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New records of phytoseiid mites (Acari: Phytoseiidae) on solanaceous plants in the Syrian coastal region

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Original research

ABSTRACT

Phytoseiid mites have been considered the most promising predators for the control of pest mites and small insects. Their use in solanaceous crops for the biological control of major mite pests represents an important challenge and requires continued research. This study aimed at investigating the phytoseiid species and their associated phytophagous mites on eggplant (*Solanum melongena*), tomato (*Solanum lycopersicum*) and black nightshade (*Solanum nigrum*) in the Syrian coastal region between 2018 and 2020, at 40 sites. A total of 12 species of the three subfamilies (Amblyseiinae Muma, Phytoseiinae Berlese, and Typhlodrominae Scheuten) were collected, with Amblysiinae being the most represented. Among them, *Amblyseius andersoni* (Chant) is a new record for the Syrian fauna. *Phytoseiulus persimilis* Athias-Henriot was the most abundant (223 specimens; 47.3%) and frequent (found in 22 out of 40 sites) species collected on all plant species surveyed and the only common phytoseiid species in greenhouses. The second most abundant species was *Neoseiulus californicus* (McGregor) (83 specimens: 17.6%), while the second most frequent was *Phytoseius finitimus* Ribaga (8 sites). Species found in this study should be considered in future research on phytoseiid mites as biological control agents of pests of tomato and eggplant cultivated in greenhouses and open fields in this region.

Keywords biological control; natural enemies; predatory mites; Solanaceae

Introduction

Several solanaceous plants are of considerable economic importance worldwide because they are used as food, ornamentals and sources of medicinal compounds. In Syria, solanaceous species such as tomato, eggplant, potato, and pepper are widely cultivated. They are affected by some phytophagous mites, among which the two-spotted spider mite and the tomato red spider mite (respectively, *Tetranychus urticae* Koch and *Tetranychus evansi* Baker and Pritchard, Tetranychidae), the broad mite (*Polyphagotarsonemus latus* (Banks), Tarsonemidae), and the tomato russet mite (*Aculops lycopersici* (Tryon), Eriophyidae) are some of the main pests of solanaceous crops worldwide (Zhang 2003; Navajas *et al.* 2013).

Phytoseiids are the best known and most studied group of predatory mites, owing to their known successful use for the biological control of small insect and mite pests on numerous crops (McMurtry *et al.* 2013; Knapp *et al.* 2018). However, on solanaceous crops, the presence of unfavorable traits (physical and chemical barriers) for phytoseiid predators, notably in tomato, often makes their efficacy unsatisfactory (Gerson *et al.* 2003; Vervaet *et al.* 2021; Paspati *et al.* 2021). The control of the major mite pests of these crops remains a great challenge and requires continued research. Therefore, prospecting for predatory mites in different agroecosystems, as well as on wild host plants which serve as reservoirs, may lead to the discovery of promising species for biological control programs.

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The Syrian coastal region, which includes Latakia and Tartus governorates, produces more than a third of the total national production of tomato and eggplant under both open-field and protected conditions (AASA 2020). Surveys were conducted in this region between 2018 and 2020 to identify the natural enemies of phytophagous mites on solanaceous plants. Five phytoseiid species have been reported in association with *T. evansi* on cultivated and wild solanaceous plants (Dayoub *et al.* 2022). In this study, we present additional records of phytoseiid mites found in association with other phytophagous mites on solanaceous plants in the Syrian coastal region.

Material and methods

Surveys of phytoseiids and associated phytophagous mites on some wild and cultivated Solanaceae plants were conducted in Latakia and Tartus governorates between 2018 and 2020, at 40 sites. These sites included 37 that were cultivated with tomato, *Solanum lycopersicum* L., (4 greenhouses + 5 open fields) and eggplant, *Solanum melongena* L., (7 greenhouses + 21 open fields), as well as three uncultivated areas with naturally growing black nightshade plants (*Solanum nigrum* L.). At each site, 30 leaves of each plant species were randomly collected, placed in a plastic bag and transported to the laboratory, where samples were examined under a stereomicroscope (Micros, Ladybird MZ1240, Austria). Mites were collected in 70% ethanol, subsequently mounted in Hoyer's medium and identified using a microscope (OPTIKA B195, Italy) with an attached digital camera (OPTIKA C-B10, 10 megapixel, Italy). The measurements of the single newly recorded species from Syria are given in micrometers, adopting the systems of setal notation for the dorsum and venter of Rowell *et al.* (1978) and Chant and Yoshida-Shaul (1991), respectively. Relevant taxonomic structures were measured using OPTIKA PROVIEW software (version x64, 4.11.18081.20201205). Voucher specimens were deposited at the Laboratory of Plant Protection Research, Faculty of Agriculture, Tishreen University, Latakia, Syria.

Identification was carried out to genus/species level using the identification keys provided in the following publications: Tetranychidae (Jeppson *et al.* 1975), Tenuipalpidae (Welbourn *et al.* 2003; Mesa *et al.* 2009; Çobanoğlu *et al.* 2016), Tarsonemidae (Zhang 2003; Nucifora and Vacante 2004), Phytoseiidae (Chant 1960; Barbar 2013; Kreiter *et al.* 2016, 2020; Toyoshima *et al.* 2016; Ferragut 2018; Döker *et al.* 2020).

Results

A total of 471 phytoseiid specimens of 12 species of the three subfamilies (Amblysiinae Muma, Phytoseiinae Berlese and Typhlodrominae Scheuten) were collected (Table 1). Most species belonged to Amblyseiinae (8 species), followed by Typhlodrominae (3 species) and Phytoseiinae (1 species). The most abundant and frequent phytoseiid species was *Phytoseiulus persimilis* Athias-Henriot; 223 specimens (ca. 47.3% of all phytoseiids); these were collected in 22 sites (21 cultivated and one uncultivated sites). The following most abundant species were *Neoseiulus californicus* (McGregor) (83 specimens, ca. 17.6%) and *Phytoseius finitimus* Ribaga (73 specimens, ca. 15.5%), but the former was only collected at two localities (an eggplant greenhouse and an open eggplant field), while the latter was more frequent (collected in one tomato and seven eggplant open fields). The remaining phytoseiids were found in much lower numbers, though some were frequent, such as *Typhlodromus* (*Typhlodromus*) *athiasae* Porath and Swirski (6 sites), *Amblyseius swirskii* Athias-Henriot (5 sites), and *Typhlodromus* (*Anthoseius*) *recki* Wainstein (4 sites). Only three phytoseiid species were detected in greenhouses; *P. persimilis* was the only species found in all 11 greenhouses surveyed, while *N. californicus* and *N. barkeri* Hughes were only detected there once each (Table 2).

Five species of phytophagous mites from three families were found in association with the phytoseiids: *T. urticae* (Tetranychidae), *Brevipalpus obovatus* Donnadieu, *Brevipalpus californicus* (Banks), *Tenuipalpus punicae* Pritchard and Baker (Tenuipalpidae), and *P. latus* (Tarsonemidae) (Table 2). *Tetranychus urticae* was the most common phytophagous species, sometimes found at very high population levels. It was also the sole pest mite collected from greenhouses crops in association with the predatory mite *P. persimilis*.

In this study, *Amblyseius andersoni* (Chant) is reported for the first time from Syria. It was collected on open-field tomato plants infested with *T. urticae*. The measurements of the single female collected in this study are: dorsal shield 370 long and 219 wide. Setae *j1* 28, *j3* 52, *j4* 7, *j5* 6, *j6* 8, *J2* 8, *J5* 10, *z2* 13, *z4* 17, *z5* 6, *Z1* 10, *Z4* 85, *Z5* 165, *s4* 81, *S2* 17, *S4* 11, *S5* 9, *r3* 24, *R1* 13. Distances between *st1–st3* 63, *st2–st2* 64, *st5–st5* 74. Ventrianal shield 133 long, 90 wide at level of *ZV2* and 91 wide at anus level; *JV5* 68. Calyx of spermatheca 8 long. Fixed cheliceral digit 30 long, with 8 teeth and a pilus dentilis; movable digit 28 long, with three teeth. Leg macrosetae: *SgeI* 31, *SgeII* 35, *SgeIII* 44, *StiIII* 31, *SgeIV* 81, *StiIV* 65, *StIV* 74.

Discussion

This study documents the occurrence of 12 phytoseiid species on solanaceous plants in the Syrian coastal region, among which 5 are recorded for the first time in Tartus governorate: *Euseius stipulatus* (Athias-Henriot), *P. persimilis, N. barkeri, N. californicus* and *T.* (*A.*) *recki*. One phytoseiid species, (*Typhlodromus* (*Anthoseius*) *rickeri* Chant), was never reported on Solanaceae before, while *A. andersoni* is a new record for the Syrian phytoseiid fauna, as its previous citations in Syria referred to misidentifications of *A. swirskii*, according to Barbar *et al.* (2022). The latter two species are very similar, but can be distinguished by a few morphological characteristics, as the considerably longer seta *Z5* and macrosetae *SgeIV* and *StiIV*, and the u-shaped spermathecal calyx in *A. andersoni*, as opposed to the v-shaped calyx in *A. swirskii* (Ferragut *et al.* 2010; Döker *et al.* 2020).

Phytoseiulus persimilis was the predominant phytoseiid species found both in greenhouses and on outdoor solanaceous plants, while the remaining species were mainly collected from outdoor solanaceous plants. In a previous survey for natural enemies of *T. evansi* on solanaceous plants in the Syrian coastal region, *P. persimilis* was also the most frequent and abundant phytoseiid species collected (Dayoub *et al.* 2022). This species is one of the most common phytoseiids reported on solanaceous plants in different countries, certainly

Table 1 Phytoseiid mites collected from solanaceous plants in surveys conducted in Latakia and Tartus governorates, Syria, between 2018 and 2020.

Phytoseiid mite species	Number of specimens	Number of sites
Amblyseiinae Muma		
Amblyseius swirskii Athias-Henriot	19	5
Amblyseius andersoni (Chant)*	1	1
Euseius scutalis (Athias-Henriot)	24	4
Euseius stipulatus (Athias-Henriot)	9	1
Iphiseius degenerans (Berlese)	7	2
Neoseiulus californicus (McGregor)	83	2
Neoseiulus barkeri Hughes	3	2
Phytoseiulus persimilis Athias-Henriot	223	22
Phytoseiinae Berlese		
Phytoseius finitimus Ribaga	73	8
Typhlodrominae Scheuten		
Typhlodromus (*Anthoseius*) *recki* Wainstein	8	4
Typhlodromus (*Anthoseius*) *rickeri* Chant	9	2
Typhlodromus (*Typhlodromus*) *athiasae* Porath and Swirski	12	6

* New record for Syrian mite fauna

because of commercial biological control introductions (Tixier *et al.* 2020a). In Syria, an Egyptian strain of *P. persimilis*, adapted to greenhouse conditions, was introduced in 2005, mass reared and released to control *T. urticae* in greenhouses strawberry in Latakia since 2006 (Halloum and Shaabo 2006). Many evaluations have shown its efficacy for controlling *T. urticae* in experimental tomato greenhouses in the Syrian coastal region (Mofleh 2010; Sakr *et al.* 2018). However, we presume that *P. persimilis* was already present in this region where natural populations of this predator are currently observed on wild plants and in areas where introductions have not been done (Barbar 2013, 2014; Dayoub *et al.* 2022). In addition, this species has been recorded since the last century in various countries neighboring Syria, as Lebanon (Dosse and Musa 1967) and Turkey (Sekeroglu and Kazak 1993), in areas on the Mediterranean coastal strip bordering the Syrian coastal region.

Other phytoseiids frequently found in this study were *P. finitimus*, *T.* (*T.*) *athiasae*, *A. swirskii*, and *T.* (*A.*) *recki*. These have also been commonly found on different cultivated

Table 2 Phytoseiid and associated phytophagous mites from each solanaceous species of each sampling site visited between 2018 and 2020 in Latakia and Tartus governorates in the Syrian coastal region.

Site	Geographic coordinates /a.a.s.l.	Collection date	Plant species (Type of locality)	Predatory mite species	Number of specimens	Associated phytophagous mites
Latakia						
Zaghreen	35°43'54.6"N, 35°52'59.2"E /47 m	2-XI-2018	*Solanum melongena* (Open-field)	*Amblyseius swirskii*	5♀♀, 2♂♂	*Tetranychus urticae* *Brevipalpus obovatus*
Wadi Qandil	35°42'48.5"N 35°52'08.7"E /23 m	4-XI-2018	*S. melongena* (Open-field)	*A. swirskii*	2♀♀, 1♂, 2i*	*T. urticae*
Burj Islam	35°40'41.5"N, 35°47'46.0"E /26 m	4-XI-2018	*S. melongena* (Open-field)	*Typhlodromus* (*Anthoseius*) *rickeri*	2♀♀, 4i	*T. urticae*
Al-Qutailibiyah	35°18'43.1"N, 35°59'41.1"E /74 m	1-III-2019	*S. lycopersicum* (Greenhouse)	*Phytoseiulus persimilis*	1♀	*T. urticae*
Al-Aaqbiyeh	35°16'27.8"N, 35°58'03.4"E /20 m	8-IX-2019	*S. melongena* (Open-field)	*Neoseiulus barkeri*	2♀♀	*T. urticae*
Al-Aaqbiyeh	35°16'43.7"N, 35°58'20.7"E /28 m	8-IX-2019	*S. melongena* (Greenhouse)	*P. persimilis*	1♀	*T. urticae*
Al-Borjan	35°18'10.5"N, 35°57'46.0"E /32 m	8-IX-2019	*S. melongena* (Open-field)	*P. persimilis*	2♀♀	*T. urticae*
Al-Borjan	35°17'46.4"N, 35°58'45.0"E /56 m	8-IX-2019	*S. melongena* (Open-field)	*Phytoseius finitimus*	1♀, 1♂, 2i	*T. urticae* *Polyphagotarsonemus latus*
Al-Mrouj	35°33'52.2"N, 35°45'37.2"E /10 m	13-IX-2019	*S. nigrum* (Uncultivated)	*P. persimilis* *Iphiseius degenerans* *Typhlodromus* (*Typhlodromus*) *athiasae*	2♀♀, 3♂♂ 3♀♀, 1♂ 2♀♀	*T. urticae*
AL-Maghrit	35°36'13.1"N, 35°49'19.9"E /60 m	15-XI-2019	*S. nigrum* (Uncultivated)	*I. degenerans* *T.* (*A.*) *rickeri*	3♀♀ 2♀♀, 1♂	*T. urticae*
Bereen	35°36'00.8"N, 36°05'35.7"E /624 m	18-IX-2019	*S. lycopersicum* (Open-field)	*Typhlodromus* (*Anthoseius*) *recki*	2♀♀	*T. urticae*
Al-Dakleyiah	35°37'04.0"N, 36°04'28.7"E /530 m	18-IX-2019	*S. melongena* (Open-field)	*P. persimilis* *T.* (*T.*) *athiasae*	24♀♀, 10♂♂, 13i 2♀♀, 1♂, 1i	*T. urticae*
Er Ruwaysah	35°50'32.0"N, 35°52'42.3"E /33 m	19-XI-2019	*S. melongena* (Open-field)	*T.* (*T.*) *athiasae*	2♀♀	*T. urticae*
Al-Isawiyah	35°47'24.8"N, 35°51'02.5"E /116 m	19-XI-2019	*S. melongena* (Open-field)	*T.*(*A.*) *recki* *P. finitimus* *Euseius scutalis*	4♀♀ 9♀♀, 1i 10♀♀, 1i	*B. obovatus*
Wadi Qandil	35°42'49.7"N, 35°51'28.7"E /20 m	26-XI-2019	*S. melongena* (Open-field)	*A. swirskii* *T.* (*T.*) *athiasae*	3♀♀ 1♀	*T. urticae*
Slago	35°26'13.7"N, 36°01'14.7"E /154 m	2-IX-2020	*S. lycopersicum* (Open-field)	*T.* (*T.*) *athiasae* *P. persimilis* *Amblyseius andersoni*	2♀♀ 3♀♀ 1♀	*T. urticae*
Slago	35°26'18.0"N, 36°01'17.4"E /162 m	2-IX-2020	*S. lycopersicum* (Open-field)	*P. persimilis* *T.*(*A.*) *recki*	4♀♀ 1♀	*T. urticae*
Rouiset Qasmin	35°37'31.5"N, 35°53'55.4"E /209 m	29-X-2020	*S. melongena* (Open-field)	*E. scutalis* *P. finitimus*	4♀♀ 4♀♀	*T. urticae*
Zaghreen	35°43'08.5"N, 35°53'28.7"E /39 m	31-X-2020	*S. melongena* (Open-field)	*P. persimilis*	1♀	*T. urticae* *B. obovatus*
Zaghreen	35°43'05.0"N, 35°53'24.5"E /40 m	31-X-2020	*S. melongena* (Open-field)	*P. finitimus*	1♀	*T. urticae* *B. obovatus* *Brevipalpus californicus*

*: immatures; [1]: associated with a phytophagous thrips species.

Table 2 Continued.

Site	Geographic coordinates /a.a.s.l.	Collection date	Plant species (Type of locality)	Predatory mite species	Number of specimens	Associated phytophagous mites
Asurskia	35°42'26.8"N, 35°54'19.5"E /34 m	31-X-2020	*S. melongena* (Open-field)	*A. swirskii*	1♀	*T. urticae*
Asurskia	35°42'26.5"N, 35°53'27.5"E /32 m	31-X-2020	*S. melongena* (Open-field)	*P. finitimus*	10♀♀, 4♂♂	*T. urticae*
				A. swirskii	3♀♀	*B. obovatus*
Tartus						
Ibtellah	35°13'19.9"N, 35°59'17.9"E /141 m	27-IV-2019	*S. melongena* (Greenhouse)	*P. persimilis*	2♀♀, 2♂♂, 2i	*T. urticae*
Kharab Marqueh	35°02'49.3"N, 35°53'48.7"E /20 m	11-V-2019	*S. lycopersicum* (Greenhouse)	*P. persimilis*	6♀♀, 2♂♂, 5i	*T. urticae*
Al-Rawda	35°03'54.1"N, 35°53'29.7"E /13 m	11-V-2019	*S. melongena* (Greenhouse)	*P. persimilis*	2♀♀	*T. urticae*
				Neoseiulus californicus	4♀♀	
Al-Khrab	35°02'49.3"N, 35°53'48.7"E /20 m	11-V-2019	*S. nigrum* (Uncultivated)	*E. scutalis*	8♀♀	none
Yahmoor	34°48'06.6"N, 35°58'11.5"E /57 m	31-V-2019	*S. melongena* (Greenhouse)	*P. persimilis*	62♀♀, 4♂♂, 2i	*T. urticae*
				N. barkeri	1♀	
Talsnon	34°40'22.8"N, 36°06'11.4"E /44 m	13-VI-2019	*S. melongena* (Greenhouse)	*P. persimilis*	1♀	*T. urticae*
Talsnon	34°40'39.5"N, 36°06'00.4"E /44 m	13-VI-2019	*S. melongena* (Greenhouse)	*P. persimilis*	2♀♀	*T. urticae*
Maten Al-Sahel	35°01'18.4"N, 35°54'34.8"E /25 m	15-VI-2019	*S. lycopersicum* (Greenhouse)	*P. persimilis*	3♀♀	*T. urticae*
Busayrah Al-Jadidah	34°59'35.3"N, 35°53'24.5"E /10 m	15-VI-2019	*S. lycopersicum* (Greenhouse)	*P. persimilis*	1♀, 4i	*T. urticae*
Zahed	34°41'34.0"N, 36°00'05.2"E /20 m	1-VII-2019	*S. melongena* (Greenhouse)	*P. persimilis*	11♀♀, 11♂♂, 14i	*T. urticae*
Al-Qlue	35°15'39.8"N, 35°56'17.8"E /12 m	31-VII-2019	*S. melongena* (Open-field)	*N. californicus*	48♀♀, 24♂♂, 7i	none[1]
				E. scutalis	1♀	
Salib	35°06'20.6"N, 36°06'29.3"E /703 m	20-X-2019	*S. melongena* (Open-field)	*P. persimilis*	4♀♀	*T. urticae*
				P. finitimus	28♀♀, 4♂, 1i	
				T. (*T.*) *athiasae*	1♀	
Nab'e El-Dulbah	34°55'10.8"N, 36°08'48.5"E /380 m	24-IX-2020	*S. melongena* (Open-field)	*P. persimilis*	1♀	*T. urticae*
						Tenuipalpus punicae
Bait Yousef	34°55'45.0"N, 36°12'51.2"E /840 m	24-IX-2020	*S. lycopersicum* (Open-field)	*P. persimilis*	3♀♀	*T. urticae*
				P. finitimus	2♀♀	
Bait Yousef	34°55'47.7"N 36°12'50.2"E /847 m	24-IX-2020	*S. melongena* (Open-field)	*P. persimilis*	10♀♀	*T. urticae*
Bait Yousef	34°55'37.7"N, 36°12'57.6"E /888 m	24-IX-2020	*S. lycopersicum* (Open-field)	*P. persimilis*	5♀♀	*T. urticae*
Al-Shaykh Badr	34°59'23.7"N, 36°03'38.4"E /508 m	9-XI-2020	*S. melongena* (Open-field)	*Euseius stipulatus*	8♀♀, 1♂	*T. urticae*
						B. obovatus
Al-Wardieh	35°01'08.7"N, 36°02'49.3"E /479 m	9-XI-2020	*S. melongena* (Open-field)	*P. finitimus*	4♀♀, 1♂	*T. urticae*
				T. (*A.*) *recki*	1♀	*B. obovatus*

*: immatures; [1]: associated with a phytophagous thrips species.

and wild solanaceous plants, in association with various prey mites, in previous surveys in this region (Barbar 2016, 2017; Dayoub *et al.* 2022; Ebraheem *et al.* 2022). They are considered among the phytoseiid species prevalent on Solanaceae in the West Palearctic region (Tixier *et al.* 2020a). Their high occurrence on solanaceous plants and their usual association with phytophagous mites suggest them to be promising for biological control applications on solanaceous crops. The results of recent laboratory experiments using *T.* (*A.*) *recki* were encouraging enough to consider this predator a good candidate for biological control of *T. urticae* (Tixier *et al.* 2020b; Ersin *et al.* 2021). Thus, further studies on the potential of the phytoseiid species identified here as biological control agents should be conducted on tomato and eggplant in greenhouses and open fields in the Syrian coastal region.

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