Volume 11 (2). Published October, 15, 2019
www.jnsciences.org
E-ISSN 2286-5314

A preliminary checklist and survey of the diurnal entomofauna associated to Citrus orchards in the region of Mograne (Zaghouan) in Tunisia within environmental parameters

M. ELIMEM[1], M. GUESMI1[*], C. LAHFEF[1,4], B. JAMMELI[2], B. BESSOUDA[1], R. FERSI[3]

[1]*High School of Agriculture of Mograne (ESAMo), Mograne, Zaghouan, University of Carthage, Tunisia*
[2]*High School of Agriculture of Mateur (ESAMa), Mateur, University of Carthage, Tunisia*
[3]*Co-founder and CEO at iFarming solutions, Station F, Founders Program, Guild #5 14 Rue Eugène Freyssinet, 75013 Paris – France*
[4]*National Agronomy Institute of Tunis (INAT), University of Tunis. 43 Avenue Charles Nicolle, Tunis 1082, Tunisia*

*Corresponding author: mohammed.elimem123@gmail.com

Abstract –The study of the biodiversity of the diurnal entomofauna associated to citrus orchard in the region of Mograne in Zaghouan led us to spot many insects' groups containing both pests and beneficial insects. According to the obtained results, nine orders have been reported. Many predators were spotted such as the Chrysoperla carnea complex belonging to the Neuroptera order. The Coccinellidae family that belongs to the Coleoptera order was present with just one species during the study period which was *Scymnus* sp. concerning pests, many Orders have been listed where the most important ones based on the economic damage level are Diptera; like the Mediterranean fruit fly *Ceratitis capitata*, and Hemiptera such as Aphididae and Aleyrodidae. In the same order, many mealybugs species were noticed *Parlatoria ziziphi* and *Parlatoria pergandii*, *Planococcus citri*, *Coccus hesperidum*, *Coccus pseudomagnolarium*, *Saissetia oleae*, *Aonidiella aurantii*, *Icerya purchasi*, *Coccus viridis* and *Ceroplastes sinensis*. Regarding the Thysanoptera order four species were identified: *Frankliniella occidentalis*, *Thrips tabaci*, *Thrips angusticeps* and *Pezothrips kellyanus*. Monitoring diurnal entomofauna dynamic populations associated to the Citrus orchards, within the temperature and relative humidity, allowed to determine critical time of appearance and damages during hot season to establish a reasonable program of Integrated Pest Management in the future.

Keywords: Citrus, Biodiversity, beneficial insects, relative humidity, temperature, thrips, scale insects

1. Introduction

In Tunisia, Citrus crop occupies a strategic place in the national economy. This sector shows certain dynamism and holds an important position with nearly 1.3% of arboreal areas that corresponds approximately to 27.000 ha. They are distributed mainly in the northern regions with almost 95% of total Citrus orchards areas, 4% in the center and less than 1 % in the southern parts (USDA 2017). Nevertheless, Citrus orchards are threatened by many pests and diseases that seriously affect Citrus yield. Among most famous pests that may attack Citrus crop, the Mediterranean fruit fly Ceratitis capitata Wiedemann (1824) (Diptera; Tephritidae), the citrus leafminer Phyllocnistis citrella Stainton (1856) (Lepidoptera; Gracillariidae), mealybugs, whiteflies, aphids, thrips and mites (Jerraya 2003). On the other hand, it must be noted that Citrus crop hosts many predators and parasitoids that may control naturally those pests or also employed in an IPM program. In fact, these auxiliaries present a major interest for biological control and significant role in the establishment of a biological balance.

Given that insects are poikilothermic organisms, they are strongly affected by several abiotic factors such as climatic conditions; these ones will influence on the entomofauna dynamic populations including temperature, daylight and relative humidity. In fact, according to authors such as Elimem and Chermiti 2009, high temperatures between 24 and 28°C and a low relative humidity (50%) may

cause a considerable increase of thrips population. The biological life cycle of the Mediterranean fruit fly, from Egg to adult, lasted 71.2 days in an average temperature equal to 15 °C and 17.1 days in 30 °C (Ricalde et al. 2012).

A plethora of studies carried out on aphids reveal that many species prefer a day-average temperature between 24 and 26 °C, for example, the developmental time of Aphis spiraecola was ranged from 14.4 days for 15°C to 6.5 days for 25°C (Satar and Uygun 2008). For Myzus persicae (Sulzer), on a degree-day time scale, a temperature of 23°C and 25°C provides the best thermal conditions for the population growth of this pest (Cividanes and Souza 2003).

Regarding the superfamily of Coccoidea, their population fluctuates in the function of stage of development of the Citrus tree and the climatic conditions. For instance, the population of the black parlatoria scale or Parlatoria ziziphi (Lucas 1853) peaks in the summer when the temperature is high (El Choubassi et al. 2001), also, the biology of olive scale (Saissetia oleae) is affected mainly by abiotic factors (Jarraya 1974)

The aim of this study was to identify entomofauna species associated to Citrus orchards and to monitor their dynamic population during hot season, according to some climatic parameters (temperature and relative humidity) in order to determine their critical periods of appearance and damage.

2. MaterialsandMethods

2.1. Experimental site

The study was carried out in a citrus orchard located in the Higher School of Agriculture of Mograne in the region of Mograne (36 ° 25'46.05"N 10 ° 05'37.00"E, elevation 146 m) that belongs to the Governorate of Zaghouan, north-eastern region of Tunisia from June to August 2018. This orchard, which area is approximately 66330 m² (6.63 ha), is divided into 10 plots, each one has, approximately, an area of about 6630 m² with 10 lines each. In each line 20 trees are present with multiple varieties of orange: Navel Thomson, Valencia late, "half-blood" Maltese, clementine, mandarins and pomelo with a spacing of 3m x 3m. All these plots are delimited by a windbreak which is the Mediterranean cypress (Cupressus sempervirens). Throughout the study period, only one mechanical weeding was carried out and there were no insecticide treatments applied against citrus pests in this orchard since many years.

2.2. Environmental parameter monitoring

Climatic parameters (temperature T (°C) and relative humidity (R.H.)) were, daily, taken from a meteorological station, located in the Higher School of Agriculture of Mograne, Zaghouan, which belongs to the National Meteorological Institute of Tunisia (INMT).

2.3. Insects' survey

2.3.1. Beating Sheet

This monitoring method was carried out weekly from June 5th to August 14th, 2018. It consists in collecting insects by beating one tree randomly chosen by plot using a stick while holding a beating sheet under the area being beaten. Fallen specimens were collected using an aspirator and conserved in special vials containing alcohol (70%).

2.3.2. Fruits and branches sampling

This method was carried out weekly during the same period. Two branches and two fruits were sampled randomly from the northern and southern parts of a random tree randomly from a random in each plot Samples were taken to the laboratory to collect insects and estimate pests' damages.

2.3.3. Medfly trapping

The Mediterranean fruit fly population monitoring was carried out using McPhail traps which consists on putting alimentary attractant in a yellow base with pheromone dispenser in same trap, installed, randomly, in two plots in form of "Z"., and they were surveyed from June 5, 2018 to August 14, 2018.

3. Results and Discussion

3.1. Monitoring of climatic parameters in the experimental site

The climatic parameters, in the region of Mograne, varied throughout the study period. Highest average temperature was about 27.75°C registered on June 26th, 2018, while the lowest mean average value (14.50°C) was reported on June 09th 2018. Subsequently, temperature increased gradually over the next month to reach average values approaching 35°C on July 21st, 2018. From August 1st till 14th, the highest average of temperature was 32 °C on August 3rd (Figure 1). Regarding relative humidity (R.H.); the highest average was 74 % on June 25th, 2018 while the lowest was about 54.5 % next month. Mean values of R.H. tended to decrease (Figure 2).

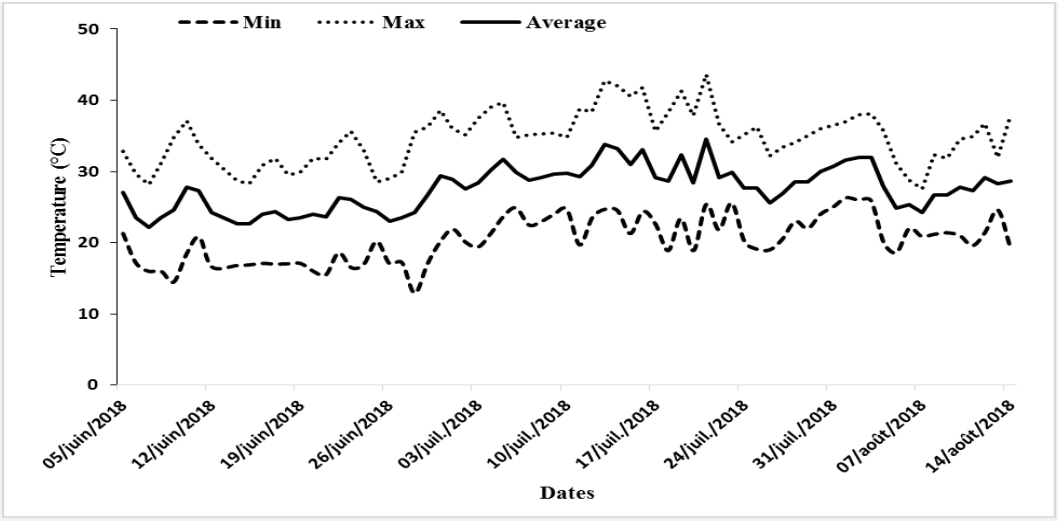

Figure 1. Temperature (Min, Max and average) in the region of Mograne (Zaghouan, Tunisia) in 2018.

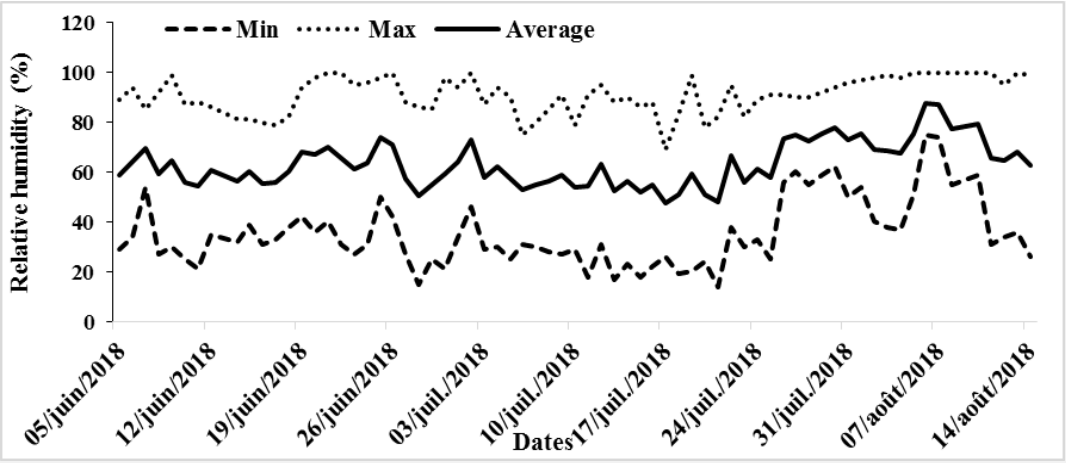

Figure 2. Relative humidity (Min, Max and average) in the region of Mograne (Zaghouan, Tunisia) in 2018.

3.2. Survey of the Citrus leafminer's *Phyllocnistis citrella* Stainton (1856) (Lepidoptera; Gracillariidae) damages

Damaged leaves mean number per branch varied throughout the study period (Fig. 3). According to the obtained results, three phases were detected. The first phase was observed from June 5th and 19th 2018, the damaged leaves mean number per branch decreased from an average value of about 3.15 to 0.6 damaged leaf recorded on June 19th, 2018, during this phase, the average recorded temperature was between 22.1 °C and 27.75 °C and a relative humidity between 54.5 % and 69.5 %. The second phase, starting from June 20, 2018 to July 31st, 2018, the mean number of leaves attacked per branch by the citrus leaf miner has increased to record a peak with an average equal to 4.25 of attacked, this is due to the raise of the values temperature and reduction of the percentage of relative humidity, also this period corresponds to the second vegetative spurt of citrus crop (Jerraya 2003). The last phase

looks like the first one, where we can find an average of temperature under than 28 °C and a high relative humidity.

The mean number of the damages per leaf of this pest was correlated to climatic conditions in the region of Mograne (Figure 4, 5). The first graph shows that the harmful damages per leaf correspond to a mean temperature ranged between 25 and 30°C. Relating to correlation between damages per leaf of the citrus leaf miner and mean relative humidity, high relative humidity correlates negatively to the development and the increase of this pest. So, The survey of the Citrus leaf miner showed that dynamic populations, development and biological characteristics of this pest are strongly associated to the phenology of the citrus tree (Kheder et al. 2002; Jerraya 2003) and climatic conditions such as temperature and relative humidity (Hyun et al. 2017). According to authors such as Chagas and Parra (2000), *P. citrella* develops best at temperatures between 29 and 32 °C and a relative humidity equal to 60 ±10 %, so low temperatures reduce the development rate.

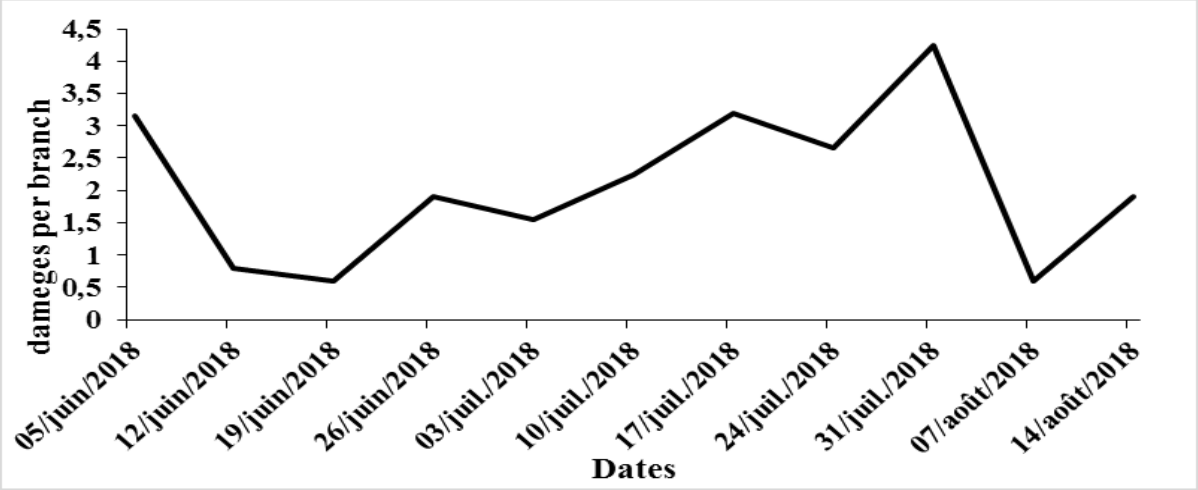

Figure 3. Mean number of leaves attacked by *P. citrella* ina citrus orchard in the region of Mograne (Zaghouan, Tunisia) in 2018.

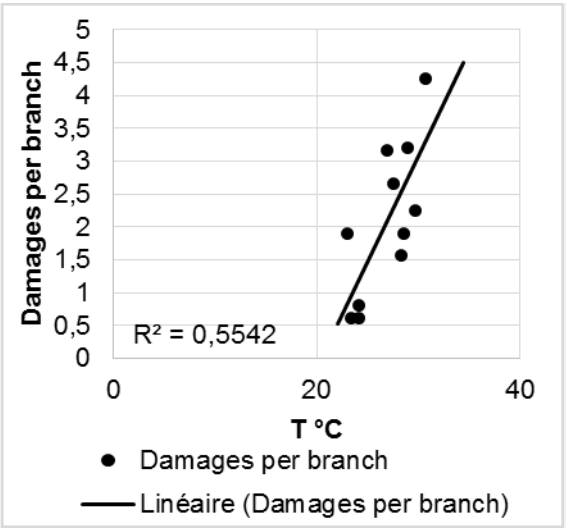

Figure 4. A correlation between a daily average of temperature and damages per leaf of the Citrus leafminer

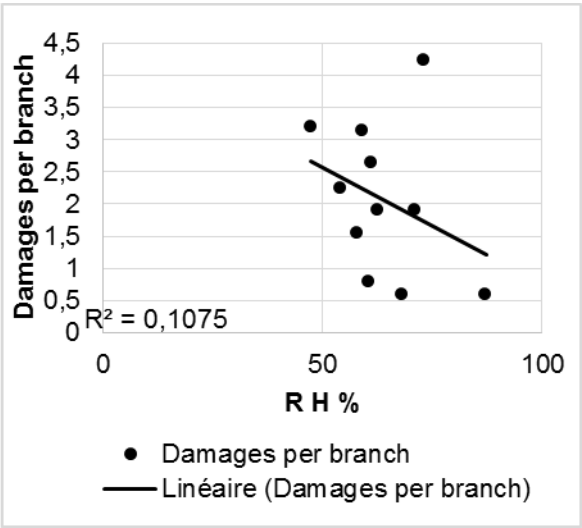

Figure 5. A correlation between a daily average of relative humidity and damages per leaf of the Citrus leafminer

3.3. Survey of thrips numbers and their damages

Monitoring of the population of all thrips species combined has been made possible through the Japanese umbrella technique. The results show that the number of thrips vary considerably with climate parameters (temperature, relative humidity) (Figure 4), we can separate the graph into three phases, During the first phase between June 05th, 2018 and June 19th, 2018, the number of trapped adults and their damages per branch went through decreasing, for example the amount of specimens fall down from 4 to 0. In this phase, the climatic conditions in the region of Mograne where, in terms

of temperature, between 22.1 °C and 27.75 °C, and a relative humidity between 54.5 % and 69.5 %. The second phase, starting from June 20, 2018 to July 31st, 2018, the mean number of leaves attacked by thrips and their number has increased considerably, we recorded a peak with an average equal to 2,1 of attacked leaves on July 10th, 2018. The last phase, from July 24th, 2018 to the end of the study, looks like the first one, where we can find an average of temperature under than 28 °C and a high relative humidity.

Hence, the number of Thrips varied considerably and this is could be referred to the unfavorable climate conditions like temperature and relative humidity (Bournier 1983; Loomans and van Lenteren 1995; Guérineau 2003; Trdan et al. 2003), also to the phenology of the varieties cultivated which there is no flowers (Pons et al. 2012).

The correlation between the number of thrips' damages per leaf and environmental conditions (temperature and relative humidity) (Figures 7, 8), shows that the highest numbers of damages per leaf occurred when mean temperature ranged between 24 and 30°C. Similarly, correlation between number of thrips' damages per leaf and mean relative humidity illustrates that this pest develops and increases when this variable decrease. Tese results; in terms of relative moisture, confirm the information mentioned by Bournier (1983) that high relative humidity prevents thrips to develop and increase, and that pest population increases when this parameter begins to decrease.

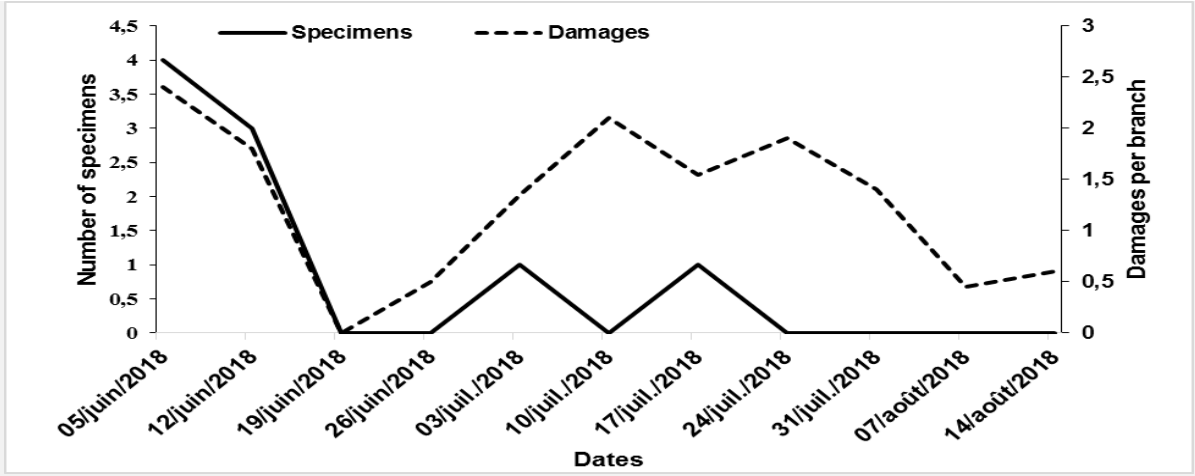

Figure 6. Mean number of leaves attacked by thrips and tracking of their population in a citrus orchard in the region of Mograne (Zaghouan, Tunisia) in 2018.

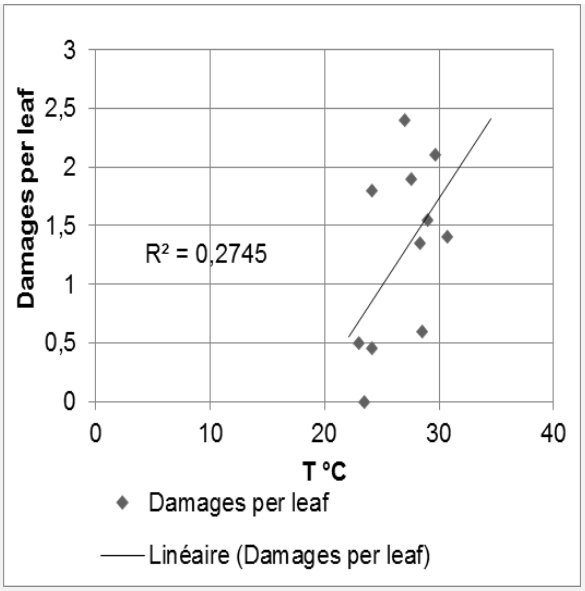

Figure 7. A correlation between a daily average of temperature and damages per leaf of the Citrus thrips

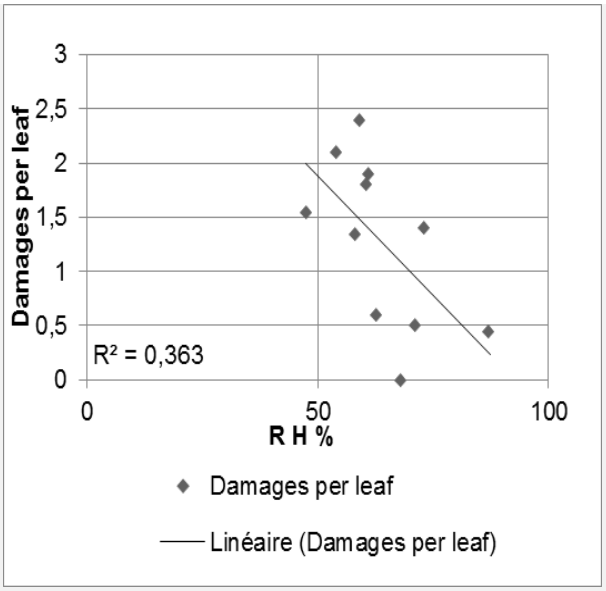

Figure 8. A correlation between a daily average of relative humidity and damages per leaf caused by thrips

During the period of the study, we identified, only, 9 specimens belonging to three genera (Table 1). The most specie found was *Frankliniella occidentalis* with a percentage equal to 33.33%, followed by *Thrips angusticeps*, *Pezothrips Pezothrips* kellyanus reaching 22.22% and the least abundant is *Thrips tabaci* with 11.11%.

Tableau 1. Number and percentage of Thrips species recorded in a citrus orchard in the region of Mograne (Zaghouan, Tunisia) in 2018.

Genus	Species	Date	Collected Specimens	Percentage (%)
Frankliniella	*occidentalis*	07.03.2018 06.05.2018 06.12.2018	2♀ 1♀ 1♀	33.33
Thrips	*angusticeps*	06.05.2018 06.12.2018	1♀ 1♀	22.22
	tabaci	07.17.2018	1♀	11.11
Pezothrips	*kellyanus*	06.05.2018 06.12.2018	1♀ 1♀	22.22

Legend: ♀: female

3.4. Survey of the number of the Mediterranean Fruit Fly (*Ceratitis capitata* Wied.) and their damages

During the survey period, we only recorded damaged fruit on July 3rd, 2018 with an average value equal to 0.35 stings per fruit in a late-ripening fruit variety.

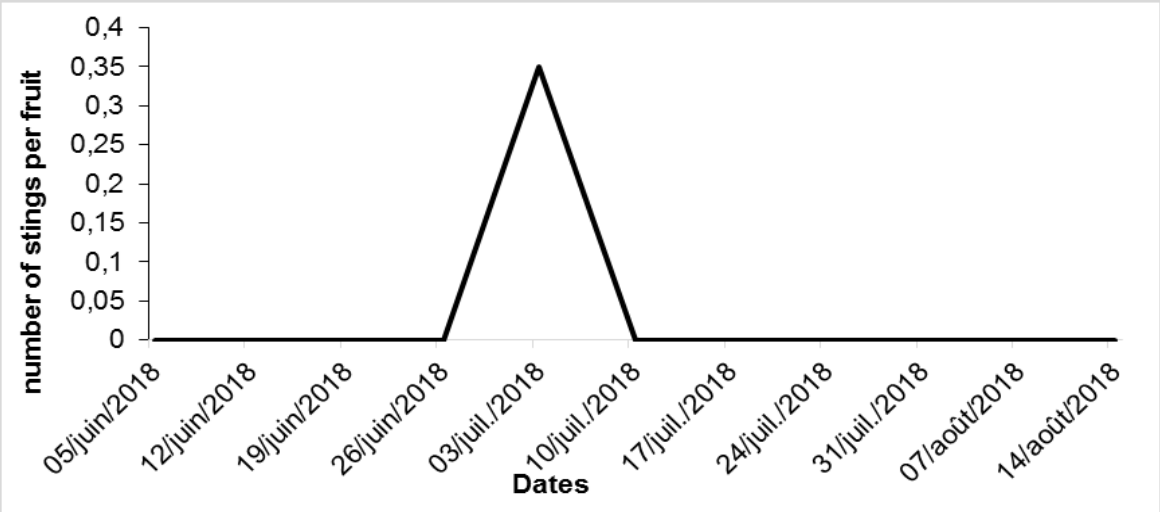

Figure 9. Number of stings per fruit in a citrus orchard in the region of Mograne (Zaghouan, Tunisia) in 2018.

The activity of the Mediterranean Fruit Fly (medfly) is great in spring and autumn and lowest in summer, and drought (in May) and extreme heat (in August) cause a reduction in an amber of gravid females and the number of eggs per female and this results concord with those found authors Klfin and Paker (1942). We should also mention that, during the month of July 2018 and despite of, the climatic conditions were favorable to this pest to develop, but the fruits weren't mature enough to feed the medfly's larva. (Dhouibi et al. 1995).

3.5. Survey of the evolution of aphid's population

Weekly monitoring of aphid's population in citrus orchard (Figure 10) decreased progressively throughout the study period ($R^2 = 0.1851$). From June 5th, 2018 to June 26th, 2018 and despite some slight variation, the number of individuals per branch increased with the drop of degrees of temperature (23.05 °C) and the rise of percentage of relative humidity (74%) on June 26th, 2018. Finally, between July 3rd, 2018 till the end of the study period, aphid's population was almost zero due to unfavorable climatic conditions.

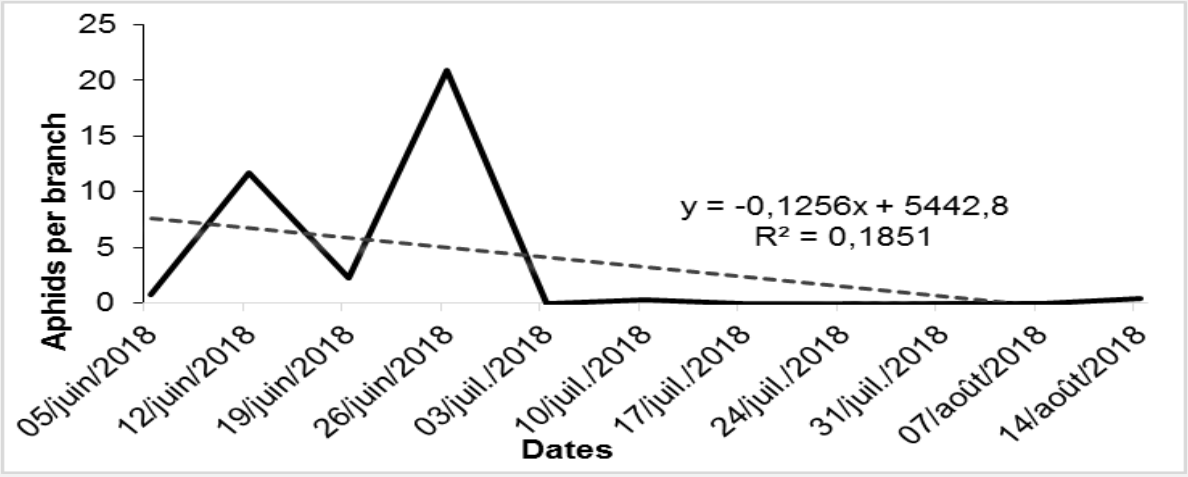

Figure 10. Mean number of aphids per branch in a citrus orchard in the region of Mograne (Zaghouan, Tunisia) in 2018.

The correlation between the number of aphids per branch environmental conditions (temperature and relative humidity) (Figures 11, 12) illustrates that the number of aphids is correlated negatively to the mean temperature and a high value of this latter can reduce their abundance. Contrarily, correlation between the number of aphids per branch and mean relative humidity shows that the population of this pest increase meanwhile with relative moisture.

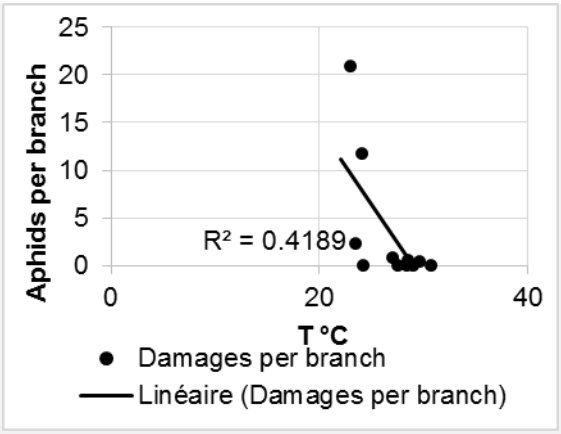

Figure 11. A correlation between a daily average of temperature and aphids per leaf

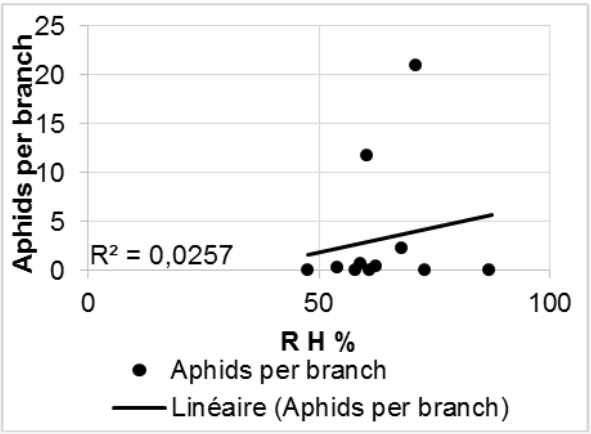

Figure 12. A correlation between a daily average of relative humidity and number of aphids per branch

The number of the aphids was low in the period of study due to climatic conditions in the region of Mograne. According to Miller (1928), a temperature between 22 and 25°C and high relative humidity (70-79 %) are the greatest values to the development of *Aphis spiraecola* (Patch). The results of the correlation within climatic parameters coincide with those found by (Rivnay 1938; Rocha et al. 2008; Sharma 2004) who mentioned that the presence of Citrus aphids is in its lowest during the summer; also, Zehavi and Rosen (1987) reveal that hot dry desert winds cause sudden, mass mortality of aphids.

3.6. Survey of the evolution of the whitefly's larvae (*Aleurothrixus floccosus* Mask.)

Weekly monitoring of whitefly's larvae in citrus orchard (Figure 13) showed fluctuations throughout the study period (R^2 = 0.2625). According to the results, three phases could be detected in mean number of whitefly's larvae on citrus orchard. During the first phase between June 5th, 2018 and June 26th, 2018, the mean number of leaves damaged per branch has decreased, from an average equal to 3.95 to zero larvae per branch. During this phase, the average recorded temperature was between 22.1 °C and 27.75 °C and an average of relative humidity between 54.5 % and 74 %. And this could be due to climatic conditions in the region of Mograne. Such conditions inhibit the population's development of this pest. According to authors such as Bene and Gargani (1991), *A. floccosus* develops best at temperatures between 25 and 30 °C and a relative humidity between 60 and 70 %.

The second phase starts from June 27th, 2018 to July 10th, 2018, the mean number of leaves attacked by whitefly's larvae has increased considerably to record a peak with an average equal to 0.95, The last phase, from July 17th, 2018 to the end of this survey, looks like the first one, where we can find big fluctuations of the averages of temperature (average between 24.25 and 34.5 °C) and relative humidity (average between 48 and 87.5 %).
The correlation made (Figures 14, 15) depicts that larvae per branch of the Citrus whitefly increase when mean temperature ranged between 22 and 30 °C. Regarding the correlation with mean relative humidity, the graph shows that the larvae of this insect are negatively-correlated to the relative moisture.

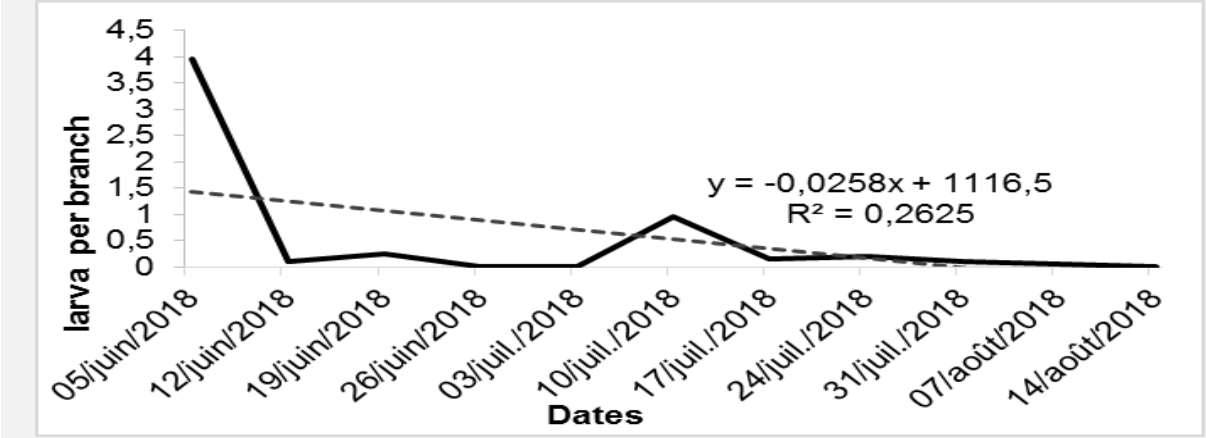

Figure 13. Mean number of leaves attacked by A. floccosus in a citrus orchard in the region of Mograne (Zaghouan, Tunisia) in 2018

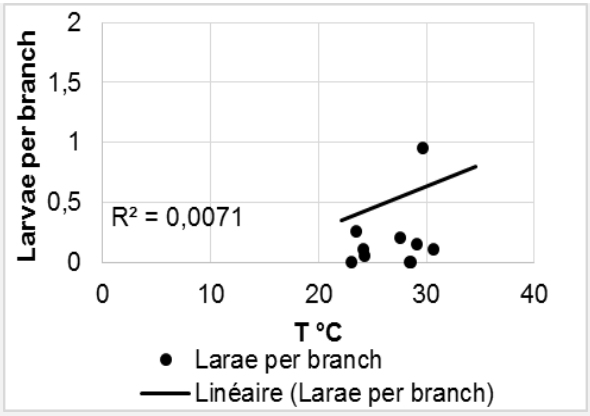

Figure 14. A correlation between a daily average of temperature and larvae per branch of the citrus whitefly

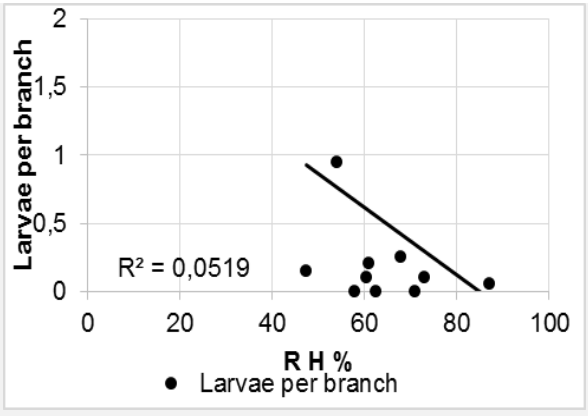

Figure 15. A correlation between a daily average of relative humidity and larvae per branch of the citrus whitefly

3.7. Survey of the dominance of mealybugs (superfamily of Coccoidea)

During this study, 10 species of mealybugs were recorded. These species that belong to 7 genera are represented below by order of importance, *Parlatoria ziziphi*, *Parlatoria pergandii*, *Saissetia oleae*, *Coccus hesperidum*, *Planococcus citri*, *Icerya purchasi*, *Aonidiella aurantii*, *Ceroplastes sinensis*, *Coccus viridis* and *Coccus pseudomagnolarium*. The population of these species, apart from the black parlatoria scale, where it was present during the whole period of the survey with huge numbers, we recorded a continuous fluctuation of their numbers with a higher density during the month of July. All individuals encountered mealybug species on twigs and fruits were counted. Indeed, a clear difference of actual point of view and abundance has been revealed in favor of *Parlatoria ziziphi* which was the most common and the most abundant with tremendous values far exceeding other species. These species have been classified into different groups according to Kucharczyk et al. (2011) based on their percentages. The species is regarded as eudominant if the percentage exceeds 10%, dominant if between 5.1 and 10%, subdominant if between 2.1 and 5%, recedent if between 1 and 2% and subrecedent if less than 1%.

From the results obtained, the black Parlatoria scale is eudominante of leaves with a percentage greater than 96% and a very high average cumulative value of the order of 33 550 individuals. Regarding the other species, C. hesperidum was eudominant at the branches. On fruits, there is an eudominance of three species *P. citri*, *S. oleae* and *C. hespiridum*. From where, at the level of the branches, in second place we find *S. olae* with a percentage of 6.23%, followed by *P.citri* with a percentage of 4.32%. As for *C. pseudomagnoliarium*, *C.viridis* and *Ceroplastes sinensis*, they are more rare with minimal percentages of presence compared to other mealybugs (≈0%)

Tableau 2. Dominance of mealybug's species recorded in citrus orchard in the region of Mograne (Zaghouan, Tunisia) in 2018.

	Branches			Leaves			Fruits		
	Total accumulated value	Percentage	Dominance	Total accumulated value	Percentage	Dominance	Total accumulated value	Percentage	Dominance
Parlatoria ziziphi	46	2,37	++	33550	96,38	+++++	13	5,93	+++
Parlatoria pergandii	0	0	-	1	0	+	0	0	-
Planococcus citri	84	4,32	++	206	0,5	+	137	62,55	+++++
Saissetia oleae	121	6,23	+++	40	0,1	+	22	10,04	+++++
Coccus pseudomagnoliarium	0	0	-	1	0	+	0	0	-
Coccus hesperidum	1607	82,83	+++++	900	2,58	++	47	21,46	+++++
Icerya purchasi	82	4,22	++	106	0,3	+	0	0	-
Aonidiella aurantii	0	0	-	5	0,01	+	0	0	-
Coccus viridis	0	0	-	1	0	+	0	0	-
Ceroplastes sinensis	0	0	-	1	0	+	0	0	-

Legend: (+ + + + +): Eudominant, (+ + + +): Dominant, (+ + +): Subdominant, (+ +): Recedent, (+): Subrecedent, (-): Absent

3.8. Survey of the number of the common green lacewing's eggs (Chrysoperla carnea Stephens.)

Weekly monitoring of the common green lacewing's eggs in citrus orchard (Figure 16) showed that there are fluctuations of the mean number of eggs per branch during the survey ($R^2 = 0.3074$). We can separate the graph into four phases. The first starts from June 5th, 2018 to June 19th, 2018. In this phase, the mean number of eggs has decreased from 0.15 eggs per branch to zero. This can be explained by a non-favorable climatic condition and citing such an example the decrease of the average of temperature to, approximately, 22 °C will make the development of eggs slower (Kowalska 1968; Kharizanov and Dimitrov 1972). The second phase starts from June 20th, 2018 to July 3rd, 2018, in this period; we recorded an increase of the mean number of eggs to reach a level of 0.05 eggs per branch. The third one, from July 4th, 2018 to August 6th, where the average values of temperature continued to increase, where we didn't record any specimen. The last phase, it seems to be like the second one, we can say that there is a similarity in the averages of temperature where we recorded 0.05 eggs per branch on August 14th, 2018.

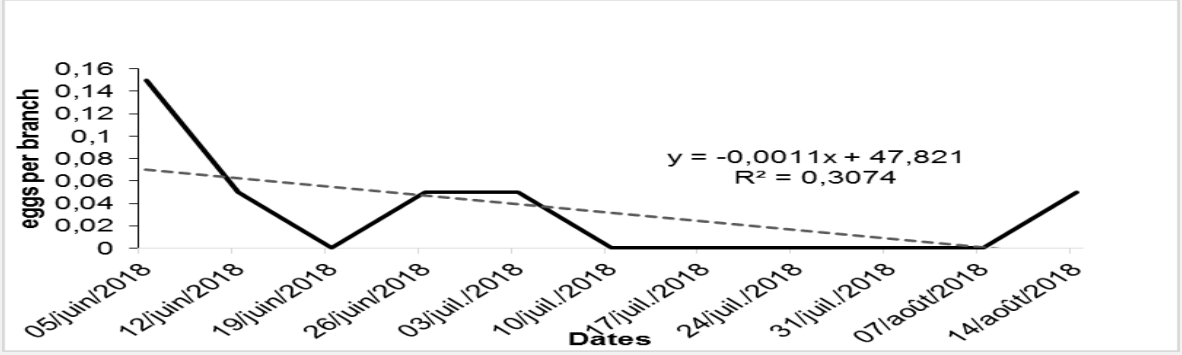

Figure 16. Mean number of the common green lacewing's eggs in a citrus orchard in the region of Mograne (Zaghouan, Tunisia) in 2018

4. Conclusion

Surveying the diurnal entomofauna associated to citrus orchard in the region of Mograne has led to identify panoply of insect devastators and auxiliaries. Dynamic monitoring of this population has made it possible to determine and identify the critical periods of their outbreaks and proliferations. Indeed, all technics used to collect insects, allowed us to better perceive the different phases characterizing their population evolution according to some natural parameters, such as temperature, relative humidity and the phenology of the host plant. The highest numbers of most listed species were recorded during the second vegetative spurt of citrus crop (July month). The study of the species richness of the citrus fruit orchard led to the identification of nine insect orders whose frequencies and abundances differ from one order to another. Many species founded on the citrus orchard, in the Order of the Neuroptera, we find the common green lacewing (*Chrysoperla carnea* Stephens (1836) complex (Chrysopidae, Neuroptera)), which is a predator of other insects. Their numbers always fluctuate during the study period, mainly due to the climate and the availability of prey. In addition, one of the formidable pests of citrus was followed; it is the Mediterranean fruit fly *Ceratitis capitata* Wiedmann (1824) (Tephritidae, Diptera), where we identified only the damages once during the entire work period. The most important order in terms of species richness and number of individuals captured is that of Hemiptera where aphids and the "fluffy whiteflies", *Aleurothrixus floccosus* Maskel (1896) were collected. Indeed, 10 species of mealybugs have been identified and listed in descending order of importance; *Parlatoria ziziphi*, *Parlatoria pergandii*, *Saissetia oleae*, *Coccus hesperidum*, *Planococcus citri*, *Icerya purchasi*, *Aonidiella aurantii*, *Ceroplastes sinensis*, *Coccus viridis* and *Coccus pseudomagnolarium*.

5. References

Bournier A (1983) Les Thrips. Biologie, Importance Agronomique, INRA, Paris, 128 pp

Chagas MC, M Parra JRP (2000)*Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae): rearing technique and biology at different temperatures. Anais da Sociedade Entomológica do Brasil. Vol.29 No.2 pp.227-235 ref.14

Cividanes F J, Souza V P (2003) Thermal requirements and age-specific life tables of *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) in laboratory. Neotropical Entomology 2003 Vol.32 No.3 pp.413-419 ref.28

Del Bene G, Gargani E (1991) Observations on *Aleurothrixus floccosus* (Mask.) (Hom. Aleyrodidae) and its natural enemy Cales noacki How. (Hym. Aphelinidae) in Tuscany. Redia. Vol.74 No.1 pp.111-126 ref.32

Dhouibi M H, Gahbiche H, Saaidia B (1995) Variations in *Ceratitis capitata* infestation of fruit according to fruit locations on the tree and orange ripeness. Fruits (Paris) 1995 Vol.50 No.1 pp.39-49 ref.24

El Choubassi W, Iparraguire Cruz M, Grillo Ravelo H (2001) Population dynamics of *Parlatoria ziziphi* (Lucas) (Homoptera: Diaspididae) and its natural enemies on Valencia orange. Centro Agrícola 2001 Vol.28 No.3 pp.37-41 ref.13

Elimem M, Chermiti B (2009) Population dynamics of *Frankliniella occidentalis* Pergande (1895) (Thysanoptera, Thripidae) and evaluation of its different ecotypes and their evolution in a rose (Rosa hybrida) greenhouse in the Sahline Region, Tunisia. Tunisian Plant Science and Biotechnology I. The African Journal of Plant Science and Biotechnology 3: 53-62.

Pons E, Peris J E, Pena L (2012) Field performance of transgenic citrus trees: Assessment of the long-term expression of uidA and nptII transgenes and its impact on relevant agronomic and phenotypic characteristics. BMC Biotechnology 2012 Vol.12 No.41 pp. (15 July 2012) ref.62

Guérineau C (2003) La culture du fraisier sur substrat. CTIFL. Centre Technique Interprofessionnel des Fruits et Légumes. Ed. Centre technique interprofessionnel des fruits et légumes, Paris, 91 pp

Hyun SeungYoung, Elekçioğlu N Z, Kim Su, Kwon SoonHwa, Kim DongSoon (2017) Parameter estimation for temperature-driven immature development and oviposition models of *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillaridae) in the laboratory. Journal of Asia-Pacific Entomology 2017 Vol.20 No.3 pp.802-808

Jerraya A (2003) Principaux nuisibles des plantes cultivées et des denrées stockées en Afrique du Nord. Ed Climat Pub. Tunis.

Jerraya A (1974) Bioecological observations on a Citrus Coccid in the region of Tunis *Saissetia oleae* (Bernard) (Homoptera, Coccoidea, Coccidae). Bulletin SROP [Section Regionale Ouest Palearctique] 1974 No.3 pp.135-157 ref.14

Kharizanov A, Dimitrov A (1972) Some biological characteristics of *Chrysopa carnea*. Rastitelna Zashchita. Vol.20 No.11 pp.36 - 38 ref.5

Kheder S B, Jerraya A, Jrad F, Fezzani M (2002) Study of the citrus leaf miner *Phyllocnistis citrella* Stainton (Lep. Gracillariidae) in the Cap Bon area (Tunisia). Fruits (Paris) 2002 Vol.57 No.1 pp.29-42 ref.30

Klfin HZ, Paker M (1942) Biologieal Sudies on the Mediterranean Fruit Fly (*Ceratitis capitata* Wied.) in the Jordan Valley. Bull. Agric. Exp. Stn., Rehovoth No.32 pp.33 + 7 pp. ref.3

Kowalska T (1968) A report of studies on the biology of the golden-eyed lace-wing (*Chrysopa carnea* Stephens= C. vulgar is Schneider) (Neuroptera, Chrysopidae). Prace Naukowe Instytutu Ochrony Roslin Vol.10 No.2 pp.145-157 ref.20

Kucharczyk H, Pawel K B, Dobrowski Z T (2011) The Species Composition and Seasonal Dynamics of Thrips (Thysanoptera) Populations on Maize (Zea mays L.) in Southeastern Poland. Journal of Plant Protection Research 51(3): 210-216.

Loomans A J M, van Lenteren J C (1995) Biological control of thrips pests: A review on thrips parasitoids. Wageningen Agricultural University Papers 95-1, Wageningen, The Netherlands, 237 pp

Chhetry M, Tara J S, Gupta R (2011) Infestation dynamics of *Phyllocnistis citrella* Stainton (Lepidoptera: Phyllocnistidae) on Mosambi (Citrus sinensis) and its relation with important weather factors in Jammu, India. Acta Entomologica Sinica 2011 Vol.54 No.3 pp.327-332 ref.30

Miller RL (1928) Biology and natural Control of the Green Citrus Aphid, *Aphis spiraecola*, Patch. Florida Entomologist. Vol.12 No.4 pp.49-56 pp.

Ricalde M P, Nava D E, Loeck A E, Donatti M G (2012) Temperature-dependent development and survival of Brazilian populations of the Mediterranean fruit fly, *Ceratitis capitata*, from tropical, subtropical and temperate regions. Journal of Insect Science (Madison) 2012 Vol.12 No.33 pp.(2 March 2012) ref.38

Rivnay E (1938) Factors affecting the Fluctuations in the Population of *Toxoptera aurantii* Boy. in Palestine. Annals of Applied Biology 1938 Vol.25 No.1 pp.143-154 ref.1

Rocha K C G, Busoli A C, Veronezzi F R B (2008) Diversity of species and seasonal occurrence of aphids (Hemiptera: Aphididae) in citrus groves in Taiúva, São Paulo State. Bragantia 2008 Vol.67 No.3 pp.717-721 ref.13

Satar S, Uygun N (2008) Life cycle of *Aphis spiraecola* Patch (Homoptera: Aphididae) in East Mediterranean region of Turkey and its development on some important host plants. IOBC/WPRS Bulletin 2008 Vol.38 pp.216-224

Sharma D R (2004) Seasonal incidence and control of aphid complex on Kinnow. Annals of Plant Protection Sciences 2004 Vol.12 No.2 pp.274-278 ref.12

Sigwalt B (1971) Demographic studies on Diaspine scales. Their application to three species injurious to orange in Tunisia. The particular case of one species with overlapping generations: *Parlatoria ziziphi* Lucas. Annales de Zoologie Ecologie Animale. Vol.3 No.1 pp.5-15 ref.13

Trdan S, Bergant K, Jenser G (2003) Monitoring of western flower thrips (*Frankliniella occidentalis* [Pergande], Thysanoptera) in the vicinity of greenhouses in different climatic conditions in Slovenia. Agricultura 2, 1-6

USDA (2017) Report of Record Citrus Crop Highlights Market Constraints. USDA Foreign Agricultural Service Tunis.

Zehavi A, Rosen D (1987) Population trends of the spirea aphid, *Aphis citricola* van der Goot, in a citrus grove in Israel. Journal of Applied Entomology 1987 Vol.104 No.3 pp.271-277.