Mite pests and their predators on seven vegetable crops (Arachnida: Acari)

Hend A. Basha a,⇑, Elsayed M. Mostafa b, Ahmed M. Eldeeb c

a Department of Plant Protection, Faculty of Agriculture, Zagazig University, Zagazig, Egypt
b Department of Plant Protection, Faculty of Agriculture, Zagazig University, Zagazig, Egypt
c Department of Plant Protection, Faculty of Agriculture, Zagazig University, Zagazig, Egypt

Article info
Article history:
Received 19 December 2020
Revised 1 March 2021
Accepted 3 March 2021
Available online 13 March 2021

Keywords:
Biological control
Integrated pest management
Occurrence
Dominance

Abstract

During this study the frequency of occurrence and dominance of phytophagous and predatory mites harboring seven vegetable crops in Egypt, namely common bean, cowpea, eggplant, okra, squash, sweet pepper and sweet potato during 2017–2018 were investigated to identify predatory mites that might be useful for the biological control of the phytophagous mites. Three phytophagous and nine predatory mite species were surveyed. The two spotted spider mite Tetranychus urticae Koch of the family Tetranychidae was the dominant pest on these vegetables, while phytoseiids Phytoseiulus persimilis (Athias- Henriot), Typhlodromips swirskii (Athias- Henriot) and Euseius scutalis Chant were the dominant predators. The population of the native or indigenous phytoseiid mite fauna in Egypt such as Phytoseiulus persimilis could be considered as a good biocontrol agent and a part of the Integrated Pest Management (IPM) program in the future. Mite fauna of Egypt especially local populations of Phytoseiulus persimilis can be considered for implementation in future Integrated Pest Management (IPM).

1. Introduction

A great number of mite fauna (Arachnida: Acari) have been reported on vegetable crops throughout the world including Egypt. Several species are phytophagous and well known as worldwide damaging pests attacking these crops, causing various types of injuries and consequently affect the crop production. Among the most important acarine pests recorded in the vegetable fields, the plant feeder mites of the families, Tetranychidae, Tenuipalpidae and Eriophyidae. In addition to the acarine pests, vegetable fields were found to have massive numbers of predatory mites from different taxa of subclass Acari, preying on eggs, immature stages and adults of phytophagous mites and various small insects (Helle and Sablies, 1985). In Egypt, Common bean Phaseolus vulgaris L.; cowpea Vigna unguiculata; eggplant Solanum melongena; okra Abelmoschus esculentus; squash Cucurbita pepo; sweet pepper Capsicum annuum and sweet potato Ipomoea batatas are considered as important popular vegetable crops and were extensively attacked by several acarine pests, that are widely spread during the growing season, together with a great number of predatory mites (Abou-Zaid et al., 2012; Jeong-Hwan et al., 2012; Nandini et al., 2012; Nandini et al., 2012; Soares et al., 2012; Binisha and Bhaskar, 2013; Haneef and Sadanandan, 2013; Maklad et al., 2014; Maheswary et al., 2015; Castro et al., 2019).

Knowledge about the prevailing native predatory mite fauna in vegetable ecosystems is very important to identify any perspective species to be used in biological control programs. Therefore, the objective of current study was to provide a database on the important phytophagous and predatory mite species associated with seven vegetable crops that mentioned above. Also, the efficiency of the native populations of the predatory mite species P. persimilis against the two-spotted spider mite T. urticae was investigated in the laboratory.

2. Materials and methods

This study was carried out in Itai El-Baroud district, Beheira governorate, Egypt (West Delta) during 2017–2018 seasons to explore the faunal composition of mite pests and their predators on seven major vegetable crops viz. common bean, Phaseolus...
vulgaris; cowpea, Vigna unguiculata; eggplant, Solanum melongena; okra, Abelmoschus esculentus; squash, Cucurbita pepo; sweet pepper, Capsicum annuum and sweet potato, Ipomoea batatas.

2.1. Incidence of mite species on the investigated crops

Twenty five leaf samples (25 leaves each) were randomly taken from half acre for each of the investigated crops during growing seasons, placed separately in polyethylene bags, brought to the laboratory and examined under stereomicroscope for counting of mite individuals. All collected individual mites were placed in lactophenol solution, then picked individually and mounted into Hoyers's medium and dried in an oven at 30 °C. (Krantz, 1978; Zaher, 1986; Chant and McMurtry, 1994). Obtained mite species were categorized using the Criteria of frequency percent (Wallwork, 1970).

Frequency percent
\[
\text{Frequency percent} = \frac{\text{Number of sampling units with species A present}}{\text{Total number of sampling units taken}} \times 100
\]

and dominance according to (Palyvos et al., 2008). Dominance is identified as the percentage of individuals of a given taxon compared with the total number of individuals of all taxa found. Three categories are recognized for the dominance of mite species and classified as dominant (D), influent (In) or recedent (R) if they constitute >10, 5–10 or <5% of the total number of individuals, respectively. Frequency percent were designed as constant (C) accessory (A) or accidental (Ac) if they occurred in >50, 25–50 or <25% of the total number of samples, respectively. All the mite specimens were deposited in the Collection of Acarology of Plant Protection Department, Faculty of Agriculture, Zagazig University (Egypt).

2.2. Duration of P. persimilis developmental stages

Laboratory cultures of P. persimilis were established on the phytophagous mite T. urticae infesting common bean, P. vulgaris leaves in the laboratory. Using individuals obtained from common bean plants. The predator was reared by the method described by Mostafa (2004). Leaf discs of common bean (one inch in diameter each) were used as a rearing substrate. Leaf discs were placed singly in petri-dishes with the adaxial surface facing upwards, on saturated cotton wool. Suitable moisture was maintained by adding few drops of water if needed. A total of 25 sexed females were placed singly on each leaf disc and left 12 h to lay their eggs. Immediately after the oviposition, females were removed to the stock culture and the deposited eggs were examined twice daily during the incubation period (2.2 ± 0.187 days). Hatched larvae were rearer singly on bean leaf discs during their life cycle. All developmental stages of the predator were supplied with 20 individual of T. urticae immature stages obtained from infested common bean leaves in the laboratory. Duration of developmental stages and the consumed prey individuals by each stage were counted daily and replaced with fresh live prey.

2.3. Oviposition and predation capacity of predator adult female

A total of 30 females of P. persimilis in the teleiochrysalis stages were singly isolated and placed individually on leaf discs as described in the previous section. Each female received 20 individuals of T. urticae. This experimental arena was replicated 30 times. For each of the tested introduced prey stages (immatures and adult females of T. urticae) and separately supplied daily with 20 individuals of each of the abovementioned prey stages. Two adult predator males were introduced to each leaf disc for mating. Each female was allowed to deposited eggs for 10 days and number of laid eggs was recorded. Also the devoured prey individuals from each prey stage by predator female were counted and replaced with another alive ones. Experiments were carried out in the laboratory at 26 ± 2 °C; 65 ± 5% RH and 14 h L: 10 D photoperiod. Obtained data were subjected to statistical analysis using t-test, Windows 95 according to (Zimmerman and Zumbo, 1993).

3. Results

3.1. Phytophagous mites

Three species of plant feeder mite species Tetranychus urticae Koch (Tetranychidae); Brevipalpus phoenicis Geij (Tenuipalpidae) and Aceria lycopersici Wolff (Eriophyidae) were recorded. Frequency occurrence and dominance of these species on the studied crops are shown in Tables 1 and 2. The family Tetranychidae was rated as constant and dominant on all of the investigated crops. The tenuipalpids species B. phoenicis was recorded only on sweet potato and classified as constant and dominant, while the eriophid species A. lycopersici was counted only on eggplant and rated as accessory and recedent.

3.2. Predatory mites

Nine species of predatory mites belonging to families Phytoseiidae, Cheyletidae and Stigmaeidae were recorded. Based on frequency, dominance analysis values of the total collected samples and total collected individuals of the surveyed predatory mite families, presented in Tables 1 and 2 indicated that family Phytoseiidae was found to be the most constant and dominant, while families Cheyletidae and Stigmaeidae were less frequent and dominant on the investigated crops.

3.3. Composition and dominance of predatory mite species

Data presented in Table 3 showed that the family Phytoseiidae formed the majority of these predators and represented by seven species namely, Cydnoseius vitis Mostafa; Euseius scutalis Chant; Neoseiulus glycini Basha; Phytoseiulus persimilis Athias-Henriot;
The predator completed its development from egg to adult within 6.2 days when fed on immature stages of T. urticae in the laboratory at 26 ± 2 °C (Table 4). The predator was inactive during the larval stage, during the nymphal and adult stages predator individuals feed voraciously on the introduced prey. Results showed that the native populations of P. persimilis are able to feed and complete their development on T. urticae in the laboratory. The predator may exhibit a high capacity for population increase when fed on immatures, thus may be able to provide effective control of this pest in the field.

4. Discussion

The present study showed that, the two-spotted spider mite T. urticae is polyphagous and classified as the most damaging among the phytophagous mites attacking the investigated vegetable crops. The predator mite families most frequently collected in this study were Phytoseiidae, Stigmaeidae and Cheyletidae. Members of the family Phytoseiidae formed the majority of these predators, of which P. persimilis, T. swirskii and E. scutalis appeared to be the most common predators associated with phytophagous mite in the investigated vegetable fields. This study also cleared that P. persimilis is a good predator against T. urticae so it can be used to estimated the mite populations.

The findings of this study are in general agreement with similar results on phytophagous and predaceous mites on many agricultural crops including vegetables in accordance with fact that, a rich predatory mite fauna occurs in vegetable fields, several of these predators as biological control agents were extensively studied especially phytoseiids (Gerson et al., 2003; parvin et al., 2010; Al-Atawi, 2011; Özsisli and Cobanoglu, 2011; Binisha and Bhaskar, 2013; Haneef and Sadanandan, 2013; Abou-Awad et al., 2014; Maheswary et al., 2015). The findings of this study also are similar to those of Escudero & Ferragut (2005); Naher et al. (2005); Karmakar and Gupta (2011); Onzo et al. (2012). They reported that P. persimilis is

### Table 2

| Mite Family | Crop          | Common bean | Cowpea | Eggplant | Okra  | Squash | Sweet pepper | Sweet potato | Total collected individuals |
|------------|---------------|-------------|--------|----------|-------|--------|--------------|--------------|-----------------------------|
| Tetranychidae | 69.24 D      | 58.69 D     | 67.07 D | 62.8 D   | 66.07 D | 62.07 D | 59.02 D      | 65.79 D      |                             |
| Tenuipalpidae | 0.00         | 0.00        | 0.00   | 0.00     | 0.00   | 0.00   | 0.00         | 1.34 R       |                             |
| Eriophyidae  | 0.00         | 0.00        | 4.81 R | 0.00     | 0.00   | 0.00   | 0.00         | 1.46 R       |                             |
| Phytoseiidae  | 21.56 D      | 31.92 D     | 13.26 D | 30.7 D   | 23.62 D | 37.93 D | 10.82 D      | 20.70 D      |                             |
| Cheyletidae  | 3.79 R       | 3.47 R      | 5.56 In | 2.87 R   | 6.28 In | 0.00   | 0.00         | 4.17 R       |                             |
| Stigmaeidae  | 5.41 In      | 5.92 In     | 9.30 In | 3.67 R   | 4.03 R  | 0.00   | 4.64 R       | 6.54 In       |                             |

Dominance: Mite species are classified as dominant (D), influent (In) or recedent (R) if they occurred > 10, 5–10 or < 5% of the total number of individuals.

### Table 3

| Mite family | Mite species | Crop          | Common bean | Cowpea | Eggplant | Okra  | Squash | Sweet pepper | Sweet potato | Total collected individuals |
|-------------|--------------|---------------|-------------|--------|----------|-------|--------|--------------|--------------|-----------------------------|
| Phytoseiidae | Cydnoseius vitis | 7.09 In      | 0.00        | 1.28 R | 5.56 In  | 4.10 R | 0.00   | 0.00         | 1.34 R       |                             |
|             | Euseius scutalis | 16.55 D      | 21.05 D     | 7.05 In | 0.00    | 13.70 D| 27.03 D | 13.89 D      | 13.78 D      |                             |
|             | Neoseius glycine | 5.44 In      | 0.00        | 5.13 In | 0.00    | 5.48 In | 0.00   | 11.11 D      | 4.89 R       |                             |
|             | Phytoseius persimilis | 33.10 D | 15.79 D | 38.46 D | 37.04 D | 27.40 D | 24.32 D | 0.00         | 31.58 D      |                             |
|             | Phytoseius finitimus | 0.00        | 0.00        | 12.18 D | 0.00    | 0.00   | 0.00   | 0.00         | 2.38 R       |                             |
|             | Typhlodromus swirskii | 23.64 D | 52.63 D | 19.87 D | 44.44 D | 28.77 D | 32.43 D | 41.67 D  | 26.69 D      |                             |
|             | Typhlodromus malus | 8.27 In      | 0.00        | 12.82 D | 9.26 In  | 0.00   | 16.22 D | 22.22 D      | 9.27 In       |                             |
|             | Cheyletidae  | Hamichyletia bakeri | 1.65 R    | 0.00    | 0.00    | 3.70 R | 4.11 R  | 0.00         | 1.51 R       |                             |
|             | Stigmaeidae  | Agistemus exsertus | 4.26 R   | 10.53 D | 3.21 R  | 0.00   | 16.44 D | 0.00         | 11.11 D      |                             |
|             | Eriophyidae  | Hemicheyletia bakeri | 1.65 R    | 0.00    | 0.00    | 3.70 R | 4.11 R  | 0.00         | 1.51 R       |                             |
|             | Tenuipalpidae | Cheyletidae  | 1.65 R      | 0.00    | 0.00    | 3.70 R | 4.11 R  | 0.00         | 1.51 R       |                             |
|             | Tetranychidae | Tetranychidae | 1.65 R      | 0.00    | 0.00    | 3.70 R | 4.11 R  | 0.00         | 1.51 R       |                             |
|             | Eriophyidae  | Tetranychidae | 1.65 R      | 0.00    | 0.00    | 3.70 R | 4.11 R  | 0.00         | 1.51 R       |                             |
|             | Stigmaeidae  | Eriophyidae  | 1.65 R      | 0.00    | 0.00    | 3.70 R | 4.11 R  | 0.00         | 1.51 R       |                             |

Dominance: Mite species are classified as dominant (D), influent (In) or recedent (R) if they occurred > 10, 5–10 or < 5% of the total number of individuals.

### Table 4

| Stage            | Average periods (in days) | SE |
|------------------|---------------------------|----|
| Egg              | 2.2 ± 0.187               |    |
| Larva            | 0.9 ± 0.187               |    |
| Protonymph       | 1.2 ± 0.122               |    |
| Deutonymph       | 1.9 ± 0.187               |    |
| Total immatures  | 4.0 ± 0.316               |    |
| Egg to adult     | 6.2 ± 0.2                 |    |

± SE Standard Error
Oviposition and prey consumption of *Phytoseius persimilis*

**Efficiency of the Integrated Pest Management for this mite.**

An effective biological control agent against the spider mite *Tetranychus urticae*.

**5. Conclusion**

Conservation of the bio-control agents for this pest and their natural enemies should be taken into consideration and be used as an alternative to acaricides. The entire group of the family Phytoseiidae identified in Egypt fauna could be considered as a part of the Integrated Pest Management for this mite.

**Availability of data and materials**

All data of the study have been presented in the manuscript, and high quality and grade materials were used in this study.

**Funding**

The study was conducted with the available laboratory resources without any aid from any funding agency.

**Authors’ contributions**

HAB designed and performed the experiments and also wrote the manuscript. EMM and AME designed experiments and reviewed the manuscript. All authors read and approved the final version.

**Declaration of Competing Interest**

The authors declare that they have no competing interests.

**Reference**

Abou-Awad, B.A., Hafez, S.M., Farahat, B.M., 2014. Biological studies of the predacious mite *Amblyseius swirskii*, a predator of the broad mite *Polyphagotarsonemus latus* on pepper plants (*Acari: Phytoseiidae*). J. Arch. Phytopatohl. Plant Protect. 47 (3), 349–354.

Abou-Zaid, A.M., Bakr, E.M., Yassin, S.A., Hameed, N.A., 2012. Abundance of three sap sucking pests on three eggplant cultivars with utilization of *Phytoseiulus persimilis* Athias-Henriot against *Tetranychus urticae* Koch control. Acarines 6, 49–53.

Al-Atawi, F.J., 2011. Phytophagous and predaceous mites associated with vegetable crops from Riyadh, Saudi Arabia. Saudi J. Biol. Sci. 18 (3), 239–246.

Bunisha, K.V., Bhaskar, H., 2013. Mite fauna associated with major vegetable crops of Thrisur district Kerala. Entomol. 38 (1), 47–52.

Castro, B.M., Soares, M.A., Andrade, V.C., Santos-Junior, V.C., Fontes, P.C., Wilkens, C.F., Serraao, J.E., Zunancia, J.C., 2019. Preference of red mite *Tetranychus ludeni* Zacher (*Acari: Tetranychidae*) to sweet potato genotypes. Braz. J. Biol. 79 (2), 208–212.

Chen, C.-C., 2013. A review of the subfamilies Phytoseiinae and Tetranychinae (*Acari: Phytoseiidae*). Int. J. Acarology 20 (4), 223–310.

Escudero, L.A., Ferragut, F., 2005. Life-history of predatory mites *Neoseiulus californicus* and *Phytoseiulus persimilis* (*Acari: Phytoseiidae*) on four spider mite species as prey, with special reference to *Tetranychus evansi* (*Acari: Tetranychidae*). Biol. Control 32 (3), 378–384.

Gerson, U., Smiley, R.L., Ochoa, R., 2003. Mites (*Acari*) for pest control, Vol. 558. Blackwell Science, Oxford.

Haneef, S., Badanandana, M.A., 2013. Survey of predatory mites (*Acari: Phytoseiidae*) associated with economically important plants of North Kerala. Biological Forum 5 (2), 119–122.

Helle, W., Sablies, M.W., 1985. Spider mites. Their biology, natural enemies and control. World Crop Pests. Vol. 1A, Amsterdam Elsevier. 1A 405 pp.

Jeong-Hwan, K., YoungWoong, B., ManYoung, C., ChangWoo, J., SuYong, B., EunMi, P., EunJin, K., 2012. Control efficacy of natural enemies on four arthropod pests found in greenhouse hot pepper, Korean J. Appl. Entomol. 51 (2), 83–90.

Karmakar, K., Gupta, S.K., 2011. Predatory mite fauna associated with agri-horticultural crops and weeds from the Gangetic Plains of West Begal, India. Zoosymposia 6 (1), 62–67.

Krantz, G.W., 1978. A manual of acarology. Oregon state University Book Stores, Inc., Corvallis, p. 509.

Maheswary, J., Bhaskar, H., Gowda, C.C., 2015. *Phytoseiidae* mite fauna associated with major vegetable crops of Thrissur District, Kerala, J. Biological Control 29 (4), 183–186.

Maklad, A.M., Yassin, S.A., El-Chafar, Y.A., 2014. Influence of certain climatic factors on some major pepper pests under Egyptian conditions. Egypt. Acad. J. Biol. Sci.; Entomol. 7 (1), 31–37.

Mostafa, E.M., 2004. Studies on mites of the family Phytoseiidae at Sharkia governorate. Ph. D. Thesis, Fac. Agric. Zagazig University.117 pp.

Maher, N., Islam, W., Hague, M.M., 2005. Predation of three predators on two-spotted spider mite, *Tetranychus urticae* Koch (*Acari: Tetranychidae*). J. Life Earth Sci. 1 (1), 1–4.

Nandini, R.S., Giradidi, S.M., Ashalatha, K.V., Manture, S.M., 2012. Monitoring of sucking pests through yellow sticky traps in *Coppisium*. Ann. Plant Prot. Sci. 20 (1), 222–223.

Onzo, A., Houdokoho, A.F., Hanna, R., 2012. Potential of the predatory mite, *Amblyseius swirskii* to suppress the broad mite, *Polyphagotarsonemus latus* on the groma plant, *Solanum macrocarpon*. J. Insect Sci. 12 (1).

Özsilii, T., Cobanoglu, S., 2011. *Mite* (*Acari*) fauna of some cultivated plants from Kahramanmaras, Turkey. African J. Biotechnol. 10 (31), 2149–2155.

Palyvos, N.E., Emmanouel, N.G., Saitanis, C.J., 2008. Mites associated with stored products in Greece. Exp. Appl. Acarol. 44 (3), 213–226.

Parvin, M.M., Asgar, M.A., Hague, M.M., 2010. Voracity of three predators on two-spotted spider mite, *Tetranychus urticae* Koch (*Acari: Tetranychidae*) and their developmental stages. Res. J. Agric. Biol. Sci. 6 (1), 77–83.

Soares, M.A., Castro, B.D.C., Andrade-Júnior, V.C., Assis-Júnior, S.L., Pires, E.M., 2012. Attack of two new spider mite species on sweet potato (*Ipomoea batatas*) in Diamantina, Minas Gerais State, Brazil. Brazil. J. Biol. 72 (4), 971–978.

Walljork, J.A., 1970. Ecology of soil animals. Mc Grow, Hill, p. 283.

Zaher, M.A., 1986. Survey and ecological studies on phytophagous, predaceous and soil mites in Egypt. II-A & B: Predaceous and non phytophagous mites (Nile Valley and Delta). Pl. 480 program USA project No. EG- ARS-30, Grant No. FG, 139: 567.

Zimmerman, D.W., Zumbo, B.D., 1993. Rank transformations and the power of the Student t-test and Welch t-test for non-normal populations with unequal variances. Can. J. Exp. Psychology/ Revue Canadienne de Psychologie Expérimentale 47 (3), 523–539.

**Table 5**

| Larva   | Protonymph | Deutonymph | Nymphal stages |
|---------|------------|------------|----------------|
| T. a    | D. m       | T. a       | D. m           | T. a | D. m |
| 0.00    | 0.00       | 6.20 ± 0.374 | 5.33±0.527     | 13.4±0.510 | 7.23±0.488 | 19.6±0.748 | 6.37±0.261 |

T. a = Total number. D. m = Daily mean ± SE Standard Error.

**Table 6**

Oviposition and prey consumption of *Phytoseius persimilis* fed on immatures and adult females of *Tetranychus urticae* (during the first 10 days of oviposition).

| Prey stage | Number of deposited eggs | Average number of devoured preys |
|------------|--------------------------|---------------------------------|
|            | T. a | D. m   | T. a | D. m   |
| Immatures  | 31.8 ± 0.86 | 3.18 ± 0.086 | 108.4 ± 0.244 | 10.84 ± 0.024 |
| Females    | 16.4 ± 0.927 | 1.64 ± 0.092 | 45.6 ± 0.678 | 4.56 ± 0.067 |
| t-test     | 12.17** | 12.17** | 87.08** | 87.08** |

T. a = Total average. D. m = Daily mean ± SE Standard Error. **significantly different at 0.01.

*P. persimilis* and high quality and grade materials were used in this study.

The study was conducted with the available laboratory resources without any aid from any funding agency.

The authors declare that they have no competing interests.