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Bioecological Study Of The Citrus Leafminer: *Phyllocnistis Citrella* Stainton (Lepidoptera: Gracillariidae) In Western Algeria

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Abstract

Phyllocnistis citrella one the most important citrus pests in its native area of South east Asia. In Algeria, the first reports were noted in 1994 in citrus orchards. Since, the citrus leaf miner has spread to citrus growing areas causing considerable damage. It's strictly endophytic lifestyle makes control difficult. A study of the biological cycle of this pest was studied in the ambient conditions of the laboratory, this revealed different life spans for the different stages: eggs, larva and pupa, the lifespan were respectively: 5 ± 4,3 d, 12± 4.5 d and 18± 9.5 d. The period of the cycle varies according to the climatic conditions. In our case, the biological cycle of this pest is 12 ± 5.2 d at a temperature of 30oC ± 1oC. The activity of P. citrella adults was observed right from the first sap flush with insignificant contamination rates and only on orange trees. This confirms that the spring shoots are spared from phytophagous attacks. Contaminations started on rebel shoots, with relatively low levels of infestation. But the latter constituted a base for the activities of the adults on the second flush of sap, the contamination rate of which reached 99% The inventory revealed the constant presence of three species of parasitoids dependent on P.citrella in the Mostaganem region: Cirrospilus pictus, Pnigalio pectinicornis and Semielacher petiolatus. Our results show that the parasitism rate goes from 70% to 69% after a few weeks and this proves that the method used is a very effective method.

Keywords: Phyllocnistis citrella, Bioecological, Parasitoids, Infestation rate, Citrus, Algeria.

Introduction

Citrus growing is one of the most important crops worldwide (MAP, 2022) with a production of 157 MT (million tonnes) (FAOStat, 2022). In general, citrus fruits are believed to be native to tropical and subtropical regions of Southeast Asia (Takarli et *al*., 2015). This culture has very significant economic potential, particularly in Algeria (Mahmoudi et *al*., 2017). The Mostaganem area is by their geographical location considered among the leading citrus production areas in Algeria.

Citrus fruits are attacked by several pests which cause significant damage to production (Mazih, 2015). The main pests are: the Mediterranean fruit fly, the red mite, the California louse, aphids and the citrus leaf miner *Phyllocnistis citrella* Stainton (Lepidoptera: Gracilariidae). The latter is a microlepidoptera belonging to the family Gracillariidae and the subfamily Phyllocnistinae. More than 25 years ago, the dispersal of this insect took place gradually across the five continents, starting with its point of origin in South-East Asia. Currently it is considered one of the most important pests recorded on citrus fruits in the Mediterranean basin since its introduction in August 1993 in Spain (Mechelany E and Matny J., 1998), in Italy (Asero C, 1995) , in France in 1995 (Lucas Espada A, 1995), in Greece (Heppner JB 1993), in Turkey in 1995 (Chermiti B, 1997), in Algeria during the summer of 1994 (Berkani A, 1995), in Morocco in the fall of 1994 (Anagnou Veroniki M, 1995), and in Tunisia in 1995 (Abassi et *al.*, 1995) and recently in Hungary in 2020 (Katona et *al*., 2020). Currently, *P. citrella* is widely present in all citrus orchards around the world (CABI, 2021).

To protect this speculation, the use of pesticides was the only practical and available means at the beginning of its appearance, but over time it turned out that the endophytic lifestyle of the phytophage complicated the action of chemical molecules. This is why researchers have moved towards a search for more interesting and less polluting methods such as the use of auxiliary parasitoid and predatory fauna dependent on this phytophage (Soltani, 2013), for regulating its populations and protecting the eco-system of residues due to abusive and unreasonable chemical treatments. Among the hymenopteran parasitoids listed as natural enemies of the Citrus leaf miner reported by Heppner (Heppner 1993), there are different species belonging to six families: Braconidae, Elasmidae, Encyrtidae, Eulophidae, Eurytomidae, Pteromalidae. In Algeria, three parasitoid species were introduced as part of a biological control program for acclimatization during in 1995 (Berkani A, 1995; Sahraoui et *al*., 2001).), These are *Ageniaspis citricola* (Hym: Encyrtidae), *Semielacher petiolatus* (Hym: Eulophidae) and *Cirrospilus quadrastriatus* (Hym: Eulophidae).

In Algeria, several studies on *Phyllocnistis citrella* and its parasitoid enemies have been undertaken by several authors, notably Berkani et *al*. (1996), Saharaoui et *al*. (2001), Boualem and Berkani (2009), Khechna (2018). In the interest of minimizing the use of chemical controls and their effects on human health and the ecosystem, we will replace it with biological control using living organisms (parasitoids).

As part of this study, the assigned goal consists of monitoring the evolutionary cycle, estimating the infestation rate and parasitism rate of *Phyllocnistis citrella* at the level of the Mazaghran agricultural workshop in the Mostaganem area. Through this study, we tried to study the influence of certain parasitoids on the citrus leaf miner *P.citrella* and on their development.

Material and Methods

Following the presentation of the study region, the choice and the description of the region selected, the various methods implemented both in the agricultural field and in the laboratory are developed.

Presentation of the study area (Mostaganem)

Experimental site

The study was carried out at the experimental farm of the agronomy department which is located between the commune of Mostaganem in the North, Mazaghran in the West, Hassi Mamèche in the South and douar Djedid in the East (GCS, 2022) (Fig. 1). This area is characterized by a semi-arid climate with humidity between 60 to 70% during the summer period, average temperatures oscillate between 25 and 35°C in summer and 8 to 14°C during winter (NMO, 2022). Mostaganem is a coastal wilaya, limited to the north by the Mediterranean, to the east by the wilayates of Chlef and Relizane, to the west by the wilaya of Oran and to the south by the wilaya of Mascara (Fig. 2). It is characterized by the importance of citrus cultivation with a total production of 1507,400 Qx and an achievement rate of 98% and a completed area of 4834.5 ha with an area completion rate of 89% (DAS, 2022) (Fig. 3).

Figure 1. Location map of the experimental site in the Mostaganem area (GCS 2022).

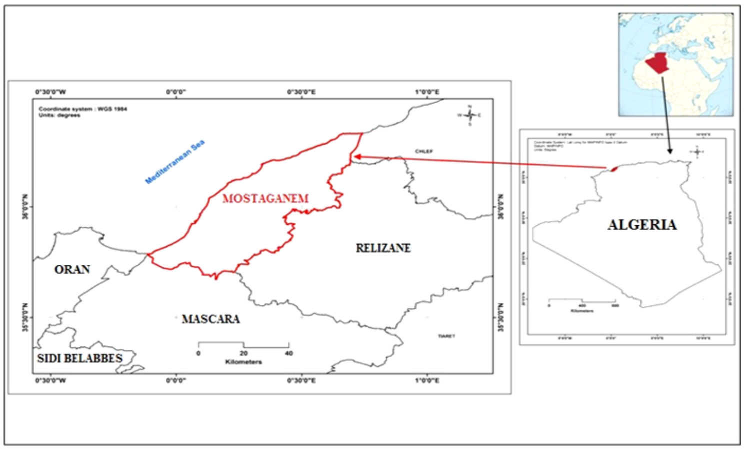

Figure 2. Geographical location of the Mostaganem area (GCS, 2022).

Figure 3. Distribution map of citrus production in the Mostaganem area (DAS 2023).

Biological material

Both the chosen biological material, whether plant or animal, is presented.

Plant biological material

In order to monitor variations in the infestation rate and the rate of pest parasitism *Phyllocnistis citrella*, the choice fell on the cultivation of orange trees (*Citrus sinensis*).

Animal biological material

It is represented by *Phyllocnistis citrella* Stanton "The citrus leafminer". Is an important pest of citrus fruits, of south east Asian origin, reported in Algeria during the summer of 1994 (Berkani A 1995).

Selection of sampling plots
Three plots of orange trees (*Citrus sinensis*), variety (W-Navels) were selected (Table 1)

Table1. Study plots by plant species (DAS, 2022).

Study zone	Species	Number of trees	Year	Density of Planting	Planted area
I	Orange trees (*C. sinensis* OSBECK)	108	1988/1989	5x5m	0,55 ha
II	Lemon trees (*C. limon* BRUN)Clementines	137	1988/1989	4x5m	0,60 ha
	(*C.clementina*BLONCO) Orange trees	40	1988/1989	4x5m	0,60 ha
	(*C.sinensis* OSBECK)	16	1988/1989	4x5m	0,60 ha
III	Bitter oranges (*C. aurantium* LINN)	60	1988/1989	4x5m	0,60 ha
	Orange trees (*C. sinensis* OSBECK)	87	1988/1989	4x5m	0,60 ha

Sampling method

For our study, a choice of three plots of orange trees was made on which weekly sampling was carried out. The samples are taken every (10) days, for each tree sampled four shoots corresponding to the four cardinal orientations (East, West, North, South) were chosen, for each of the shoots three (03) leaves are taken, one at the base, one in the middle, and a third at the top, the choice of trees is random (Table 2). The samples are put in paper bags and sent to the laboratory to calculate the infestation rate (Khechna, 2017 and Boualem, 2009).

Table 2. The number of trees selected on the three study plots (original 2021).

Plots	Number of selected trees
Plot I	10
Plot II	10
Plot III	10

Citrus leafminer parasitoids in the Mostaganem area
Inventory of the P. citrella parasite complex
For better control of the fight against the citrus leafminer, it is very important to carry out an inventory to identify all the beneficials present, followed by precise identification of each species harvested

Method used in the laboratory

The 252 leaves which are collected for each sampling and for each orange tree studied at random, are examined using a binocular magnifying glass in order to count the percentage of galleries of the citrus leafminer dug in the leaves (pre-imaginal of the insect as well as the number of living, predated parasitized and dead individuals) thus calculated the infestation rate and the parasitism rate. (Riasat A et *al.* 2020 ; Boualemb 2009; Lapointe SL 2015)(Fig 4).


Figure 4. Orange leaves infected by *Phyllocnistis citrella* (Original 2022)

Dissection

The leaves collected are kept in a refrigerator, in order to slow down the development of individuals of the different stages as much as possible. These leaves are examined under a binocular microscope, distinguishing between the upper and lower sides of the leaves. For each observation, the following data are noted:

- Date and place of collection.
- Orientation and position of the tree.

For the citrus leaf miner, we count the number of each of the biological stages:

- The egg.
- Live, parasitized, predated and dead larvae (L1, L2, L3).
- Live, parasitized, predated and dead prepupae (L4).
- Live, parasitized, predated and dead nymphs (N).

Calculations used

The analysis of the results was carried out using the following methods:
Number of infested leaves x 100

-Overall infestation rate: $IR = \frac{\text{Number of infested leaves x 100}}{\sum \text{Sampled leaves}}$

-Average larva per leaf : $XL/L = \frac{\sum \text{Number of larvae counted x 100}}{\sum \text{Sampled leaves}}$

-Parasitism rate %: $PR = \frac{\sum \text{Number of parasitic individuals x 100}}{\sum \text{Of individuals counted}}$ (Khechna 2018)

Results and Discussion

Infestation rate

Overal infestation rate

Monitoring the population dynamics of *P. citrella* during 2020 revealed relatively high infestation rates. The work began on July 8, 2020, coinciding with the appearance of the second burst of sap, which made it possible to observe the evolution of the infestation rate during this period, noting that the infestation rates on the three plots were very close. At the start of the study, observations revealed infestation rates of around 82.05,%, 62.24% and 73.50% respectively for the 1st, 2nd and 3rd plot which are considered as average rates to be compared with those recorded on the other samples which exceeded 90% and then relapsed to initial rates around 72%.The observations made on the third burst of sap indicate that the infestation rates noted were more or less lower than second burst of sap (BS2) except for the 2nd plot which showed much higher rates reaching 90% (Fig. 5). By comparing the three plots, we see that the lowest infestation rate was recorded on the 3rd plot. This can be attributed to the nature of the trees which compose them and which are more or less old and poorly maintained.

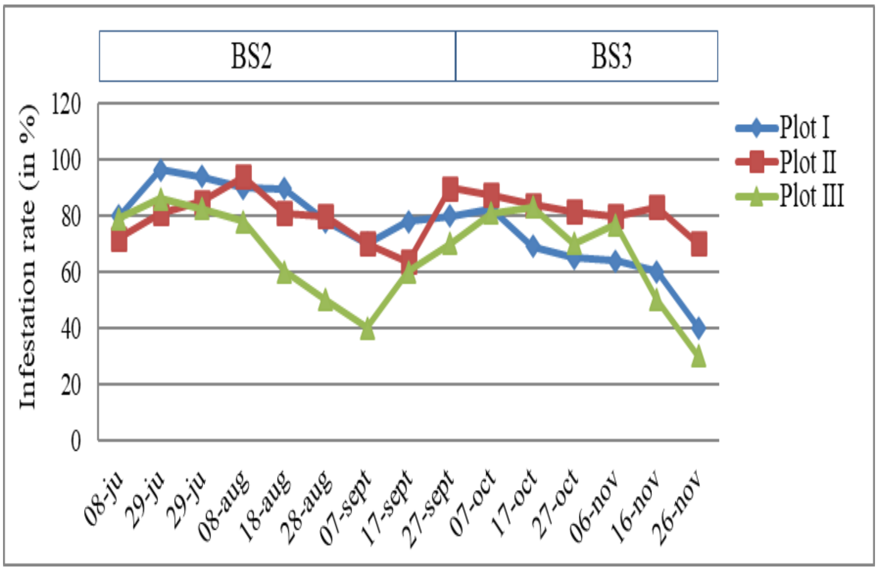

Figure 5. Evolution of the overall infestation rate of *P. citrella* on Orange trees for the three plots. SS2, second burst of sap; SS3 third burst of sap,

Infestation rate according to position

The various samplings carried out on the study plots allowed us to highlight a fluctuation in the infestation rate in relation to the location of each selected tree. For the first plot we recorded high infestation rates of around 98.86% on the date of July 19 at the edge, subsequently this value dropped to reach a rate of 60.58% on BS2 while in the center and on the same burst of sap the infestation rates were low at the beginning (65.46%) on July 8 and subsequently the latter followed a progression reaching a rate of 100% on August 18 and then stabilized at an average rate of 80% (Fig. 6). On the third burst of sap (BS3) the infestation rates followed the same path, in fact, at the edge the rates continued to decline throughout the study until the last sampling on December 6 when a rate of 25.86% was recorded. While on the central plots, maximum values of 100% were noted on several samplings, namely October 7, 17 and 27. These low proportions recorded on the edge can be explained by the fact that the latter is considered the part most affected by climatic conditions, namely temperature changes as well as by the action of hot summer winds which cause a disruption in the functioning of the trees that compose them. Comparing the results recorded on the two positions we notice that the difference between the rates recorded at the edge and in the center are quite small. The infestation rates recorded on the BS3 (Fig 7), were much higher to compare with that of the BS2; in fact maximum rates of 99% were recorded at the edge on October 7 and 100 % at the center for October 17 and 27. Indeed, the highest infestation rate was recorded on July 19 with a value of 79.99% at the edge and 100% in the center. By comparing the two positions we notice that the highest rates were recorded in the center. (Fig. 8).

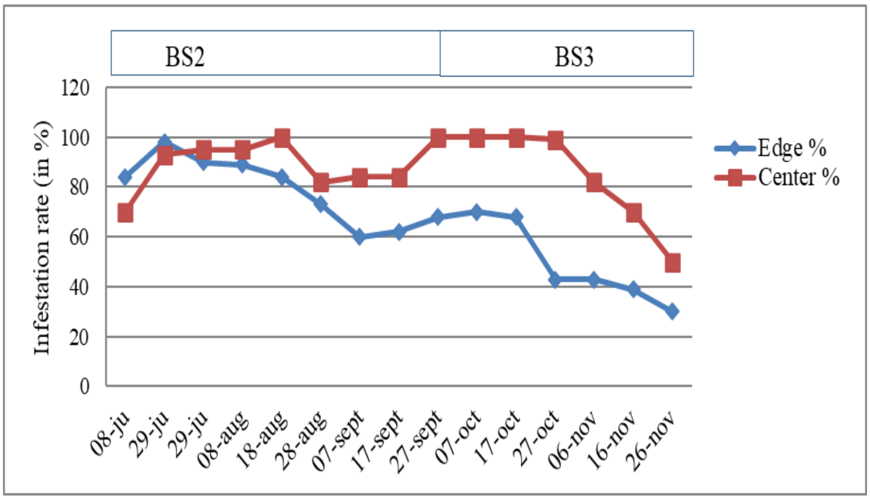

Figure 6. Infestation rate of *P. citrella* depending on the position on Orange tree (Plot I).

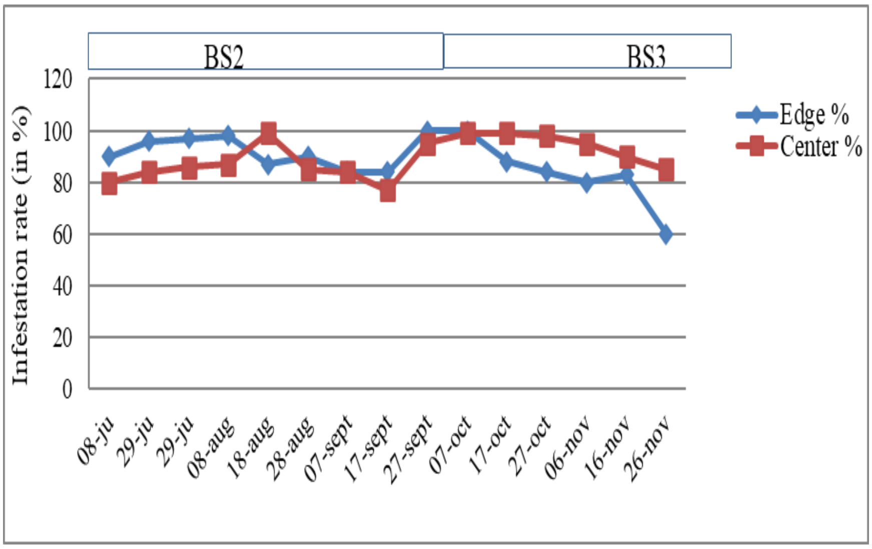

Figure 7. Infestation rate of *P. citrella* depending on the position on Orange tree (Plot II)

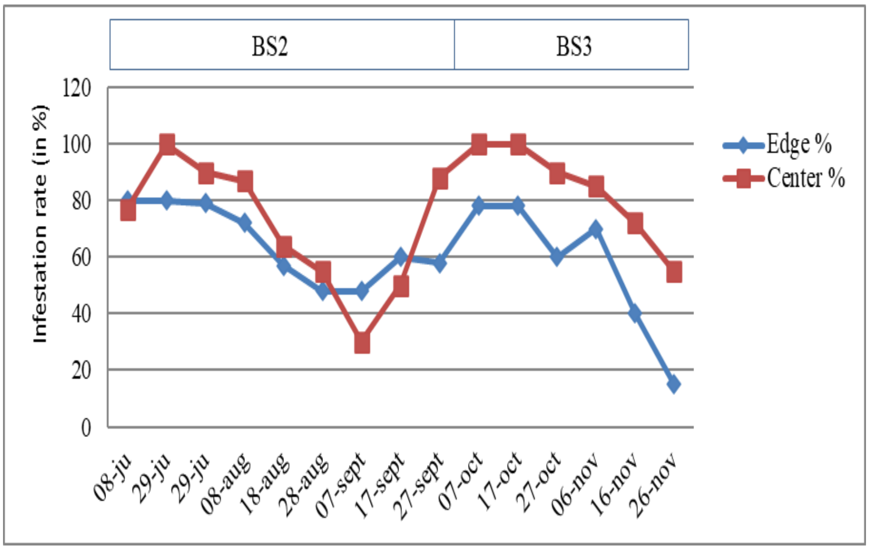

Figure 8. Infestation rate of *P. citrella* depending on the position on Orange tree (Plot III).

Infestation rate according to orientation

Weekly sampling on this plot revealed that contamination was very high on the shoots on the south side of the tree with an average of 89.88% during the entire BS2 period. At the start of the infestations these rates were 87.30%, and then evolved over time reaching the value of 97.11% corresponding to the maximum infestation rate recorded on the BS2. The same observations were made for the three other orientations namely (E, W, and N), in fact very close infestation rates were recorded with small differences depending on the sampling dates for averages of 85, 87%, 80.95% and 87.53% respectively for the orientations: South, North, West and East on the BS2 , while on the third the infestations were less significant with averages of: 69, 41%, 66.15%, 62.95% and 61.58% respectively for the orientations: South, North, West and East; we notice that the South orientation is the one which always presents the highest rates, we can attribute this to the exposure of the shoots to light which allows the tree to produce more vegetative mass and thus becomes more attractive for the phytophagous. (Fig. 9). For the North and East orientation the infestation rates were also high with maximum rates of 87.30% for the North and 93.65% for the East. (Fig.10). The highest infestation rate according to the orientation for this plot was observed mainly on the southern part with maximum rates of 90.55%, 93.83% and 95.56% respectively on: 08, 19 and 29 July, followed by the West orientation which also showed significant values close to 89% while the North and East orientation were less infested with rates of around 89.21% and 83.82% respectively for July 19 and 29 (Fig. 11).

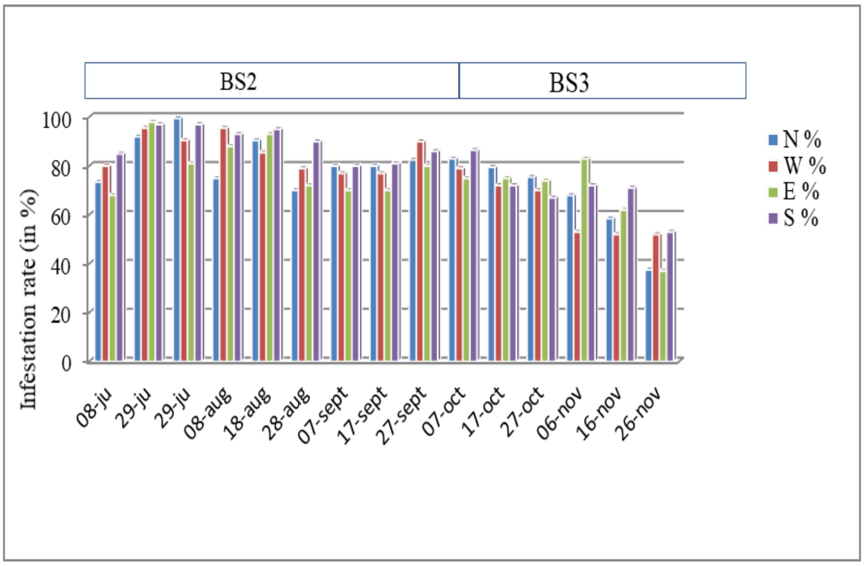

Figure 9. Infestation rate of P. citrella depending on the orientation on Orange tree (plot I).
N, North;, West ; E, East, S; South.

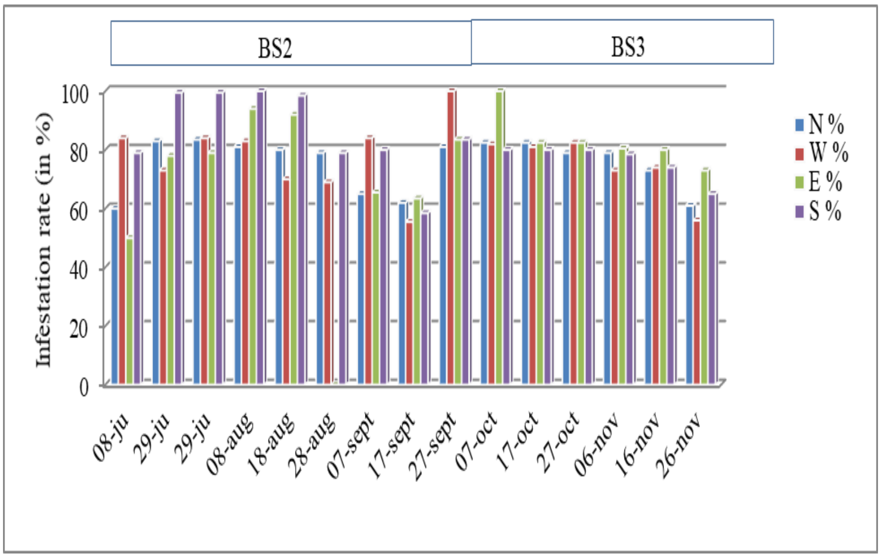

Figure 10. Infestation rate of *P. citrella* depending on the orientation on Orange tree (plot II).

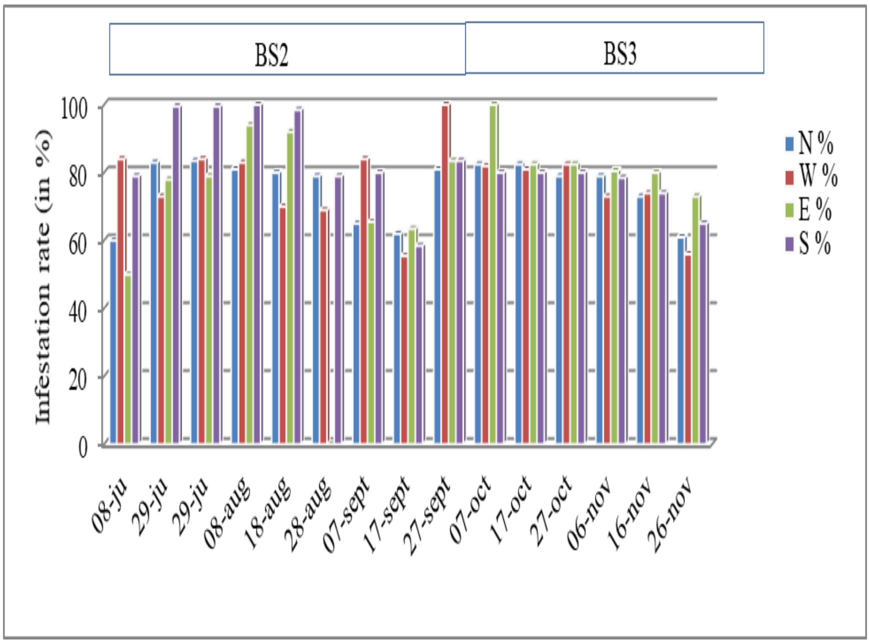

Figure 11. Infestation rate of *P. citrella* depending on the orientation on Orange tree (plot III).

Distribution of the different evolutionary stages of *P. citrella*

During the second flush, the clutches recorded maximums of 16.62%, 5.79% and 18.09% respectively for the 1st, 2nd and 3rd plot, followed by a gradual decline until the end of the flush. (Fig 12, 13 and 14)**.** Furthermore, on the BS3, the proportion of eggs was lower than that observed on the BS2, with peaks of around 8.22%, 1.9%. and 5.24% respectively on plots II, III and I**.** The importance of pupae and prepupae decreased in favor of the larval stages, on the BS2, a maximum was observed on July 8 with proportions of 72.78%, 14.74% and 32.94 % respectively for the 1st, 2nd and 3rd plot. The importance of nymphs and prepymphs decreased in favor of the larval stages, on the BS2, a maximum was observed on July 8 with proportions of 72.78%, 14.74% and 32.94 % respectively for the 1st, 2nd and 3rd plot. On the other hand, for the larvae, maximums of around 99.14% on September 7 and 100% on September 17 were observed respectively for the 1st, 2nd and 3rd plot. In addition, on the BS3, the larval proportions were very high, reaching 100% on December 6 on all three plots, while those of prepupae and nymphs were quite low, not exceeding 35% for the three plots.

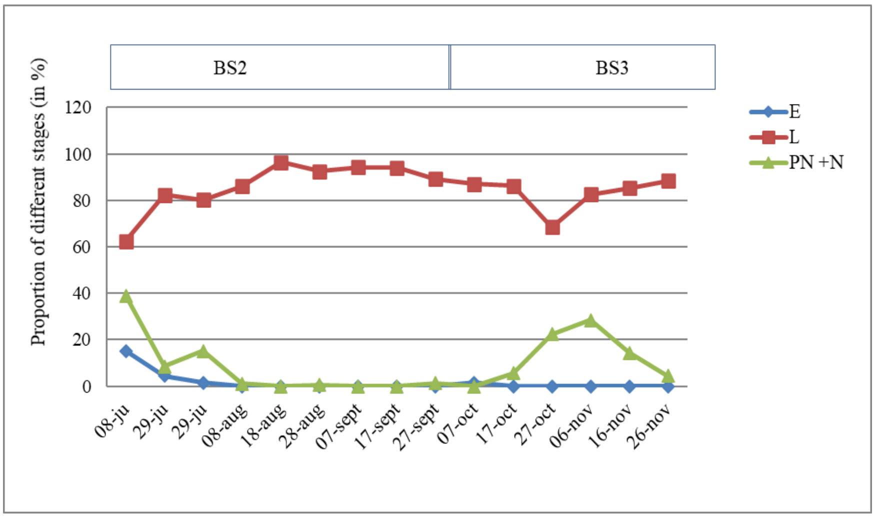

Figure 12. Distribution of the different evolutionary stages of *P. citrella* on Orange trees (plot I) E, Egg; L, Larva; PN, Prepupa; N, Nymph

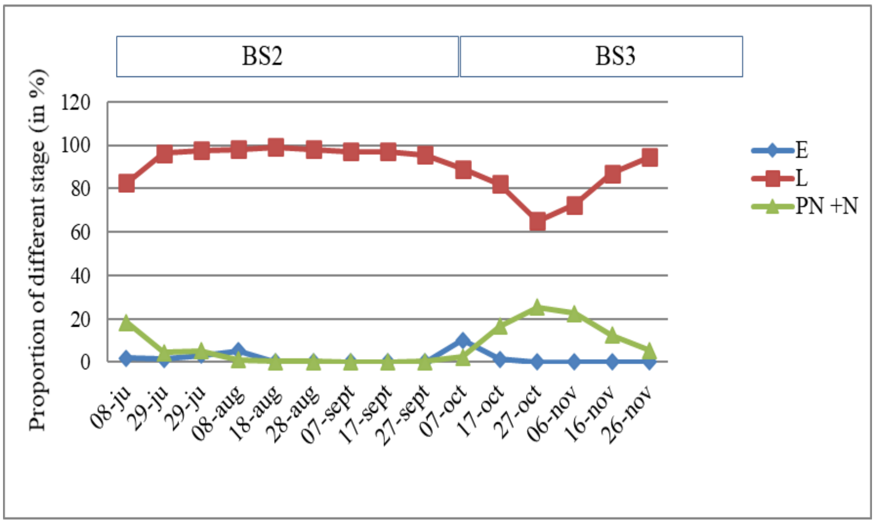

Figure13. Distribution of the different evolutionary stages of *P. citrella* on Orange trees (plot II).

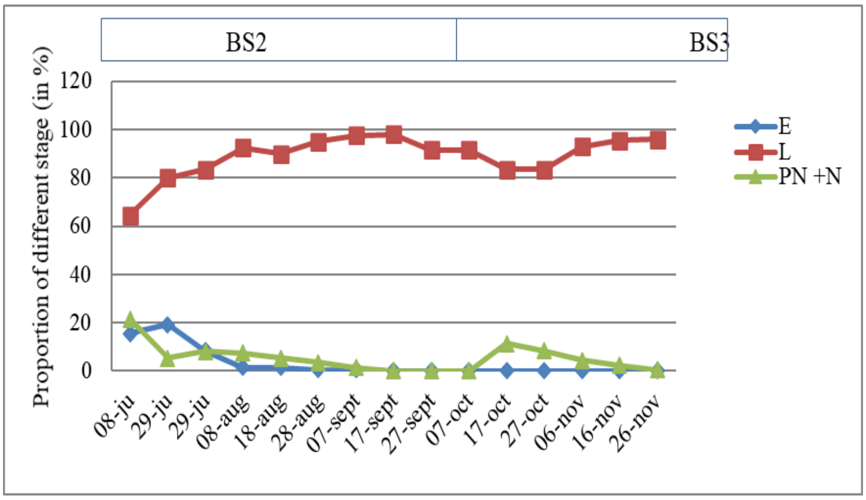

Figure 14. Distribution of the different evolutionary stages of *P. citrella* on Orange trees (plot III)

Estimation of parasitism rate

The figure below represents the estimated parasitism rate during the study period (Fig 15)
Fig 15 shows a significant increase in the parasitism rate, reaching two peaks 70% and 69% for the dates 07/19 and 07/29 (first release). After July 29, a fluctuation in the level of parasitism can be noted.

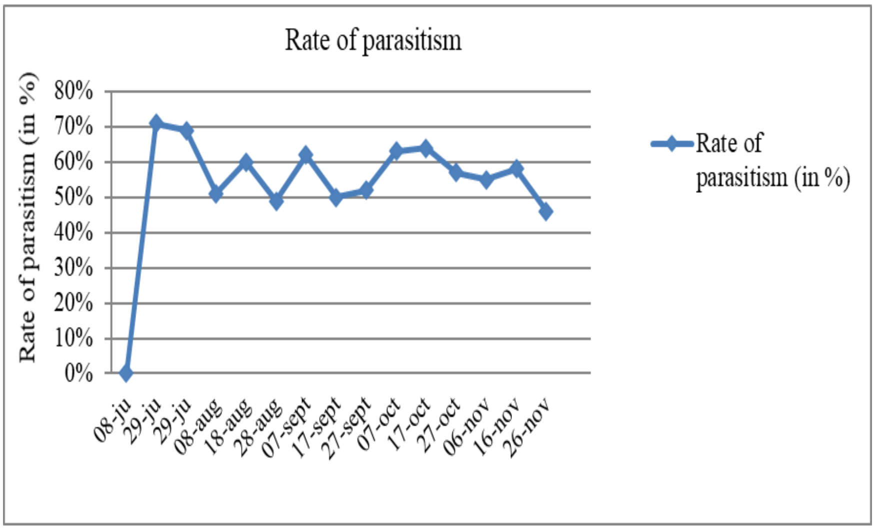

Figure15. Variations in the rate of parasitism (in %).

Inventory of citrus leafminer parasitoids in the Mostaganem area during 2019/2020

The inventory of natural enemies of the citrus leafminer continued, from 2019 to 2020, in an orange orchard (*Citrus sinensis*) of the experimental farm of the department of agricultural sciences of the University of Mostaganem. The chosen plots were not chemically treated in order to work in the most favorable natural conditions for harvesting a maximum of biological material. Four species belonging to six genera were recorded as parasitoids of *P. citrella* in the Mostaganem area (Fig. 16).

Figure 16 Parasitoid species inventoried during the year 2019-2020: **(a)** *Cirrospilus pictus*; **(b)** *Pnigalio pectinicornis* (native species); **(d)** *Semielacher petiolatus* (alochthonous species) (Boualem M and Bettouati A 2019).

Relative abundance of inventoried parasitoids

During the 2019 inventory year, three species were observed; these are: *Cirrospilus pictus*, *Pnigalio pectinicornis* and *Semielacher petiolatus* with variable abundances of (30.6, 24 and 42%) respectively (Table 3). The monthly presence of the inventoried species made it possible to highlight the constant activity of *S. petiolatus* and *C. pictus* from July to October with a dominance of *S. petiolatus* in the months of August and September, of *C. pictus* in the month of October and *P. pectinicornis* in July.

Table 3. Monthly relative abundance (%) of parasitoids collected (in 2019)

Species Month	*Cirrospilus pictus*	*Pnigalio pectinicornis*	*Semielacher petiolatus*
July	20,8	24	22,4
August	23.4	5.4	42.0
September	20,4	1.8	38.0
October	30.6	00	24.2

Many countries infested by the citrus leafminer have opted more specifically for the introduction and acclimatization of entomophagous species. Miner populations are more or less regulated by the action of the various mortality factors present, which makes it possible to mitigate its harmful action on the yield and production of citrus fruits. Our results show that *P.citrella* is subject to different mortality factors. Among those having an influence on its development (Fig. 17), climatic conditions are essential ecological parameters in development. Another factor affecting parasitism is competition between species. A very important factor is the acclimation of parasitoids.

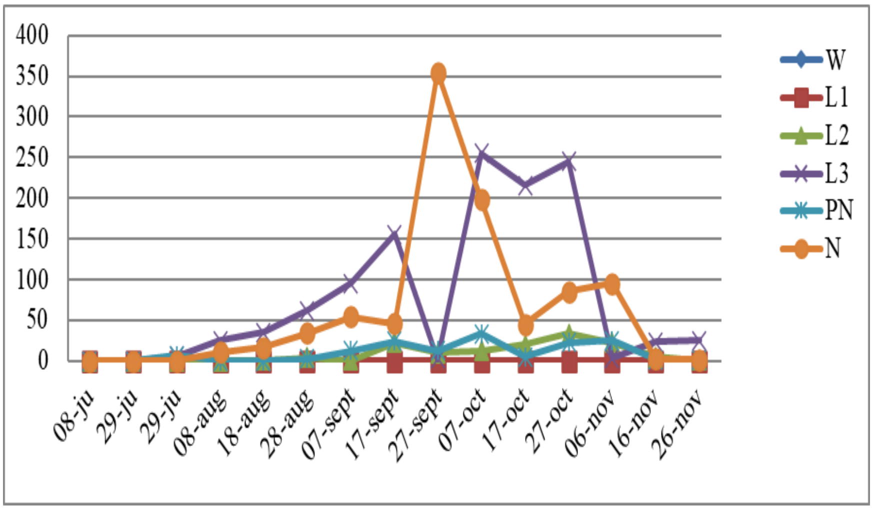

Figure 17. Number of different stages of *P. citrella* dead following parasitism in 2019
E, Egg; L1, Larva 1; L2, Larva2; L3, Larva3: PN, Prepupa; N, Nymph

Discussion

The infestation rates recorded during this study were significant. The strongest infestations were observed on summer shoots, with maximums exceeding 98% in July. The overall infestation rate observed was significant on the three plots studied, where maximums of 96.91%, 95.23% and 90% were recorded respectively on the 1st, 2nd and 3rd plot. The tree emits three bursts of sap per year: the first burst of sap in spring (BS1), the second in summer (BS2) and the third in autumn (BS3). The phenological evolution of citrus fruits, however, turns out to be more or less complex depending on other parameters such as the site, the health state of the tree, etc. (Boualem, 2009). The appearance of sap growth on citrus fruits corresponds to an emission of young tender leaves whose duration depends on temperature and humidity level which varies depending on the species and the nature of the orchard. The analysis of these results highlights an irregular evolution of the leafminer populations during this study with late maximums for the rebellious shoot and significant activity during the BS2. Our results are consistent with those observed in Japan by Mafi and Ohbayashi (2004) whose leafminer infestations reached two peaks, in July and October during the 2nd and 3rd bursts of sap (BS2 and BS3). Infestations vary depending on climatic conditions during the summer period (summer period). In Algeria, the pre-imaginal cycle of *P.citrella* is 12.57 days and this under temperature conditions of 30±1°C (Berkani, 1999) (Jacquemond. C et *al*., 2013) report that the duration of this pest between 13 and 15 days for a temperature between 27 and 30 °C in Reunion Island. In Italy Lo Pinto and Fucarino (2000) report that *P.citrella* is active during the summer and autumn months. While the spring growth is spared from infestations by the citrus leaf miner (Caleca and Lo Verde, 1997). The summer period is the most favorable for leafminer populations thanks to favorable temperatures and the presence of young tender leaves; the population of this pest is zero and negligible during winter and spring (Khechna, 2011). In Spain, (Urbaneja et *al*., 2000) found that the contamination rate was 30% during the first month, following the introduction of *P.citrella* reaching 95%. Khechna (2011), shows that in the case of clementine cultivation the most infected period is the summer period, particularly the month of July. The results that we found on the infestation rate are similar to the results obtained by Boualem (2009) where we noted the drop in the activity of *P. citrella* in recent years compared to current years for the same crop citrus fruits and the same experimental site, where infestation rates reached 99 to 100% were recorded on the BS2. (Khechna et *al*., 2017) reported that the high infestation rate on the Wachinthon variety with a rate of 50% observed on July 13 and a very high rate of 60% during August in 2011. It noted an increase in the infestation rate which begins with the appearance of the second burst of sap (BS2) during the month of June and a low infestation rate on the third burst of sap (BS3). In Algeria, similar work was carried out in the summer period on *P.citrella* showing that this pest attacks the second burst of sap (BS2) on three species of citrus fruits, namely orange, clementine and lemon, the attacks are weak during the winter period this due to the phenological stages of the culture (Berkani, 1995). Thus, the results found by Boualem (2009) show that the infestation rate on the 2nd burst of sap (BS2) varied from 67.5% to 97.40% during the month of July to August respectively depending on the temperature variation from 38.6°C (July) to 16°C (August), the same results found in 2004 on the evolution of contamination. In 2005, this pest showed low activity at the start of BS2 where the infestation rate was 10% to 13% during the month of June with a temperature of 23.6°C and a humidity level of 63% (Boualem et *al*., 2008). The duration of the evolutionary cycle varies according to climatic conditions, and mainly temperature. The average larva per leaf was higher than the harmfulness threshold (0.74 L/F) established by Huang and Li (1989) in China during the second and third sap flushes for the three plots studied. In Algeria, Berkani (1999) reported that at a temperature of 30 ± 1°C, *P. citrella* completes its life cycle in 12.57 days. Climatic factors and the availability of more or less abundant vegetation determine between 53 and 64% of variations in the density of leafminer populations (Greve and Redaelli, 2006). The results found in Spain show that the succession of sap shoots allows *P. citrella* to achieve between 10 and 1 generation per year (Urbaneja et *al*., 2000). Similar work carried out by (Bellout A et *al*., 2020) in Reunion Island, shows that the development of *P.citrella* is between 13 and 15 days, at a temperature between 26°C and 29°C, 23 days at 47 days at temperature varying between 35°C to 20°C respectively. Regarding the rate of parasitism. The *P. citrella* communities at the experimental site level at the Mazaghran workshop (Mostaganem) have the same development conditions with the parasitoids, so there is a positive relationship. So, if *P. citrella* is present, the parasites will appear, and if *P. citrella* is absent the parasites will disappear. The presence and proliferation of different stages of *P. citrella* is favored by high temperatures. In Algeria, Berkani (1995), shows that the parasitism rate is 6%; an absence of parasitism is noted from June until the end of September on the clementine variety. The work of Mechelany and Matny (1998) shows that the maximum parasitism on the lemon tree recorded at least from June by 4% with an absence of parasitism in the month of January until mid-March. On clementines the maximum parasitism is 6%, an absence of parasitism is noted from June until the end of September. The first rate of parasitism was noted on June 29, 2011 with a rate of 15% and the second with a rate of 20% reported on July 27. These percentages of parasitism are recorded after the first release of the citrus leafminer parasitoids (*Semielacher petiolatus* and *Citrostichus phyllocnistoides*) which was carried out after the appearance of the second surge of sap (Khechna et *al.,* 2018). The impact of the leafminer parasitic complex was felt much more on pre-pupae and L3 larval stages than on pupae. The mortality of organisms is linked to the effect of parasitoids (Sahraoui et *al*., 2001).The mortality rate when temperatures were around 40°C caused a significant mortality rate of around 95% for larvae and 60% for nymphs (Kheder et *al*., 2002),The same author reported that *S. pesiolatus* has been observed more regularly since 1997, the date of its first releases, thus testifying to the improvement in the rate of parasitism attributable to *S.petiolatus* which was able to wait until 87% of the advanced stages of *P.citrella* there has been an impoverishment of the local fauna.

Conclusion

The citrus leaf miner *Phyllocnistis citrella* remains one of the most important predatory species encountered in recent years in Algerian citrus orchards. Various research projects have been undertaken to develop appropriate control methods. This is how the population dynamics and biology of this insect have been studied throughout the world. Our modest contribution to this work is summarized as follows:
A study of the population dynamics and the evolutionary cycle of *P. citrella* on orange trees at the experimental site of the agricultural workshop in the commune of Mazagran, the following data can be reported:
-The overall infestation rate observed was significant on the three plots studied, where maximums of 96.91%, 95.23% and 90% were recorded respectively on the 1st, 2nd and 3rd plot,
-The infestation rate depending on the position was greater in the center with maximums of 100%, differently from the edge where rates of 97.21%, 99.07% and 82.5% respectively were noted on the 1st, 2nd and 3rd plot,
-The infestation rate according to orientation showed that the South orientation was the most infested,
-The average larva per leaf was higher than the harmfulness threshold (0.74 L/F) established by Huang and Li (1989) in China during the second and third sap flushes for the three plots studied, this study also made it possible to highlight the sensitivity of the different larval stages of *P.citrella* which essentially corresponds to the third larval stage (L3) and the prepupae.
Regarding the rate of parasitism, the *P. citrella* communities at the experimental site have the same development conditions with the parasitoids, therefore, there is a positive relationship. So, if *P. citrella* is present, the parasites will appear, and if *P. citrella* is absent the parasites will disappear.
The inventory revealed the constant presence of three species of parasitoids dependent on *P.citrella* in the Mostaganem area: *Cirrospilus pictus*, *Pnigalio pectinicornis* and *Semielacher petiolatus.*

It is very important in the future to continue the study of the population dynamics of the leafminer and its natural enemies. This is in order to be able to really follow the evolution of this insect in citrus orchards and at the same time to highlight the actions of the most effective regulatory factors. These results encourage farmers to use these parasitoids in the fight against *P. citrella* in Algeria, in particular the auxiliaries of the citrus leaf miner, to seek possible possibilities for breeding these species to properly combat this pest.

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