

Population Density of Piercing-Sucking Pests and their Associated Natural Enemies on Pepper, *Capsicum annuum* L. Plants under Greenhouse Condition at Ismailia Governorate, Egypt

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ABSTRACT

This study was conducted on pepper plants, *Capsicum annuum* L. under greenhouse condition, in the farm of El Qassaseen Horticulture Research Station, Ismailia Governorate during the two successive winter seasons of 2013/2014 and 2014/2015 to survey the main piercing-sucking pests and associated natural enemies, also determine the population density and occurrence percentage for main species of pests and associated natural enemies. The obtained results showed that, the homopterous insects were the dominant piercing – sucking pests recorded 85.87 % (at the 1st season) followed by order Acarina family Tetranychidae (the two spotted spider mite, *Tetranychus urtica* Koch.) recorded 14.32 % (at the 2nd season), but the order Thysanoptera, family Thripidae (Onion thrips, *Thrips tabaci* Lind.) was occurred by lowest occurrence percentage 2.82 % of the total numbers of surveyed pests recorded at the 2nd season. While the Aphididae was the dominant homopterous family presented with 80.96 % (at the 1st season) of the total surveyed pests with three aphid species (green peach aphid, *Myzus persicae* (Sulz.), potato aphids, *Macrosiphum euphorbiae* (Thomas) and cotton aphids, *Aphis gossypii* Glov.), the Cicadellidae recorded lowest percentage of 0.99 % at the 1st season. The *M. persicae* found colonized plants terminals with high percentage of 72.80 % than on leaves by 27.20%; in contrast with *M. euphorbiae* which recorded 83.85% on leaves and 16.14% on terminals, while *A. gossypii* found on flowers only. The highest peak (as grand mean of the three aphid species) of 165.67 individuals /plant was recorded at 11st March during the 1st season. The highest parasitism percentage on aphid species of 85.00 % was recorded at 22nd June during the 2nd season. The highest peaks for whitefly, *Bemisia tabaci* (Genn.) of 12.00 individuals / leaf were recorded at 8th February and 16th June during the 2nd season. The leafhoppers, *Empoasca* spp. gave two weak peaks throughout the short activity period during the two study seasons. In the same trend, the population of *T. tabaci* recorded relatively high peak of 7.00 individuals/ leaf at 22nd April during the 1st season. Also, the *T. urtica* recorded the relatively high peak of 30.33 individuals/ inch² at 22nd April during the 1st season. The highest peak of the general mean of insect predators (*Coccinella* spp. and *Syrphus* spp.) and that of grand mean of insect plus mite predators were recorded at 25th March with 22.00 individuals/plant and 25.67 individuals/plant throughout the 1st season for the two means, respectively. The peaks of predators were congruent in time with high activity period of pests that may be play main role in suppress piercing-sucking pests. The statistical analysis results showed that, the highest effect as explained variance, EV % = 67.92 and 59.94 % were recorded for the effect of each of parasitoid and total insect predators on aphids species during the 1st season. So, it could be recommended to use each of parasitoids and predators to control piercing-sucking pests in greenhouses.

Keywords: greenhouse pepper plants, aphids, whitefly, leafhoppers, thrips, two spotted spider mites, associated natural enemies.

INTRODUCTION

Pepper (*Capsicum annuum* L) is one of the important economic, most popular and highly remunerative vegetable crops grown in most parts of the world; that for the nutritional values of fruits, mainly due to the fact that they are an excellent source of natural colors antioxidant and bioactive nutrients (carotenoids, vitamin C and phenolic compounds) (Ellaithy *et al.*, 2015), Unlike many of the field problems, insects and animal pests problems are peculiar to greenhouse cultivation. Aphids, two spotted spider mite, thrips, whitefly, leafhoppers, caterpillars, leaf miner, gall midge, nematodes and snails are serious problems on vegetable crops under protected condition and present the major factor limiting pepper production. They multiply in large numbers under controlled temperature and relative humidity there by leading to significant crop loss (Giraddi *et al.*, 2012). The pests of, *Bemisia tabaci* (Genn.); *Tetranychus urtica* Koch, *Aphis gossypii* Glov., *Myzus persicae* Sulz. and onion thrips, *Thrips tabaci* Lind. are infest and damage protected crops, particularly pepper, also, the greenhouses can be heavily infested by aphids, which seriously affect the yield and quality of the crop (Blackman & Eastop, 2000; and Ben Halima, 2005). The piercing-sucking pests are very serious problem on pepper where both nymphs and adults suck the cell sap from leaves and tender parts thereby inducing premature senescence; also, excretes honeydew on which sooty mold grows and inhibits the photosynthesis in addition to indirect damage of spread viral diseases. The *M. persicae*, *Macrosiphum euphorbiae* (Thomas) and *A. gossypii* and whitefly, *T. vaporariorum* and *B. tabaci* are principal pests of protected pepper crops in added to that, the *M. persicae* had highest incidence in pepper greenhouses

followed by *M. euphorbiae*. (Sanchez *et al.*, 2010; Beyon *et al.* 2011, Sanchez *et al.*, 2011; Gavkare, 2012 and Dogan *et al.*, 2016)

The present work aims to survey the main piercing-sucking pests and their associated natural enemies on protected pepper cultivation, determine the population density, occurrence percentage for main species of pests, associated natural enemies and to clarify the relationships between pests and natural enemies to give the growers a picture of the risk about plant protection to be take attention to crop management.

MATERIALS AND METHODS

This study was conducted in greenhouses at El Qassaseen Horticulture Research Station, Ismailia Governorate during the two winter successive seasons of 2013/2014 and 2014/2015 to survey the piercing-sucking pests and associated natural enemies on protected pepper cultivation, determine the population dynamic and occurrence percentage for main species of pests and associated natural enemies under greenhouse condition (27 ± 3 °C and 70 ± 5 % RH). One greenhouse of traditional area, 360 m² with 40 m long, 9 m wide and 3.25 m height; consists of five rows is 1m wide, 40 m long and distance between two seedling in the row is 50 cm. The greenhouse was covered with UVI polyethylene sheets, cultivated with pepper seedling at 1st week of November in the 1st season of 2013/2014 and 2nd week of October in the 2nd season of 2014/2015. The plants were received recommended package of Horticultural practices. Briefly, no pesticide was applied to pepper plants investigated throughout the study period.

1. Sampling technique:

Weekly sample of 10 pepper plants terminals (3-5 cm) replicated three times (30 terminals / sample) were chosen randomly and inspected actually in the greenhouse, in addition to 10 pepper fully expanded leaves (representing different plant strata) replicated three times (30 leaves / sample) were performed directly for flying insects by visual assessment in the morning hours when adults are less easily disturbed, collected in paper bags and transferred to laboratory to examine using binocular stereo microscope. The numbers of different stages of inspected pests, i.e., the aphids (cotton aphid, *Aphis gossypii* Glov., green peach aphid, *Myzus persicae* (Sulz.) and potato aphids *Macrosiphum euphorbiae* (Thomas) (Homoptera: Aphididae)); the whiteflies species (*Bemisia tabaci* (Genn.) and *Trialeurodes vaporariorum* (West.) (Homoptera: Aleyrodidae)); the leafhoppers species, (*Empoasca* spp. (Homoptera: Cicadellidae)); the onion thrips, (*Thrips tabaci* Lind.) (Thysanoptera: Thripidae)), and the two spotted spider mite (*Tetranychus urtica* Koch.) (Acarina: Tetranychidae)) were recorded throughout the study growing seasons as: number per cubic inch for *T. urtica* and number per leaf for the other pests.

In regard to associated natural enemies the numbers of aphids mummies, different stages of ladybird beetles (*Coccinella* spp.), hoverflies (*Syrphus* spp.) and phytoseiid predator mites species were recorded actually on sampled pepper plants in greenhouse and on sampled leaves in laboratory throughout the study growing seasons

2. Statistical analysis:

The obtained results were subjected to statistical analysis of correlation and regression as Little and Hills (1975) to clear the relationship between pests and natural enemies populations.

RESULTS AND DISCUSSION

1. Survey and occurrence percentages of piercing-sucking pests:

Data in Table (1) revealed that, the homopterous insects were the dominant piercing-sucking pests infesting pepper plants and represented about 85.87 and 82.83 %

followed by the order Acarina family Tetranychidae presented 11.26 and 14.32 % of the total numbers of surveyed pests during the two study seasons respectively. The Aphididae family was the dominant homopterous insect pests recorded with 80.96 and 75.46 % of the total surveyed pests. Three aphid species, green peach aphid, *M. persicae* which recorded relatively highest occurrence ratio of 48.28 and 46.45% (terminals plus leaves) followed by potato aphids, *M. euphorbiae* with 46.20 and 45.7 % (terminals plus leaves) and cotton aphids, *A. gossypii* with 5.52 and 7.84 % (on flowers only) of the total surveyed Aphididae during the period of study, respectively. The Aleyrodidae family was occurred with relatively low percentages of 3.92 and 5.64 % of the total homopterous. Two whiteflies species found namely, *B. tabaci* which present whole occurrence ratio of this family and *T. vaporariorum* which found in very low numbers during irregular periods. The Cicadellidae family recorded lowest homopterous percentages of 0.99 and 1.73 % presented with leafhoppers species, *Empoasca* spp. during the two study seasons, respectively. The obtained results were in agreement with those of Beyon *et al.*, 2011; Sanchez *et al.*, 2011; Gavkare, 2012 and Dogan *et al.*, 2016, who mentioned that, *M. persicae*, *M. euphorbiae* and *A. gossypii* and whitefly, *T. vaporariorum* and *B. tabaci* are principal pests of protected pepper crops and added that the *M. persicae* had the highest incidence in pepper greenhouses followed by *M. euphorbiae*. Also, that of Sandeep-Kaur *et al.*, 2010 who stated that, *B. tabaci* was noticed only during the early season on pepper in greenhouse.

The results in Table (1) showed that, the two spotted spider mite, *T. urtica* came followed homopterous pests as occurrence ratio of 11.26 and 14.32 % of the total surveyed pests, during the period of study, respectively. Also, the lowest occurrence percentages of 2.86 and 2.82 % of the total surveyed pests were recorded for order Thysanoptera presented by family Thripidae with one species, onion thrips, *T. tabaci* during the two study seasons, respectively. The obtained results are in agreement with those of Blackman and Eastop, 2000 and Ben Halima 2005, who reported that, the *B. tabaci*, *T. urtica*, *A. gossypii*, *M. persicae* and *T. tabaci* infested and damage protected crops, particularly pepper.

Table 1. Occurrence percentage of piercing-sucking pests infesting pepper plants under greenhouse condition (27 ± 3 °C and 70 ± 5 % RH) during the two successive seasons of 2013/2014 and 2014/2015

| Seasons | Parameters | Aphids species | | | | | | | Grand total | Whiteflies | Leafhoppers | Total homopterous | Thrips | Two spotted spider mite |
|-----------|----------------|----------------------------|--------------------|----------|--------|----------------------|----------|--------|-------------|------------|-------------|-------------------|--------|-------------------------|
| | | <i>A. gossypii</i> /flower | <i>M. persicae</i> | | | <i>M. euphorbiae</i> | | | | | | | | |
| | | | Terminals | Leaves | Total | Terminals | Leaves | Total | | | | | | |
| 2013/2014 | Seasonal total | 108.34 | 689.67 | 257.64 | 947.31 | 146.34 | 760.29 | 906.63 | 1962.28 | 95.01 | 24.00 | 2081.29 | 69.33 | 272.98 |
| | Occurrence% | 5.52* | 72.8*** | 27.2*** | 48.28* | 16.14*** | 83.85*** | 46.20* | 80.96** | 3.92** | 0.99** | 85.87 | 2.86** | 11.26** |
| 2014/2015 | Seasonal total | 121.33 | 542.00 | 176.66 | 718.66 | 154.31 | 552.66 | 706.97 | 1546.96 | 115.67 | 35.66 | 1698.29 | 58.01 | 293.65 |
| | Occurrence% | 7.84* | 75.42*** | 24.58*** | 46.45* | 21.83*** | 78.17*** | 45.7* | 75.46** | 5.64** | 1.73** | 82.83 | 2.82** | 14.32** |

*=Calculated depend on grand total of aphids species **= Calculated depend on total of each aphids species

***= Calculated depend on grand total of surveyed pests

Obtained results in Table (2) cleared that, visual count of aphid mummies colored dark to light brown or a brassy brown with spherical round shape were recorded on pepper plants in relatively low numbers of 260 and 340 mummy/season during the two study seasons, respectively. The noticed mummies color gave clear indication about parasitoids species (*Aphidius matricariae*, *A. colemani*, *Diaeretiella rapae*, and *Lysiphlebus testaceipes* Cresson (Hymenoptera: Aphidiidae) which parasitized surveyed

aphids species, as results of El-Heneidy & Adly, 2009. The obtained results in Table (2) pointed the highest parasitism percentages of 26.14 and 85.00 % were recorded at 27th May and 22nd June during the two study seasons, respectively; These results found in agreement with that of Sanchez *et al.*, 2011 who found the parasitism percentages of all aphid species in greenhouses was low, *Aphidius matricariae* and *Aphidius colemani* being the most abundant parasitoids.

The results in Table (2) recorded two insect predators (*Coccinella* spp and *Syrphus* spp.) together presented 72.06 and 68.74 % of the total numbers of surveyed predators during the period of study, respectively. Also, the phytoseiid predator mites, *Neoseiulus* and *Euseius* were found as dominant phytoseiid predator species but in relatively low numbers associated with pests on pepper plants presented 27.93 and 31.26 % of the total numbers of surveyed predators during the two study seasons, respectively. The

obtained results found in agreement with those of Ana-Pineda, 2008 who cleared that, nine species of aphidophagous syrphids were found as larvae, preying on aphids on sweet pepper plants. Also, with those of Gallardo *et al.*, 2005 who mentioned that the *Neoseiulus* predator mites was found as dominant phytoseiid predator mite's species associated with phytophagous mite on pepper plants in greenhouse

Table 2. Occurrence percentage of natural enemies associated with pests on pepper plants under greenhouse condition (27 ± 3 °C and 70 ± 5 % RH) during the two successive seasons of 2013/2014 and 2014/2015.

| Aphid mummies no.* | Seasonal mean of parasitism % | Season 2013/2014 | | | | | | Aphid mummies no.* | Seasonal mean of parasitism % | Season 2014/2015 | | | | | |
|--------------------|-------------------------------|--------------------|-----------------|-----------------------|----------------|--------------|--------------------------|--------------------|-------------------------------|------------------|--------------------|-----------------------|----------------|--------------|--------------------------|
| | | Ladybird beetles** | Syrphus flies** | total insect pred.*** | Mites pred.*** | Total pred.* | Total of pred. & mummies | | | Syrphus flies** | Ladybird beetles** | total insect pred.*** | Mites pred.*** | Total pred.* | Total of pred. & mummies |
| 260.00 | - | 143.33 | 19.99 | 163.32 | 63.32 | 226.64 | 486.64 | 340.00 | - | 47.33 | 126.35 | 173.68 | 78.99 | 252.67 | 592.67 |
| 53.43 | 9.64 | 87.76 | 12.24 | 72.06 | 27.93 | 46.57 | - | 57.36 | 28.81 | 27.25 | 72.75 | 68.74 | 31.26 | 42.63 | - |

*=Calculated depend Total of pred. & mummies **= Calculated depend on total insect pred. ***= Calculated depend on total pred.

2. Population density of major pests:

• **Aphids species:**

The data illustrated in Figs (1&2) showed that, the activity peaks of listed aphid species were varied as a number, time, and values. The aphid species populations were oscillated and fluctuated on different pepper plants parts drawing numbers of peaks varied as aphid species and plant parts. The cotton aphid, *A. gossypii* recorded two peaks

throughout activity period extended from, 3rd February till 13rd May during the 1st season of 2013/2014, the peaks of 17.33 and 9.67 individuals/ flower were regarded at 11th March and 22nd April, while at the 2nd season of 2014/2015 the activity period extended from 2nd March till 9th June patterned by two peaks at 6th April and 11th May with mean numbers of 19.00 and 10.33 individuals / flower for the two peaks, respectively.

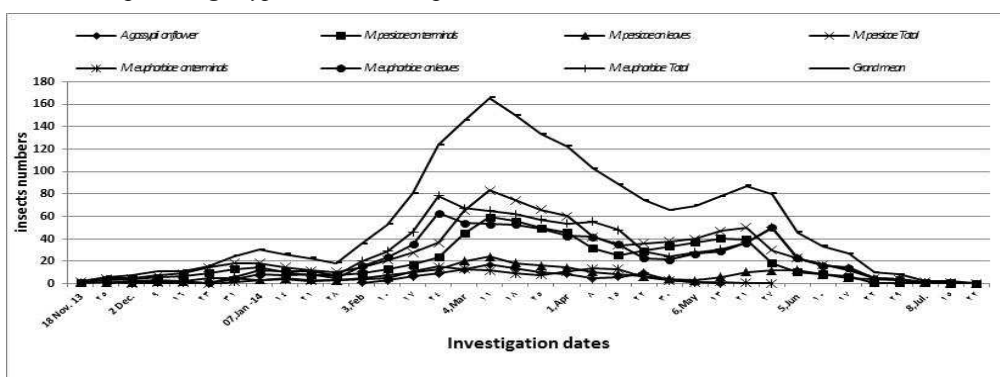


Fig. 1. Population fluctuation of aphid species infested pepper plants in greenhouse, 2013/2014 Season

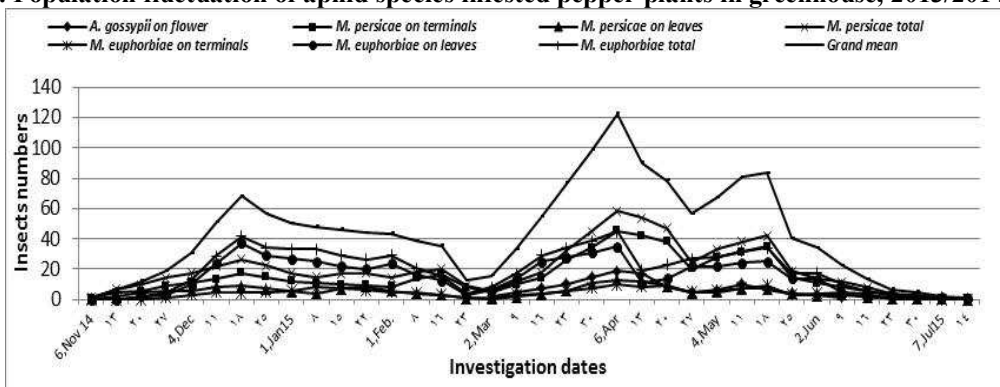


Fig. 2. Population fluctuation of aphid species infested pepper plants in greenhouse, 2014/2015 Season

The green peach aphid, *M. persicae* found colonized the terminal part and leaves of pepper plant all over the two

study seasons; recorded three peaks on each of the two plant parts and as general mean. During the 1st season, the three

peaks on terminals of 14.67, 59.33 and 40.66 individuals/terminal were recorded at 7th January, 11th March and 13 May; while on leaves the peaks of 5.33, 24.00, and 12.33 individuals/leaf were recorded at 31st December, 11th March and 5th June for the three peaks, respectively. In case of general mean of *M. persicae* on the two plant parts the three peaks of 18.66, 83.33 and 50.34 individuals/plant recorded at 31st December, 11th March and 21st May for the three peaks, respectively. In the second season, *M. persicae* recorded four peaks on each of the two plant parts and five peaks as general mean, the peaks of 17.67, 16.67, 45.33 and 35.00 individuals/terminal were recorded at 18th December, 16th February, 6th April and 18th May; while on leaves the peaks of 9.00, 8.34, 13.00 and 7.33 individuals/leaf were recorded at 18th December, 22nd January, 6th April and 18th May; in case of general mean of *M. persicae* on the two plant parts the peaks recorded at 18th December, 22nd January, 16th February, 6th April and 18th May with general mean of 26.66, 16.67, 20.00, 58.33 and 42.34 individuals/plant for the five peaks, respectively Figs (1&2).

The potato aphid, *M. euphorbiae* found colonized terminal part and leaves of pepper plant all over the two

investigation seasons; recorded three peaks on terminals, four peaks on leaves and as general mean during the 1st season. The three peaks on terminals of 4.00, 15.33 and 13.66 individual/terminal were recorded at 14th January, 24th February and 8th April; while the four peaks on leaves of 2.67, 8.67, 63.00, and 50.00 individuals/leaf were recorded at 9th December, 7th January, 24th February and 27th May; in case of general mean, the five peaks of 3.66, 12.00, 78.33, 55.67 and 50.34 individuals/plant were recorded at 9th December, 7th January, 24th February, 8th April and 27th May for the five peaks, respectively. In the 2nd season, the aphids numbers showed four peaks on terminals with 5.00, 8.00, 10.00 and 9.33 individuals/terminal which recorded at 11th December, 8th January, 6th April and 18th May; while on leaves the peaks recorded at 25th December, 1st February, 6th April and 18th May with mean numbers of 37.33, 24.00, 35.00 and 25.00 individuals/leaf; also, the peaks of general mean were recorded at 18th December, 1st February, 6th April and 18th May with mean numbers of 41.66, 29.00, 45.00, and 34.34 individual/plant for the four peaks of *M. euphorbiae* on pepper plants, respectively Figs (1&2).

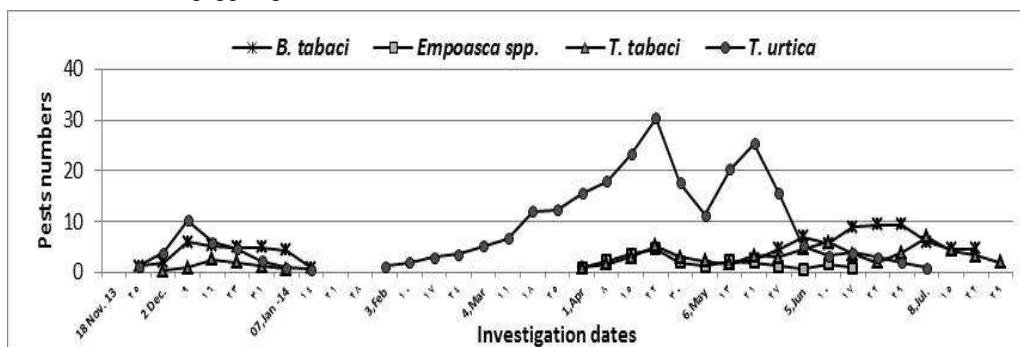


Fig. 3. Population fluctuation of piercing sucking pests infested pepper plants in greenhouse, 2013/2014 season

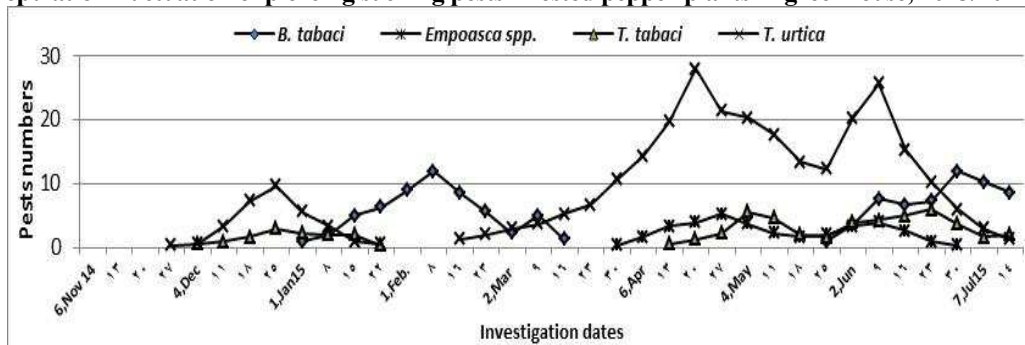


Fig. 4. Population fluctuation of piercing sucking pests infested pepper plants in greenhouse, 2014/2015 season.

As grand mean data illustrated in Figs (1&2), cleared that, the grand mean of three aphids species revealed three peaks during each of the two study seasons. During the 1st season, the peaks of 30.34, 165.67 and 87.34 individuals/plant were recorded at 7th January, 11th March and 21st May, while during the 2nd one the peaks of 68.33, 122.33 and 83.33 individuals/plant were recorded at 18th December, 6th April and 18th May for the three peaks respectively.

Generally, it could be concluded that, *M. persicae* found colonized the terminals of pepper plants with highly percentage (72.80 %) than on leaves (27.20%) in contrast with *M. euphorbiae* which found on leaves (83.85%) more than plants terminals (16.14%), while the cotton aphids found on flowers only. The total mean

numbers of the three aphids species was relatively high during the first season (1962.28 individuals/plant) than the second one (1546.96 individuals/plant), that found in contrast with other pests which recorded relatively high numbers at the second season more than the first one. The obtained results found agree these of Gavgare 2012 and Gavgare *et al.*, 2014 who showed that, *M. persicae* is a very serious pest of the pepper at different times under protected environment at different tested locations in Himachal Pradesh. Also that of, Gavgare *et al.*, 2015 who mentioned that, *M. euphorbiae* is one of the most problematic aphids in protected environments worldwide.

The statistical analysis results in table (3) revealed highly significant positive correlation coefficient between grand total mean of the three aphids species and aphid

mummies numbers ($r = 0.82^{**}$) during 1st season, while negative insignificant correlation coefficient ($r = -0.04ns$) was fulfilled during the 2nd season. Also, the results pointed out that the numbers of parasitoids was influenced aphids numbers and vice versa regardless of the signal of regression, where highly significant effect as explained

variance (EV %) of 67.92 % was noticed during the 1st season. In the same trend, highly significant positive correlation ($r = 0.774^{**}$) was realized between the grand total mean of aphids species and total insect predators with highly significant effect $EV = 59.94\%$ during the 1st season.

Table 3. Results of simple correlation, simple and partial regression, and explained variance between mean numbers of pests and natural enemies during the two successive seasons of 2013/2014 and 2014/2015.

| parameters | seasons | A(y) | A(x) | A(y) | A(x) | WF(y) | WF(x) | LH(y) | LH(x) | Th.(y) | Th.(x) | M(y) | M(y) | M(x) | M(x) |
|-----------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------|--------|--------|-------|-------------|-------------|-------|
| | | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | | m(x) | m(y) | IP(x) | IP(y) | TP(x) | TP(y) | IP(x) | IP(y) | TP(x) | TP(y) | TP(x) | TP(x) | MP(y) | MP(y) |
| Simple corr.(r) | 2013/2014 | 0.82 | | 0.77 | | -0.42 | | -0.04 | | -0.33 | | 0.26 | | 0.53 | |
| p | | ≥ 0.01 | | ≥ 0.01 | | ≥ 0.01 | | NS | | NS | | NS | | ≥ 0.01 | |
| Simple reg. (b) | | 6.36 | 0.11 | 6.28 | 0.10 | -0.41 | -0.45 | -0.07 | -0.14 | -0.12 | -0.87 | 0.33 | 0.20 | 2.81 | 0.11 |
| Se+/- | | 0.48 | 0.01 | 0.86 | 0.01 | 0.21 | 0.23 | 0.04 | 1.12 | 0.08 | 0.53 | 0.23 | 0.13 | 0.96 | 0.03 |
| t +/- | | 7.56 | | 7.23 | | -1.93 | | -0.12 | | -1.68 | | 1.49 | | 2.9 | |
| EV % | | 67.92 | | 59.94 | | 18.07 | | 0.16 | | 11.39 | | 6.73 | | 28.67 | |
| F probability | ≥ 0.01 | | ≥ 0.01 | | ≥ 0.05 | | NS | | NS | | NS | | ≥ 0.01 | | |
| Simple corr.(r) | 2014/2015 | -0.04 | | 0.27 | | -0.57 | | 0.53 | | 0.06 | | 0.20 | | 0.58 | |
| p | | NS | | NS | | ≥ 0.01 | | ≥ 0.05 | | NS | | NS | | ≥ 0.01 | |
| Simple reg. (b) | | -0.14 | -0.01 | 1.58 | 0.46 | -0.42 | -0.79 | 0.14 | 2.06 | 0.02 | 0.19 | 0.31 | 0.13 | 2.41 | 0.14 |
| Se+/- | | 0.59 | 0.05 | 1.04 | 0.03 | 0.14 | 0.27 | 0.07 | 1.03 | 0.08 | 0.68 | 0.28 | 0.11 | 0.69 | 0.04 |
| t +/- | | -0.23 | | 1.51 | | -2.91 | | 1.99 | | 0.28 | | 1.12 | | 3.46 | |
| EV % | | 0.15 | | 7.35 | | 33.26 | | 28.37 | | 0.41 | | 4.13 | | 34.3 | |
| F | NS | | NS | | ≥ 0.01 | | ≥ 0.05 | | NS | | NS | | ≥ 0.01 | | |

A (y) * m (x) = Aphids (y) * mummies (x), A (y) * IP (x) = Aphids (y) * insect predators (x) WF (y) * TP (x) = Whitefly (y) * total predators (x), LH (y) * IP (x) = Leafhoppers (y) * insect predators (x) Th. (y) * TP (x) = Thrips (y) * total predators (x) M (y) * TP (x) = Mite (y) * total predators (x), M (y) * MP (x) = Mite (y) * mite predators (x) and inverse that from (x) to (y) for regression. *insect predators = total of lady bird beetles + Syrphus flies **total predators = total of insect predators + predator mite (PM). ≥ 0.01 = highly significant correlation coefficient. ≥ 0.05 = only significant correlation coefficient. NS = non-significant correlation coefficient

• **Whitefly, *B. tabaci*:**

The obtained results in Figs (2&4) cleared that, the population of whitefly was oscillated and fluctuated on pepper plants recorded three peaks throughout two activity periods extended from, 25th November till 14th January and from 13th may till 22nd July during the 1st season of 2013/2014, the peaks of 6.00, 7.00 and 9.33 individual/ leaf were regarded at 9th December 5th June, and 29th June, respectively. In the 2nd season of 2014/2015, four peaks were observed throughout two activity period extended from 1st January till 16th march and from 25th may till 14th July, the peaks of 12.00, 5.00, 7.66 and 12.00 individuals / leaf were recorded at 8th February, 9th march and 16th June for the four peaks, respectively. The obtained results found agree these of Sandeep-Kaur, *et al.*, 2010 who stated that *B. tabaci* was noticed only during the early season on pepper in greenhouse.

The statistical analysis in Table (3) showed that highly significant negative correlation coefficient between mean numbers of whitefly and total numbers of predators ($r = -0.42^{**}$) during the 1st season, negative highly significant correlation coefficient ($r = -0.57^{**}$) during the 2nd one. Also, the results realized that the predators were influenced whitefly numbers, where, the relatively high effect as explained variance (EV %) of 33.26 % was deduced during the 2nd season.

• **Leafhoppers *Empoasca* spp.:**

The obtained results in Figs (2&4) showed that the occurred of leafhoppers population on pepper plants with low numbers patterned two weak peaks throughout one short activity period extended from 1st April till 17th June during the season of 2013/2014, the peaks were noticed at 22nd April and 13th may with 4.67 and 2.33 individuals/ leaf, respectively. In the same trend, two weak peaks of 5.33 and 4.00 individuals / leaf were observed throughout the short

activity period of 2014/2015 season at 27th April and 9th June for the two peaks, respectively.

The results of statistical analysis in Table (3) revealed insignificant negative correlation coefficient between the mean numbers of leafhoppers and total numbers of predators ($r = -0.04ns$) during 1st season, positive significant correlation coefficient ($r = 0.53^{*}$) during the 2nd one. Also, the predators influenced leafhoppers numbers, where the relatively high significant effect as explained variance (EV %) of 28.37 % was recorded during the 2nd season.

• **Onion thrips *T. tabaci*:**

The data presented in Figs (2&4) showed that two activity periods, four and three peaks were recorded for *T. tabaci* during the two study seasons, respectively. During the 1st season the periods were extended from 2nd December till 7th January and from 1st April till 29th July, in a while the four peaks of 2.67, 5.33, 6.00 and 7.00 individuals/ leaf were recorded at 16th December, 22nd April, 10th June and 8th July for the inspected peaks, respectively. During the 2nd season the two activity periods of thrips were extended from 4th December till 22nd January and the 2nd period from 27th April till 29th July with three peaks of 3.00, 5.67 and 6.00 individuals/ leaf set at 25th December, 4th May and 23rd June for the inspected peaks, respectively. The obtained results found agree these of Ben Halima, 2005 who stated that the onion thrips *T. tabaci* infested and damage protected crops, particularly pepper

The statistical analysis results in Table (3) revealed that insignificant negative correlation coefficient between mean numbers of thrips and total numbers of predators ($r = -0.33ns$) during 1st season, positive insignificant correlation coefficient ($r = 0.064ns$) during the 2nd one. Also, the results pointed that the predators was influenced thrips numbers, where, insignificant relatively high effect as explained variance (EV %) of 11.39 was noticed during the 1st season.

• **Two spotted spider mite, *T. urtica*:**

The population of the two spotted spider mites on pepper plants as seen in Figs (2&4) was oscillated, fluctuated and drawn out four peaks throughout the two activity periods extended from, 25th November till 14th January and from 3rd February till 8th July during 2013/2014 season; The peaks were realized at 9th December, 22nd April, 21st May and 17th June with 10, 33, 30.33, 25.33 and 4.00 individuals/ inch², respectively. Also, at 2014/2015 season, three peaks were appeared throughout the two activity period which extended from 27th November till 22nd January and from 16th February till 14th July; the peaks recorded at 25th December, 20th April and 9th June with mean numbers of 9.67, 28.00 and 25.67 individuals / inch² for the three peaks, respectively. The obtained results found agree with these of Giraddi *et al.*, (2012) who reported that, the two spotted spider mite, *T. urtica* infest and damage protected crops; particularly pepper

The results of statistical analysis presented in Table (3) cleared that insignificant positive correlation coefficient between mean numbers of mite and total numbers of predators ($r = 0.26ns$ and $0.20ns$ during the period of study, respectively. Also, the results pointed that, the predators was influenced the numbers of *T. urtica*, where insignificant effect as relatively low explained variance (EV %) ranged 4.13 to 6.73 % was noticed. On the other hand the relationship between the two spider mite and predator mite revealed highly significant positive correlation coefficient, $r = 0.53^{**}$ and 0.58^{**} during the two seasons, respectively. Also, the results pointed that the predator mites were influenced the numbers of the two spider mite, where highly significant effects of predator mites as explained variance (EV %) of 34.30 % were noticed during the 2nd seasons.

Generally, the relatively highest numbers of aphids, leafhoppers and two spotted spider mite were recorded during March and April, while the relatively highest numbers of each of whitefly and thrips noticed during June,

that during the flowering and fruiting period resulting in a shortage of both quality and quantity of yield. The obtained results found agree with these of Saad, 2002 in Egypt, who stated that vegetables under protected cultivation are attacked by numerous insects and mites caused serious damage and high yield losses. While the results found in partially agree with those of Roopa and Nandihalli, (2009) who reported three peaks of incidence of mite, two in April-May and one in November. While the results found in contrast with these of Amna *et al.*, (2012), who stated that, the maximum population of whitefly were observed during May, but maximum population of spider mites and thrips were observed during June.

3. Population density of associated natural enemies:

• **Aphid mummies:**

The illustrated data in Figs (5&6) cleared relatively low numbers of aphid parasitoids during the 2013/2014 season, that throughout activity period extended from 9th December till 22nd June with three mummies peaks of 8.33, 20.00 and 21.00 mummies/plant which realized at 7th January, 25th March and 27th May, respectively. The unexpected results showed that, the peaks of parasitism percentages were not in timing with that of mummies, which may be return to the effect of other factors. The relatively high parasitism percentages of 28.39 and 26.14 % were noticed early in the 1st season at 31st December and late in the season at 27th May, respectively. During 2014/2015 season, the activity period of parasitoids was extended from 27 November till 14 July with five peaks realized at 4th December, 8th February, 9th March, 27th April and 2nd June with mean numbers of 2.33, 24.33, 8.33, 16.00 and 22.67 mummies /plant. In the same trend, the highest parasitism percentages of 85.00 % were noticed late in the season at 16 June. The obtained results found in agree those of Sanchez *et al.*, (2011) who reported that, the parasitism of all aphid species in greenhouses was relatively low.

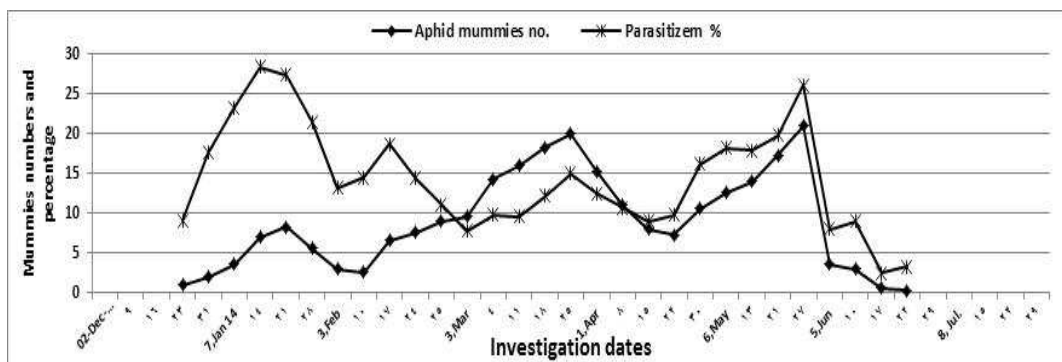


Fig. 5. Mean numbers of aphid's mummies and parasitism % on pepper plants in greenhouse 2013/2014 season.

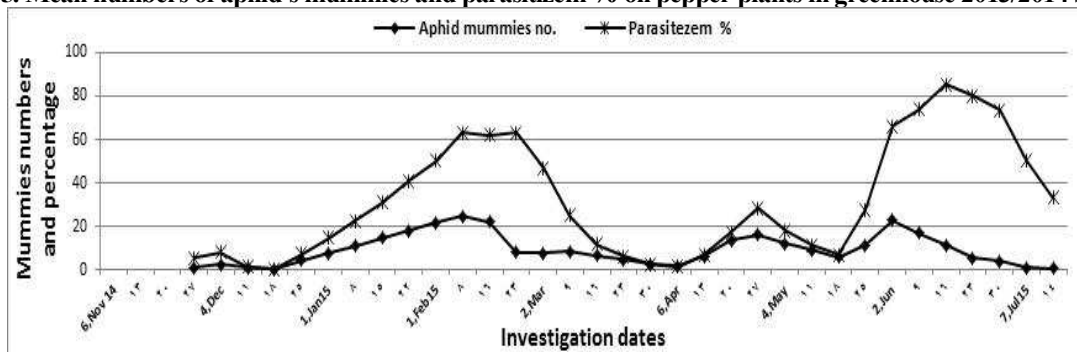


Fig. 6. Mean numbers of aphid's mummies and parasitism % on pepper plants in greenhouse 2014/2015 season

• **Insect predators:**

As seen in Figs (7&8) there were two insect predators found associated with the scouted pests on pepper plant; the ladybird beetles, *Coccinella* spp. were the dominant insect predator recorded activity periods extended from 31st December till 6th May at the 1st season and from 7th January till 27th June at the 2nd one with two and three peaks throughout the two seasons, respectively. The two peaks of the 1st season were recorded at 24th February and 25th March with 17.33 and 22.00 individuals /plant, respectively. During

the 2nd season, the three peaks were recorded at 15th January, 9th March and 4th May with 6.00, 17.33 and 6 individuals /plant, respectively. The second insect predator *Syrphus* spp. found in relatively low numbers during two short activity periods at the 1st season and one activity periods at the 2nd one with two peaks for each of the two seasons. The two peaks of the 1st season were recorded at 10th February and 13th may with 3.00 and 2.67 individual /plant, while during the 2nd season, the peaks were recorded at 23rd February and 16th June with 6.00 and 7.00 individual /plant, respectively.

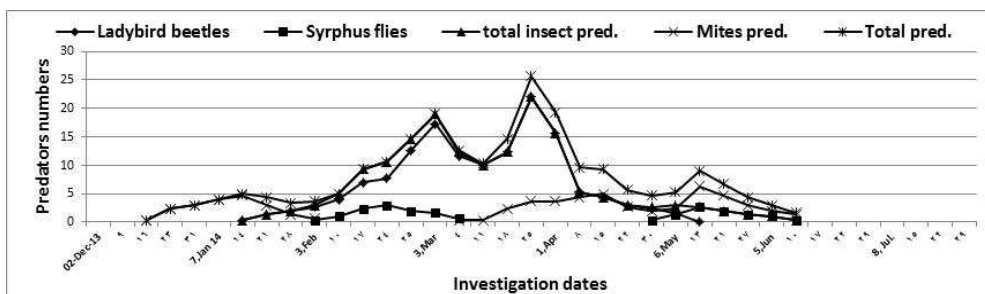


Fig. 7. Seasonal abundance of predators associated with pepper pests in greenhouse during 2013/2014 season.

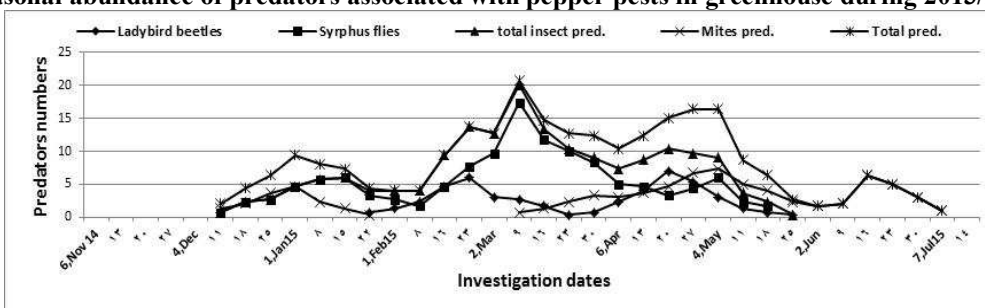


Fig. 8. Seasonal abundance of predators associated with pepper pests in greenhouse during 2014/2015 season.

• **Predator mite:**

The obtained results in Figs (7&8) revealed that, the total mean of phytoseiid predator mites were found in relatively low numbers, recorded two activity periods with three relatively weak peaks during each of the two study seasons. The peaks of the first season were recorded at 31st December, 15th April and 13th May with 4.67, 5.00 and 6.33 individuals/leaf, respectively. In the same trend, the peaks of the second season were recorded at 1st January, 4th May and 16th June with 4.67, 7.33 and 6.33 individuals/leaf, respectively

Generally, the highest parasitism percentage of 85.00 % was noticed late in the 2nd season at 22 June. Also, the highest peak of the total of the two insect predators of 22 individuals /plant and that of grand total (the total of the insect predators plus the mite predators) of 25.67 individuals /plant were pointed at 25th March during the two study seasons. The peaks of predators were congruent in time with the relatively high activity of pests during the study period that may be play main role in suppress piercing-sucking pests. The obtained results are agree with these of Riddick, 2017 reported that, the combined action of ladybirds and hymenopteran parasitoids could have a net positive effect on aphid population suppression. In addition to that of Valério et al., 2007 who stated that the *Coccinella* spp. suppress primarily *A. gossypii* and *A. craccivora* on sweet pepper (*C. annuum*) and added that, the parasitoid *Aphidius colemani*

suppress *M. persicae*. In the same trend, Obyrcki & Kring, 1998 and Lara De Backer et al., 2015 who cleared that the predators ability were affected by aphid population and the aphids population had negative correlation with predator numbers

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الكثافة العددية للأفات الثاقبة الماصة والاعداء الحيوية المصاحبة لها علي نباتات الفلفل تحت ظروف البيوت المحمية في محافظة الاسماعيلية - مصر

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أجريت هذه الدراسة علي نباتات الفلفل تحت ظروف البيوت المحمية في مزرعة محطة بحوث البساتين بالقصاصين - محافظة الاسماعيلية خلال موسمين متتاليين 2014/2013 ، 2015/2014 وذلك لحصر اهم الافات الثاقبة الماصة والاعداء الحيوية المصاحبة لها وكذلك تحديد الكثافة العددية ونسب تواجد لاهم الانواع من الافات والاعداء الطبيعية. وأوضحت النتائج أن الحشرات التابعة لرتبة نصفية الاجنحة كانت لها السيادة بنسبة 85.87% (في الموسم الاول) تلتها رتبة اللحم - عائلة النترانيكيدي (اللحم نو البقعتين) بنسبة 14.32% (في الموسم الثاني)، بينما تواجدت رتبة هديبة الاجنحة - عائلة التريس (تريس البصل) بأقل نسبة تواجد 2.82% من مجموع أعداد الافات التي تم حصرها خلال ذلك خلال الموسم الثاني. وبينما كانت السيادة لعائلة حشرات المن من الحشرات نصفية الاجنحة بنسبة 80.96% (في الموسم الاول) من مجموع الحشرات التي تم حصرها وتمثلت بثلاث انواع من حشرات المن (حشرات من الخوخ الاخضر ومن البطاطس ومن القطن) ، فإن عائلة نطاطات الأوراق قد تواجدت بأقل نسبة لحشرات نصفية الاجنحة 0.99% خلال الموسم الاول. وجد ان حشرات من الخوخ الاخضر على قمم نباتات الفلفل بنسبة عالية نسبيا 72.80% بينما كانت على الأوراق 27.20% وعلى العكس من ذلك كانت حشرات من البطاطس والتي سجلت 83.85% على الأوراق ، 16.14% على قمم نباتات الفلفل، بينما وجد من القطن على الازهار فقط. وسجلت اعلى ذروة للمتوسط الكلي لتعداد الثلاث انواع من حشرات المن 165.67 فرد/نبات في 11 مارس خلال الموسم الاول. وسجلت اعلى نسبة علي انواع المن الثلاث 85.00% في 22 يونيو خلال الموسم الثاني. سجلت اعلى ذروة لتعداد الذباب الابيض 12.00 فرد/ورقة في 8 فبراير ، 16 يونيو خلال الموسم الثاني. اعطى تعداد نطاطات الأوراق ذروتين ضعيفتين خلال فترتين قصيرتين النشاط خلال موسمي الدراسة. وفي نفس الاتجاه سجل تريس البصل اعلى ذروة 7.00 فرد/ورقة في 22 ابريل خلال الموسم الاول. سجل تعداد اللحم نو البقعتين اعلى ذروة نسبيا 30.33 فرد/بوصة مربعة في 22 ابريل خلال الموسم الاول. اما اعلى ذروة لمتوسط تعداد اعطي المقترسات الحشرية (خنافس ابي العيد وذب السيفرس) والمتوسط العام لكل من المقترسات الحشرية والحلم المقترس فقد سجلت في 25 مارس بتعداد 22.00 ، 25.67 فرد/نبات خلال الموسم الاول لكلا المتوسطين علي الترتيب. وتوافقت ذروات نشاط المقترسات مع فترات نشاط الافات خلال فترات الدراسة مما يعطي دلالة علي الدور الاساسي الذي يمكن ان تلعبه المقترسات في ضبط او خفض تعداد الافات الثاقبة الماصة. اوضحت نتائج التحليل الاصصائي للعلاقة بين الافات والاعداء الحيوية ان اعلى تأثيرات حسب معامل الاختلاف وهي 67.92 ، 59.94% قد سجلت لتأثير كل من الطفيليات ومجموع المقترسات الحشرية علي حشرات المن خلال الموسم الاول. لذلك يمكن التوصية بتعظيم استخدام الطفيليات والمقترسات كعناصر اساسية لمكافحة الافات الثاقبة الماصة علي نباتات الفلفل في البيوت المحمية.

الكلمات المفتاحية: نباتات الفلفل في البيوت المحمية، حشرات المن، الذباب الابيض، نطاطات الأوراق، التريس، اللحم نو البقعتين، الاعداء الحيوية المصاحبة لافات الفلفل في البيوت المحمية.