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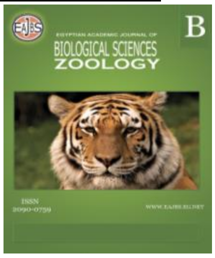

Herbaceous Weeds as Potential Host Plants for *Tetranychus urticae* and Predation Efficacy of *Typhlodromips capsicum* on Preferred Host Plants

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ABSTRACT

The two-spotted spider mite (TSSM), *Tetranychus urticae* Koch (Acari: Tetranychidae), is one of the most serious polyphagous pests worldwide. During intercropping periods, TSSM transfers to available green plants either economic or weeds. The objective of the current study was to determine the host suitability of alternative host plants. The selected promotive host plant for TSSM growth received the phytoseiid predator *Typhlodromips capsicum* Mostafa to feed on TSSM based on biological features and reproductive potential for prey and predator. Leaves of cheeseweed, bindweed and mint were promotive for TSSM females' longevity which lasted for 16.9, 16.3 and 16.3 days, respectively. The highest significant deposited eggs per TSSM female was recorded on cheeseweed leaves (43.6 eggs, and 3.57eggs/day) with a sex ratio of 2.6: 1 (72.25 % females). Based on TSSM longevity and fecundity, slender amaranth, groundsel, fleabane, wild oat and Jimson weed were less suitable host plants as sorted in descending order. The longevity, prey consumption and fecundity of *T. capsicum* females were studied on the most suitable plants for TSSM comprising rocket, parsley, mint, bindweed and cheeseweed as sorted in ascending order. The longevity *of T. capsicum* females on TSSM preferred plants were closely related and the highest significant prey consumption (total 75 and daily 3.95 prey individuals) reared on cheeseweed leaves accompanied by the greatest number of deposited eggs per female (total 38 eggs, and 2.54 eggs/day). The alternative host plants may play a role as a reservoir plant for phytophagous mites also provide food and habitat required for predators conservation during absence periods of major crops to keep biodiversity and natural balance.

INTRODUCTION

The phytophagous two-spotted spider mite (TSSM),*Tetranychus urticae* Koch (Acari: Tetranychidae), the two-spotted spider mite is a polyphagous major pest of many vegetables, flowers, and fruit trees (Gerson and Weintraub, 2012). It targets more than 140 families and 1100 types of host plants (Souza-Pimentel *et al.*, 2018). The presence of TSSM during the different seasons and intercropping cycles depends only on transferring to perennial plants either economic or weed plants. This alternative plant

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host can meet the nutritional needs required for the development of the mite in the absence of the main economic plant host and provide the necessary shelter for it (Agrawal, 2000; Puspitarini *et al.,* 2021).

Rapid developmental rate, short generation time and high net reproductive rate of *T. urticae* allow them to achieve damaging population levels very quickly when growth conditions are good, resulting in an equally rapid decline of host plant quality (James and Price, 2002; Marcic, 2003; Skorupska, 2004). Reproduction in spider mites is very sensitive to a wide variety of intrinsic and extrinsic conditions used in their biological control (Kazak and Kibritci, 2008).

In an IPM-based system, all existing resources were used in control management instead of simply relying on chemicals. In cultural control, host plants or plant cultivars may represent a viable pest management alternative and affect the population of TSSM (Opit *et al.*, 2005, 2001). The abovementioned factors maybe effect safe, cost-effective and energy-efficient means of biological control by phytoseiid species, *Typhlodromips capsicum* Mostafa as a highly viable alternative for managing TSSM.

Because of the continual presence of plant mites throughout the different growing seasons. It is considered one of the regular epidemic pests with high adaptability (Magalhães *et al.,* 2007; Sousa *et al.,* 2019), which often requires intervention with specialized chemical acaricides to reduce the population below the economic threshold (Van Leeuwen *et al.,* 2015). After the gradual dissipation of acaricides, the mite population rebuilt up gradually to cause an outbreak and reused chemical control again. The excessive use of acaricides in the control results in severe selection pressure on the exposed mite population, which leads to the development of the strain acaricides resistance (Leeuwen *et al.,* 2009; Van Leeuwen *et al.,* 2010). Therefore, there has been a search for safe, effective, and environmentally friendly alternatives such as mite pathogens, parasites and predators. These organisms associated with plant mites are specialized and persistent, and their existence is linked to the presence of their host (McMurtry and Croft, 1997; Perdikis *et al.,* 2008).

Given that the pathogenic microbes and parasites of plant mites require a long incubation period to show their effect on the affected individuals and thus the length of the damage period, attention was drawn to the predators of plant mites as an effective alternative in the rapid elimination of mites, depending on the daily food consumption rate of the predator, which results in greater effectiveness compared to the other biological control methods (Lacey, 2016; Muma *et al.,* 1975; Ridgway, 2013; Wraight *et al.,* 2017).

Typhlodromips capsicum, a phytoseiid mite species found in Egypt's Sharkia Governorate, was shown to have a wide range of distribution in conjunction with several agricultural pests. They like to attack *T. urticae*, a two-spotted spider mite that is a severe crop pest in the Tetranychidae family (Mostafa, 2004). the development, fertility, and feeding capability of two phytoseiid species fed on immature stages of the two-spotted spider mite *T. urticae* (Basha *et al.,* 2007). Releasing the predatory mite *T. capsicum* on grapevine plants under field conditions (in cages) caused a considered success in reducing phytophagous mites depending on releasing rate (Eisa and Mostafa, 2013).

The available alternative hosts vary in time and space, according to the geographical distribution of the infestation with mites. *T. urticae* adjusts their antipredator defenses based on differences in host plant volatiles in the patch they live in (Choh and Takabayashi, 2007; Puspitarini *et al.,* 2021).

The current research focuses on two issues: a) what is the preferred alternative host plant for *T. urticae* in the absence of the main economic host plant based on the nutritional preference and reproduction rate of each tested plant. b) potency of *T. capsicum* Mostafa as a mite predator in controlling *T. urticae* on the most suitable alternative host plants. The obtained results will contribute to the improvement of integrated management programs of plant mites.

MATERIALS AND METHODS

Two-spotted Spider Mites Colony:

Individual mites of TSSM, *Tetranychus urticae* Koch (Acari: Tetranychidae), were collected from Zagazig district, Sharkia governorate during the growing season 2020-2021, from infested leaves of the ten plants. The selected alternatives plant hosts were considered as weeds included slender amaranth (*Amaranthus viridis* L.; Amaranthaceae), Jimson weed also known by some names as the “Devils Trumpet” or “Thorn” or “Apple” (*Datura stramonium* L.; Solanaceae), the field bindweed (*Convolvulus arvensis* L.; Convolvulaceae), wild oat (*Avena fatua* L.; Poaceae) and two Asteraceae (fleabane, *Conyza dioscoridis* (L.) Desf. and the common groundsel, *Senecio vulgaris* L.). Besides, some economic plants comprised parsley (*Petroselinum crispum* L.; Apiaceae), rocket (*Eruca sativa* Mill.; Brassicaceae), mint (*Mentha viridis* L.; Lamiaceae) and little mallow or cheeseweed (*Malva parviflora* L.; Malvaceae).

In the laboratory, the leaves were examined under a stereomicroscope to confirm the identity of the mite. The leaves were placed singly with the upper surface down on a cotton pad soaked with water in Petri dishes of 10 cm diameter. The mite was reared according to the methods described by Gotoh, 1986 and Pontier *et al.,* 2001. Each leaf was surrounded by a cotton strip saturated with water to serve as a barrier to prevent mites from escaping. Suitable moisture was maintained by adding a few drops of water as needed. Leaves were changed every alternative day to avoid leaf deterioration and consequent small nutrition. These cultures were maintained with a 16 h Light (L): 8 h Dark (D) photoperiod at 26 ± 3 °C and 75 ± 4% RH.

Developmental Duration of *Tetranychus urticae* Females and Sex Ratio on Alternatives Host Plants:

Host-plant acceptance was measured through number of females that settled on a test plant (Yano *et al.,* 1998) under laboratory conditions at 26±3 ºC & 75±4 RH%, using a leaf-disc method was used for studying development. Detached leaves were washed with water, then with 70% ethanol, and finally air-dried. Leaf discs (1.5cm diameter) were cut to fit a Petri dish (9cm diameter) amended for mite and keep leaves fresh. Each host plant's discs were assigned, and two adult males were introduced to each leaf disc for mating. The males were removed, and the freshly mated females were placed individually on replicated leaves of each plant. Every 24 h, *T. urticae* female was transferred with a brush to another fresh disc until the adults died. Ten replicates were used for each leaf plant. The preoviposition, oviposition, postoviposition and longevity periods were measured. The number of eggs laid per female was counted to see if all ten host plants were equally acceptable for *T. urticae* performance (fecundity). The offspring were checked daily on ten tested plants to adulthood to determine the sex ratio.

Prey Preferences of *Typhlodromips capsicum*:

The *T. urticae* had developed on the most suitable five alternative host plants comprising parsley, rocket, mint, the field bindweed and cheeseweed which were selected based on the previous experimental results. Prey consumption and fecundity of *T. capsicum* (Acari: Phytoseiidae) (Basha *et al.,* 2001). the predator fed on adult females of *T. urticae* on selected five plants were used as prey under laboratory conditions of

26±3 °C and 75±4 % RH.

The leaf discs were used as rearing arenas according to the method described by (Yousef and El-Halawany, 1982). A leaf-discs of the selected plant host (1.5 cm diameter) were cut using a cork borer. The leaf discs were placed singly upside down in opened Petri dishes containing a moist cotton wool pad. Cotton wool is moistened with 5 ml of distilled water to prevent mite individuals from escaping and to supply them with water (Castagnoli and Simoni, 1999).

Newly emerged sexed females of *T. capsicum* in the teleiochrysales stage were transferred individually onto leaf discs. The disc was supplied daily with 5 adult females of *T. urticae* and each predator female was allowed to deposit eggs through adulthood on leaf discs and recorded the numbers of laid eggs were recorded. The consumed prey individuals by predator females during longevity were recorded and replaced with another live ones. Each host plant consisted of five discs as replicates. Experiments were carried out in the laboratory at 26±3 °C and 75±4 % RH.

Statistical Analysis:

The obtained data were subjected to a one-way analysis of variance and means were separated by Duncan's multiple range test at a 5% level using the Statistix statistical software 8.1.

RESULTS AND DISCUSSION

Herbivorous pests must choose appropriate host plants to develop and survive. At some point in their lives, many mite species rely on plant resources. Plant-related cues regulate critical behaviors determining mite fitness in herbivorous mites, such as feeding, mating, and oviposition. spatial and temporal variation make most habitats dynamic, with major variations in plant resources, plant availability, and the presence of natural enemies occurring over time and space. This study attempts to explore another perspective on the multiplicity of alternative hosts of the phytophagous TSSM, *T. urticae* and its suitability for the growth and development of the mite during the absence of the main plant hosts in the time intervals between planting seasons and the preparation of the land for cultivation with a new crop. During that period of the life of the mite, it has fewer options for suitable host plants available, and it must be transferred to alternative host plants that differ in the extent of their validity to provide the nutritional requirements and habitat necessary to protect against natural enemies (Carrasco *et al.*, 2015). The high colonization capacity of *T. urticae* appears to be its most distinguishing feature. Polyphagy has aided its spread and may have resulted in population connection over the world (Navajas, 1998).

Effect of Different Alternative Host Plants on Longevity, Fecundity and Sex Ratio of *Tetranychus urticae* Females:

The longevity of *T. urticae* on alternative host plants **(**weed or ornamental plants) were significantly **(**$P \leq 0.05$**)** varied according to *in vitro* tested plants (Table 1; Fig. 1) and the shortest preoviposition period (2.20 days) was recorded on leaves of bindweed and cheeseweed**.** However, no significant differences in preoviposition were found on leaves of bindweed, cheeseweed, mint and parsley and recorded at 2.20, 2.20, 2.30 and 2.30 days, respectively. Whereas, rearing of *T. urticae* on leaves of rocket and wild oat prolonged preoviposition to 2.40 days with insignificant differences in each of them. On the other hand, the longest period of preoviposition was found on leaves of Jimson weed (3.10 days) followed by groundsel (2.80 days), slender amaranth (2.70 days) and fleabane (2.50), respectively.

The longest oviposition period value of *T. urticae* for all tested plants was detected when the female of *T. urticae* reared on cheeseweed to record 12.20 days. Oviposition period values of *T. urticae* decreased significantly to reach 4.40, 4.40 and 4.10 days with leaves of fleabane, groundsel and wild oat, respectively. On the other hand, the shortest oviposition period (3.30 days) was detected with Jimson weed leaves as shown in Table (1).

Table 1 Impact of different alternative host plants on the longevity of *Tetranychus urticae* females.

Host plant	Duration (days)			
	Preoviposition	Oviposition	Postoviposition	Longevity
Bindweed	2.20^{d}	11.60^{b}	2.50^{c}	16.30^{a}
Cheeseweed	2.20^{d}	12.20^{a}	2.50^{c}	16.90^{a}
Slender amaranth	2.70^{abc}	5.80^{d}	3.20^{a}	11.70^{c}
Fleabane	2.50^{bcd}	4.40^{e}	3.10^{ab}	10.00^{de}
Groundsel	2.80^{ab}	4.40^{e}	3.30^{a}	10.50^{d}
Jimson weed	3.10^{a}	3.30^{f}	3.30^{a}	9.70^{e}
Mint	2.30^{cd}	11.70^{ab}	2.30^{c}	16.30^{a}
Parsley	2.30^{cd}	10.20^{c}	2.70^{bc}	15.20^{b}
Rocket	2.4^{bcd}	10.00^{c}	2.60^{c}	15.00^{b}
Wild oat	2.40^{bcd}	4.10^{e}	3.30^{a}	9.80^{de}

Different letters in the same column indicate significant differences ($P \leq 0.05$) according to Duncan`s multiple range test, reported numbers represent the means of 10 replicates.

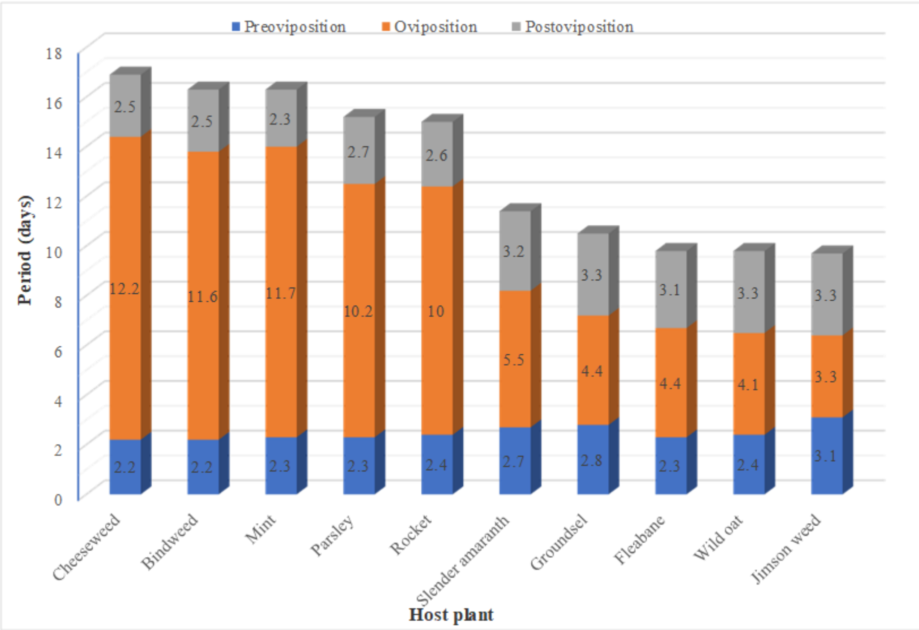

Fig. 1 Effect of different host plants on *Tetranychus urticae* females' longevity (preoviposition, oviposition and postoviposition durations).

Variables expressed as alternatives host plant's effect on postoviposition of *T. urticae* adult females. Before the death of *T. urticae* adult females, it stopped egg-laying for a period of 3.30 days on leaves of groundsel, Jimson weed and wild oat. The parallel values with slender amaranth and fleabane leaves were 3.20 and 3.10 days, respectively with insignificant differences. On other alternative host plant leaves, the postoviposition periods were not significantly differed and the duration was 2.70 days on parsley and 2.60 days on rocket leaves. On the other hand, leaves of bindweed and cheeseweed showed a high effect in decreasing values of postoviposition to record 2.50 days with each of them.

For Adult female longevity of *T. urticae*, it was clear that cheeseweed, bindweed and mint showed the greatest effect on female longevity. The longevity of *T. urticae* female were 16.90, 16.30 and 16.30 days with the mentioned plants and the shortest longevities were recorded with jasmine weed (9.70 days) and wild oat leaves (9.80 days), respectively.

Generally, highly significant differences were detected between ten alternative host plants on the longevity of *T. urticae* female and *in vitro* conditions, cheeseweed, bindweed and mint leaves prolonged longevity of *T. urticae* whereas Jimson weed, and wild oat significantly reduced significantly longevity of *T. urticae* female. As clearly shown in Table (2), the successful rearing of *T. urticae* female on leaves of ten alternative host plants revealed that the total average and daily mean of deposited eggs per TSSM female were significantly influenced by the leaves of host plant. Feeding on leaves of cheeseweed resulted in a significantly greater number of deposited eggs (43.60 eggs) with the highest daily mean of 3.57 eggs/day. From current results, the least number of deposited eggs were recorded on Jimson weed leaves (3.80 eggs) with the least value of the daily rate of 1.14 eggs/day. Contrarily, the highest numbers of laid eggs were 39.10 and 36.40 eggs on the leaves of bindweed and mint with daily means of deposited eggs reached 3.37 and 3.12 eggs/day, respectively. A moderate number of eggs was obtained on the rocket and parsley leaves (27.70 and 26.90 eggs) with a daily mean number of deposited eggs of 2.78 and 2.64 eggs/day, respectively. The females of TSSM laid 10.70 eggs on slender amaranth leaves with a daily mean of deposited eggs of 1.84 eggs/day. A little number of eggs was recorded on the leaves of groundsel, fleabane and wild oat of 6.00, 5.90 and 5.90, respectively. The daily counted eggs on these hosts were 1.37, 1.34 and 1.44 eggs/day, respectively.

Concerning the sex ratio, the number of deposited eggs for adult TSSM females besides adult females and males were scheduled in Table (2). The highest sex ratios (♂: ♀) were recorded on cheeseweed leaves (1: 2.60) and bindweed leaves (1:2.10) followed by mint leaves (1:2.06) while moderate sex ratios were recorded on parsley leaves (1:1.86), rocket (1: 1.80), fleabane (1:1.27), wild oat leaves (1:1.27) and groundsel (1:1.22), respectively. The least sex ratios were recorded with *T. urticae* female reared on leaves of Jimson weed (1: 1.11) and slender amaranth (1: 1.14). Generally, the fecundity and sex ratio of *T. urticae* varied greatly when reared on the abovementioned plants under *in vitro* conditions **(**Table 2; Fig. 3**).**

Table 2 Fecundity and sex ratio of *Tetranychus urticae* on leaves of the ten selected alternative host plants.

Host plant	**Deposited eggs mean**		**Sexes number**		**Sex ratio**	**Female (%)**
	Total	**Daily**	♀	♂	♂**:** ♀	
Bindweed	39.10^{b}	3.37^{b}	265	126	1: 2.10	67.77
Cheeseweed	43.60^{a}	3.57^{a}	315	121	1: 2.60	72.25
Slender amaranth	10.70^{e}	1.84^{f}	57	50	1: 1.14	53.27
Fleabane	5.90^{f}	1.34^{g}	33	26	1: 1.27	55.93
Groundsel	6.00^{f}	1.37^{g}	33	27	1: 1.22	55.00
Jimson weed	3.80^{g}	1.14^{h}	20	18	1: 1.11	52.63
Mint	36.40^{c}	3.12^{c}	245	119	1: 2.06	67.31
Parsley	26.90^{d}	2.64^{e}	175	94	1: 1.86	65.06
Rocket	27.70^{d}	2.78^{d}	178	99	1: 1.80	64.26
Wild Oat	5.90^{f}	1.44^{g}	33	26	1: 1.27	55.93

Different letters in the same column indicate significant differences ($P \leq 0.05$) according to Duncan`s multiple range test.

Biological and fecundity of the TSSM, *T. urticae* showed a variation not only in host plant level but also varieties levels and nitrogen and protein content resulting from fertilization (El-Dein and A, 2018; Mead *et al.,* 2017; Nasr *et al.,* 2019). Most of the plants in the environment are considered as susceptible plant hosts susceptible to TSSMs infestation, but they vary in their degree of preference and meet the needs necessary for the growth and reproduction of the mite. Bindweed (*Convolvulus arvensis*) was monitored as the main source for TSSMs infested tomatoes in the greenhouse (Castagnoli *et al.,* 1998), this association between TSSMs and bindweed reconfirmed again as alternative host accompanying tomato infestation (Castagnoli *et al.,* 2003). While cheeseweed (*Malva parviflora*) plants hosted *T. urticae* during all 12 months in vineyards (de Villiers and Pringle, 2011). (Mureithi *et al.,* 2017) indicate an association of arthropod pests *e.g.* TSSM with leafy Amaranth (*Amaranthus viridis*) besides the identification of spider mites from green pigweed (*A. viridis*) as a host plant (Smith *et al.,* 2013). Another study used hairy fleabane (*Conyza dioscoridis*) leaf for rearing TSSM (Amer and Rasmy, 1994), this enhances the possibility of susceptibility to an infestation in the natural environment regardless of the preference for infestation by a spider. While *T. urticae* was highly abundant on groundsel (*Senecio vulgaris*) in pear orchards (Flexner *et al.,* 1991).

Thorn apple or Jimson weed *(Datura stramonium),* could serve as a reservoir plant for phytophagous mites, allowing pest populations to grow in locations where solanaceous vegetables are grown. (Kasap *et al.,* 2015; Kumral and Cobanoglu, 2015). Hollingsworth and Berry, 1982 studied the TSSM population dynamics in peppermint and noticed that mites outbreak-related with water-stressed peppermint plants. Also, Parsley is an economic leafy vegetable, infested with *T. urticae* and always faced with using acaricides (Greco *et al.,* 2006; Venzon *et al.,* 2020).

It is noted in the previous studies related to the study of the host range of the TSSM that they deal with all plants as potential hosts, but they vary in their economic importance. The same plant may be economic in one place, and it may be uneconomical in another place or treated as a weed elsewhere is controlled.

Although the tested plant proposed as an alternative host may use for rearing TSSM nutritional food supply may differ in suitability morphological, nutritive requirements and contain repellent or nutritive or toxic components or secondary metabolites led to hinder mite growth and reproduction (Boom *et al.,* 2003). For example, larvae of the TSSM, *T. urticae* did not develop to the protonymphal stage when reared on excised leaves of hairy fleabane (*Conyza dioscoridis*) resulting in females laying fewer eggs compared to control, also, the crude extracts of *Conyza dioscoridis* showed a pronounceable acaricidal effects on adults and eggs (Amer and Rasmy, 1994). The ethanol extracts obtained from both leaves in the thorn apple (*Datura stramonium* L.) caused 98 and 25% mortality among TSSM adults after 48 h (Barakat *et al.,* 1984; Kumral *et al.,* 2010; Mateeva *et al.,* 2003). Besides, the methanol leaves extract of wild mint caused high mortality of adult females of *T. urticae*. The major constituents in the wild mint extract are pulegone, menthol, trans menthone and cis-menthone (Hassan *et al.,* 2021) and monterpene ketone (piperitone oxide) was the main component of essential oil extracted from leaves of the *Mentha longifolia* (Momen *et al.,* 2018). The higher amount of erucin and fatty acids in the oil rocket (*Eruca sativa*) oil, caused the higher acaricidal activity of *E. sativa* oil compared to methanolic extract (Masoumi *et al.,* 2019).

Many volatiles, such as particular terpenoids, aromatic compounds, and green leaf volatiles (short-chain alcohols, esters, and aldehydes), are reasonably universal among plants from various families (Dudareva *et al.,* 2004). Most herbivores appear to differentiate hosts from non-hosts mostly by the use of specific mixes of ubiquitous volatiles, however, taxonomically distinctive chemicals may also play a role in the location of some specialized herbivores (Bruce *et al.,* 2005; Bruce, 2014). Single chemicals can sometimes provide valid information about the resource's features and stimulate behaviors such as eating, oviposition, or both (Dweck *et al.*, 2013; Reisenman *et al.,* 2010). So, plants with a high level of direct defence appear to put more effort into developing new chemicals. When Fabaceae plant species were compared to Solanaceae plant species, qualitative differences in spider mite-induced volatile blends were more noticeable in the Fabaceae than in the Solanaceae (Boom *et al.*, 2004).

Morphological characteristics of the host plant may play a role in host preferences. Plants have a wide range of characteristics (such as color, shape, and odor) that insects can use to make informed judgments (Ismail *et al.*, 2011). Olfactory and other chemosensory signals are critical for plant recognition and oviposition in most herbivorous insects (Bruce *et al.,* 2005). Glandular hair, trichomes, oily glands, trichomes and respiratory stomata densities may contribute to plant resistance (Allam *et al.,* 2018; Castagnoli *et al.,* 2003). Plants are grown with high nitrogen and water availability and a low C/N ratio boost mite nutrition. This preference was confirmed in an olfactory experiment in which the mites were exposed to solely the scents produced by leaves with damaged trichomes (Hoffland *et al.,* 2000).

Longevity, Prey Consumption and Fecundity of Predatory Mite, *Typhlodromips capsicum* fed on *Tetranychus urticae* Females Reared on Proper Five Alternative Host Plants:

In current *in vitro* tests, parameters of predatory mite *T. capsicum* such as preoviposition, oviposition, postoviposition and longevity were assessed when feeding *T. urticae* females reared on proper host plants. Statistically, no significant differences ($P \leq 0.05$) were found in the preoviposition period of the predatory mite *T. capsicum* fed on the female of TSSM reared on bindweed, cheeseweed, mint, parsley and rocket plants. Maximize postoviposition periods were found in treatments of cheeseweed and parsley followed by mint, bindweed and rocket and preoviposition ranged from 1.6 to 1.4 days (Table 3).

Table 3 Longevity of *Typhlodromips capsicum* fed on *Tetranychus urticae* females reared on most suitable five alternative host plants.

Host plant	Duration (days)			
	Preoviposition	**Oviposition**	**Postoviposition**	**Longevity**
Bindweed	1.4[a]	14.2[ab]	2.2 [a]	17.8 [a]
Cheeseweed	1.6[a]	15.0[a]	2.4 [a]	19.0 [a]
Mint	1.4[a]	14.2[ab]	2.4 [a]	18.0 [a]
Parsley	1.6[a]	13.6[b]	2.4 [a]	17.6 [a]
Rocket	1.4[a]	14.0[ab]	2.2 [a]	17.6 [a]

Different letters in the same column indicate significant differences ($P \leq 0.05$) according to Duncan`s multiple range test.

Even though *T. capsicum* displayed the longest period of the preoviposition period when fed on the female of TSSM reared on parsley, it displayed the shortest oviposition period when compared to other host plant leaves. The statistical analysis shows little significant differences between means of oviposition period on five tested plant leaves (Table 3 and Fig. 2). The postoviposition period of *T. capsicum* was not significantly different on five leaves of tested plants and ranged from 2.2 days in treatments of bindweed and rocket leaves to 2.4 days on cheeseweed, mint and parsley leaves (Table 3). On the other hand, statistical analysis ($P \leq 0.05$) revealed that differences in preoviposition, oviposition and postoviposition periods were not companied with variation in the longevity of predatory mite *T. capsicum*. However, the maximum longevity period of *T. capsicum* adult females was recorded 19.0 and 18.0 days with cheeseweed and mint leaves, respectively while the minimum longevity period of *T. capsicum* adult females was recorded with parsley and rocket (Table 3 and Fig. 2).

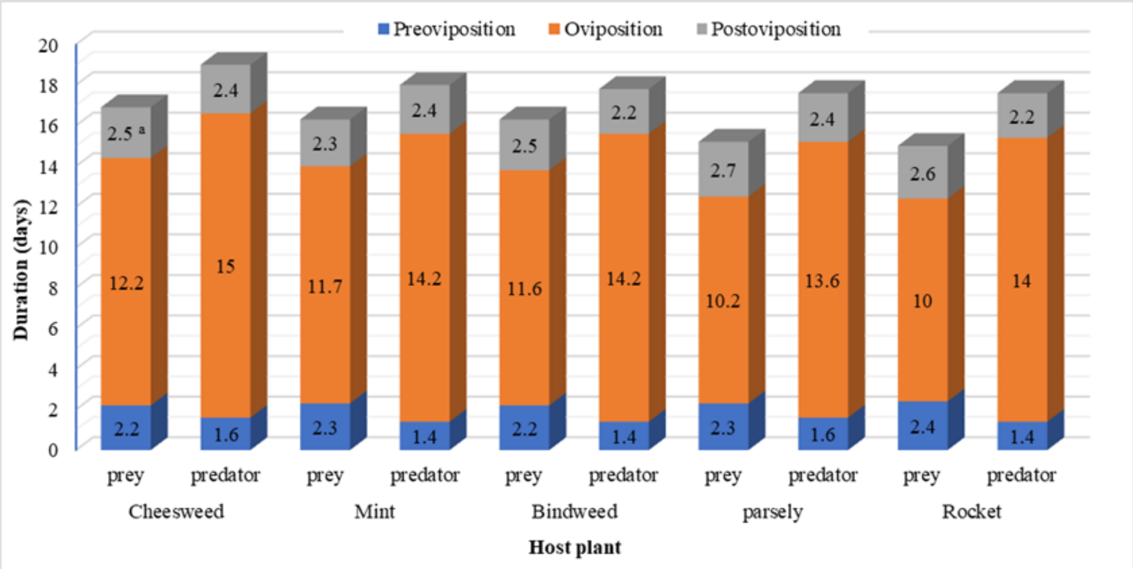

Fig. 2 *Typhlodromips capsicum* predation on *Tetranychus urticae* females' longevity (preoviposition, oviposition and postoviposition durations) on favorable host plants for prey.

In general, preoviposition, oviposition and postoviposition periods of *T. capsicum* showed slight differences after feeding on *T. urticae* females reared on proper five alternative host plants and produce insignificant differences ($P \leq 0.05$) *in vitro* longevity. Oviposition and longevity were evaluated on females of *T. urticae* reared on bindweed, cheeseweed, mint, parsley and rocket under laboratory conditions.

As Table 4 shown, during the preoviposition period adult females of *T. capsicum* consumed 4.80, 4.40, 4.20, 4.00 and 3.80 with a daily mean of 3.00, 2.80, 3.00, 2.90 and 2.70 prey individuals on leaves of cheeseweed, parsley, bindweed, mint and rocket, respectively without significant differences ($P \leq 0.05$). During the oviposition period, the total consumption rate for the female of *T. capsicum* reached 85.50, 83.90, 83.50, 83.20 and 83.10 % of the total devoured prey during longevity on plant leaves of parsley, rocket, cheeseweed, mint and bindweed, respectively. The consumption preys during the oviposition period were 62.60, 52.20, 51.40, 50.00 and 48.40 prey individuals with daily mean for consumption of 4.18, 3.68, 3.62, 3.57 and 3.56 prey on the plant leaves of cheeseweed, bindweed, mint, rocket and parsley, respectively. In the postoviposition period, high total consumption preys were documented with cheeseweed with 7.60 preys. Contrarily, parsley recorded the least total prey consumed (3.80 prey) when compared with other host plants. The greater number of devoured prey individuals for *T. capsicum* during complete its livelihood 75 prey individuals was recorded on cheeseweed leaves with a daily mean of consumption of 3.95 prey individuals. The followed prey consumed during longevity averaged 62.80 prey individuals with a daily mean of 3.53 prey individuals on bindweed leaves and 61.80 prey individuals with a daily mean of 3.43 prey individuals on mint leaves. From current results, it could be concluded that cheeseweed maximized the longevity of *T. capsicum* to reach 19 days followed by mint (18 days) whereas parsley as well rocket minimized their longevity period to reach 17.60 days only (Table 3).

Table 4 Prey consumption of *Typhlodromips capsicum* individuals during its longevity, when fed on females of *Tetranychus urticae,* reared on the most suitable five alternative host plants.

Host plant	Mean of *Typhlodromips capsicum* consumption during							
	Preoviposition		Oviposition		Postoviposition		Longevity	
	Daily	Total	Daily	Total	Daily	Total	Daily	Total
Bindweed	3.00[a]	4.20[a]	3.68[b]	52.20[b]	2.90[ab]	6.40[a]	3.53[b]	62.80[b]
Cheeseweed	3.00[a]	4.80[a]	4.18[a]	62.60[a]	3.17[a]	7.60[a]	3.95[a]	75.00[a]
Mint	2.90[a]	4.00[a]	3.62[b]	51.40[b]	2.63[b]	6.40[a]	3.43[b]	61.80[bc]
Parsley	2.80[a]	4.40[a]	3.56[b]	48.40[b]	1.60[c]	3.80[b]	3.22[c]	56.60[c]
Rocket	2.70[a]	3.80[a]	3.57[b]	50.00[b]	2.57[b]	5.80[ab]	3.38[b]	59.60[bc]

Different letters in the same column indicate significant differences ($P \leq 0.05$) according to Duncan`s multiple range test.

Results indicated significantly ($P \leq 0.05$) effectiveness in increasing deposited eggs laid by females of *T. capsicum* fed on proper host plants, particularly with the adult female of *T. capsicum* laid a total average of 38 eggs with a daily mean amount of 2.54 eggs/day when fed on females on *T. urticae* on cheeseweed leaves.

Compared to other tested plants, cheeseweed plant leaves maximized daily and the total average of deposited eggs from other total laid eggs on other tested leaves plants. While the total deposited eggs of *T. capsicum* female on other leaves of the host plants could be arranged in descending order as follows: mint showed 34.8 eggs with a daily mean of 2.45 eggs/day, bindweed 34.6 eggs with a daily mean of 2.44 eggs/day and parsley 27.8 eggs with a daily mean 2.05 eggs/day (Table 5 and Fig. 3). From the obtained results it could be concluded that the fecundity of *T. capsicum* increased to reach 38.00 eggs when fed on cheeseweed and decreased greatly in the treatment of parsley to reach 27.80 eggs only.

Table 5 Fecundity of *Typhlodromips capsicum* fed on *Tetranychus urticae* females reared on most proper five alternative host plants.

Host plant	Deposited eggs	
	Daily	Total
Bindweed	2.44[a]	34.60[b]
Cheeseweed	2.54[a]	38.00[ab]
Mint	2.45[a]	34.80[b]
Parsley	2.05[b]	27.80[c]
Rocket	2.40[a]	33.60[b]

Different letters in the same column indicate significant differences ($P \leq 0.05$) according to Duncan`s multiple range test.

The two-spotted spider mites are biologically controlled by predaceous insects and mites. *T. urticae* is one of the main reasons for identifying and using predatory mites from the Phytoseiiadae family for biological control. Oviposition choices can also be influenced by constraints such as longevity and time limitation of the adult female that may eventually govern optimal foraging strategies (Scheirs and De Bruyn, 2002).

Adult female of the predatory mite *T. capsicum* Mostafa was provided daily during their adulthood with a constant number of *T. urticae* adult females (5 preys/

predator female). *T. capsicum* longevity values averaged 18.5 days. Adult females of *T. capsicum* showed higher fecundity, where they deposited a significantly greater number of eggs (17.67 eggs) during a significantly longer oviposition period (14.33 days) with a daily mean of 1.33 eggs. Adult females of *T. capsicum* showed a higher rate of predation during adulthood, where they attacked a significantly greater number of 63.00 prey as a total average with a significantly greater daily mean of 3.41 preys (Basha *et al.*, 2007).

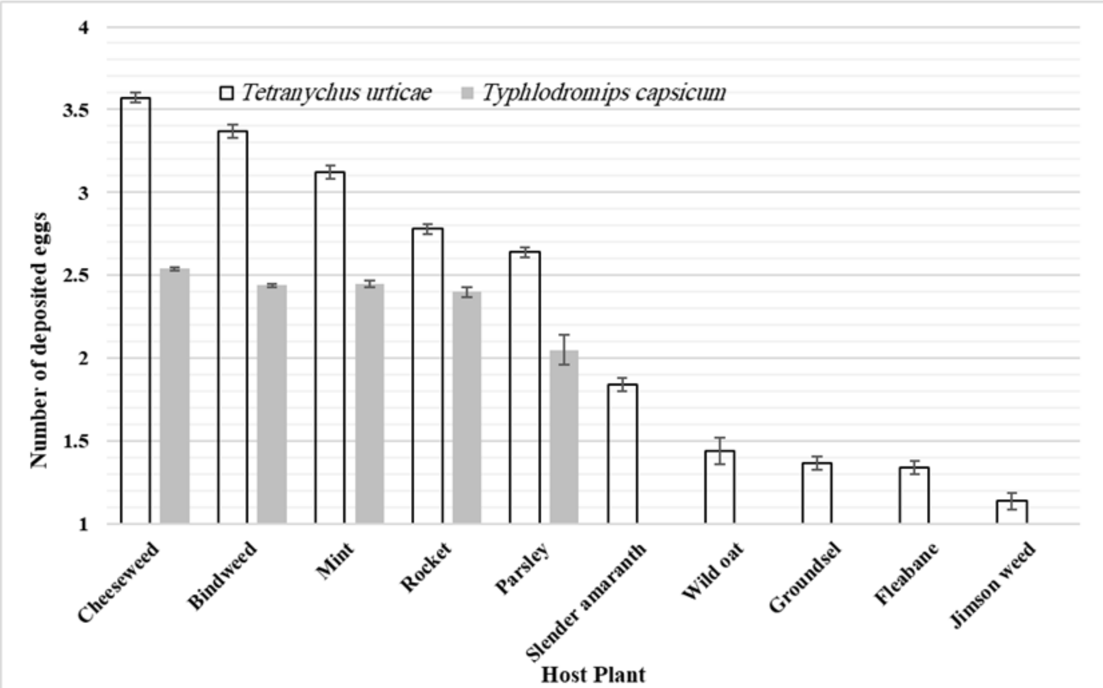

Fig. 3 Number of daily deposited eggs of *Tetranychus urticae* on different alternative host plants and *Typhlodromips capsicum* on preferred host plants for prey.

The mean adult female longevity of predatory mite *T. caspiansis* was 47.1 days. Fecundity in the average oviposition period (32.4 days) was 1.3 eggs per day per female. Reproductive and feeding behavior were studied at 26± 1°C, 14 L:10 D photoperiod and 70-80% RH (Rafati-fard *et al.,* 2004). While the female life cycle and life span of *T. swirskii* averaged 6.26 days and 43.20 days at 28±1 °C. During its life span, the average female fed on 345.66 with a daily rate of 8.00 *T. urticae* immatures respectively. The net rate of natural increase (rm) and the finite rate of increase (erm) of the predators was 0.261 and 1.29. These of *T. urticae* were 0.222 and 1.24, respectively (Osman *et al.*, 2010).

Due to predators' delayed response to spider mite populations, alternate host plants and weeds may serve as a reservoir plant for phytophagous mites, allowing pest numbers to grow in regions used for solanaceous vegetable growth (Aucejo *et al.*, 2003; Kumral and Cobanoglu, 2015). Weed populations were adequate to protect hop plants from mite damage. However, the weeds were insufficient to manage the pests, and an acaricide had to be used (Schweizer, 1992), perhaps the conservation, protection and improvement of existing biodiversity significantly reduced any form of attack on crops (Lagunovschi-Luchian and Corbu, 2012).

Conclusion

Based on the obtained results, the unsuitable host plants for *T. urticae* as indicated by longevity and fecundity parameter included slender amaranth, groundsel, fleabane, wild oat and Jimson weed as the least suitable host plants sorted in descending order. The longevity, prey consumption and fecundity of *T. capsicum* females were studied on the most suitable plants for TSSM comprising rocket, parsley, mint, bindweed and cheeseweed sorted in ascending order. Also, the predatory phytoseiid species *T. capsicum* may be used as a potential biological control agent against *T. urticae* on altered host plants as weeds and other plants in the field due to its higher rates of prey consumption, higher fecundity, longer oviposition period and longevity. leaving the most preferred alternative host plants of TSSM depends on the natural balance and the existence of outbreaks of spider mites or keeping them to ensure the survival of natural enemies via preservation of the ecological biodiversity responsible for keeping the TSSM under the economic threshold levels.

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ARABIC SUMMARY

الحشائش العشبية كعوائل نباتية مُحتملة لـحلم العنكبوت ذو البقعتين وفعالية افتراس تيفلودروميبس كابسيكم على النباتات المفضلة

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يعتبر حلم العنكبوت ذو البقعتين ***Tetranychus urticae*** أحد أخطر الآفات نباتية التغذية متعددة العوائل والأكثر انتشاراً عالمياً متعددة العوائل، ينتقل هذا الحلم اثناء الفواصل بين المحاصيل للنباتات الخضراء الموجودة سواء كانت ذات أهمية اقتصادية أو حشائش، لذلك تهدف هذه الدراسة لتحديد مدى ملائمة بعض النباتات المصاحبة للمحاصيل كعوائل بديلة مناسبة لنمو وتكاثر حلم العنكبوت ذو البقعتين وأيضا تقيم الكفاءة الافتراسية للحلم الفيتوسيدي المفترس (تيفلودروميبس كابسيكم) ***Typhlodromips capsicum*** علي العوائل النباتية المفضلة لنمو وتكاثر حلم العنكبوت ذو البقعتين عن طريق دراسة الخصائص البيولوجية والقدرة التناسلية للفريسة والمفترس.

وأوضحت النتائج أن اوراق نباتات الخبيزة والعليق والنعناع البلدي تُعتبر مُفضله لحلم العنكبوت ذو البقعتين حيث بلغت فترات طول عمر الأنثى 16.9، 16.3، 16.3 يوماً على هذه النباتات على التوالي، في حين سُجل اعلى معدل معنوي لوضع البيض لحلم العنكبوت ذو البقعتين على اوراق الخبيزة (بمعدل كلي 43.6 بيضة و3.57 بيضة/يوم) وبنسبة جنسية 2.6: 1 (72.25 ٪ إناث). وبناءً على الترتيب التنازلي لمدة طول العمر وخصوبة أفراد حلم العنكبوت ذو البقعتين كانت نباتات الزُربيح والجُعضيض والبرنوف والزُمير والداتورة العوائل النباتية الأقل تفضيلاً.

وعند دراسة فترة طول العمر والاستهلاك الغذائي وخصوبة الحلم المفترس تيفلودروميبس كابسيكم على النباتات الأكثر تفضيلاً لحلم العنكبوت ذو البقعتين والمرتبة تصاعديا لتشمل الجرجير والبقدونس والنعناع البلدي والعليق والخبيزة، فكانت فتره طول العمر لأنثى الحلم المفترس على النباتات المفضلة لحلم العنكبوت ذو البقعتين مُتقاربة وكان معدل الافتراس الأعلى (كلي 75 ويومي 3.95 فرد من الفريسة/مفترس) بدرجه معنوية عند تربيه حلم العنكبوت ذو البقعتين على أوراق الخبيزة مصحوباً بأعلى معدل وضع بيض للأنثى (بمعدل كلي 38 بيضة و يومي 2.54 بيضة).

وقد خلصت الدراسة للدور الذي تلعبه العوائل النباتية البديلة كمخزون غذائي يمد الحلم النباتي باحتياجاته ويوفر له المأوى وأيضا كمأوى حاضن للفرائس اللازمة لإبقاء المفترسات الأكاروسية خلال فترات غياب المحاصيل الرئيسية للحفاظ على التنوع البيولوجي والتوازن الطبيعي.