs and protonymphs as prey for one adult female *Phytoseiulus persimilis*

² Trichome density

³ Means within same row are not significantly different between varieties according to Student–Newman–Keuls Test ($P < 0.05$)

feeding on prey eggs and protonymphs on the different cotton varieties. This result can be explained by the prey specialization of *P. persimilis* on *Tetranychus* species (McMurtry *et al.* 2013). The handling time is the time that is spend by the predators between the first encounter, capture, feed, and digestion of a prey item (Fathipour *et al.* 2018; Papanikolaou *et al.* 2020). Therefore, due to the prey specialization of *P. persimilis*, the time between the first encounter with a prey and its digestion, and search for the next prey items was not influenced by the host plant characteristics.

No significant difference was found in terms of food consumption of *P. persimilis* on *T. urticae* eggs on different cotton varieties. In contrast, food consumptions of *P. persimilis* in all protonymph densities (except 160) were significantly higher on varieties with low trichome density (Gloria and Lima) compared to varieties with high trichome density (Edessa and ST-468). Similarly, Krips *et al.* (1999) reported that the consumption rate of *P. persimilis* fed on *T. urticae* eggs on low-high hairy gerbera plants was affected by leaf hairiness, especially at low prey densities (1, 3, and 2.5 eggs/cm²). The authors found that consumption was higher in a low-hairy variety at low prey densities, but no difference between varieties at high prey densities (8 eggs/cm²). Nassar *et al.* (2010) also reported that the number of *T. urticae* nymphs consumed by *P. persimilis* on seven different cultivated plants vary between 5.91 and 16.37 depending on the leaf hairiness. In addition, Camporese and Duso (1996) found that the abundance of *A. andersoni* in hairless grape varieties was substantially higher compared to hairy varieties under field conditions.

Similarly, there was no significant difference between the number of eggs laid by *P. persimilis* fed on *T. urticae* eggs and protonymphs depending on different prey densities, and cotton varieties. However, the number of eggs laid by *P. persimilis* was increased with increasing egg and protonymph densities of *T. urticae*. Similarly, Ottaviano *et al.* (2013) reported that the number of eggs laid by *Neoseiulus californicus* (McGregor) on strawberry varieties with different trichome densities were increased depending on the prey density but did not differ between varieties. In contrast, Nassar *et al.* (2010) observed a statistical difference in the number of eggs laid by *P. persimilis* in seven different cultivated plants (bean, apple, fig, zucchini, cucumber, mango and cotton) with varying amounts of hairiness. The authors reported the lowest number of eggs on medium hairy mango (2.56 eggs/day) and cotton (2.51 eggs/day). The number of eggs laid in beans and apples with low hair rate was reported as 3.95 eggs/day and 3.73 eggs/day, respectively (Nassar *et al.* 2010).

In conclusion, determination of prey consumption capacity of a predator on different host plants is a keystone for the success of biological control (Skirvin and Fenlon 2001). Plant characteristics such as hairiness on the leaf surface may influence prey and predator relationships (Roda *et al.* 2001). The current study showed that the leaf trichome density of the cotton plant affected the prey consumption capacity of *P. persimilis* on *T. urticae* protonymphs. However, more studies are needed to address the issue from a wider perspective, especially to observe the performance and biological control potential of *P. persimilis* on cotton varieties under field conditions.

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