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Micro- and Macro-Habitable Distribution of Citrus Leaf Miner, *Phyllocnistis citrella* (Stainton) (Lipidoptera, Gracillariidae, Phyllocnistidae) on Navel Orange Trees

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Abstract

The Citrus leaf miner, *Phyllocnistis citrella* (Stainton) (Lepidoptera: Gracillariidae), is one of the most deleterious insect pests of all citrus species and varieties, especially seedlings in Egypt and other countries all over the world. The immature and mature pest stages distribution on upper and lower leaf surfaces and those found within the tree canopy were investigated on navel orange trees in Sharkia governorate during spring flushes of the two successive seasons of 2022 and 2023. Results showed that individuals of the citrus leaf miner significantly occurred in higher average numbers on the upper surface of navel orange leaves than the lower ones during the first season. But, in the case of the second season, the differences were insignificantly varied. With regard to the quadrants of the tree canopy, individuals of the pest were insignificantly investigated, with high average numbers in both the north and west directions (during the first season) and the south direction (during the second one).

Keywords: *Phyllocnistis citrella* (CLM), Navel orange, Distribution.

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1. Introduction

The Citrus Leaf Miner (CLM), *Phyllocnistis citrella* (Stainton) (Lepidoptera, Gracillariidae, Phyllocnistidae), is one of the dangerous insect pests for citrus trees, especially seedlings and young trees in most citrus-growing areas worldwide [1,2,3,4,5,6,7]. In Egypt, CLM was found in 1994 and eleven annual generations were recorded [8,9]. Larvae of the pest devoured the new vegetative or tender flushes, feeding internally through four larval instars mostly beneath the lower epidermis, causing deleterious damage to leaves through serpentine mines that reduce leaf ability to photosynthesis [10,11.12,13,14,15]. The seasonal abundance and spatial distribution of insects were studied by many authors in several countries to determine the distribution behavior of insects for oviposition, shelter, feeding, and others that help us in control methods or IPM programs [16,17,3,18,19,20,21,22,23]. Accordingly, the aim of this study is to determine the micro-distribution (spatial distribution on the upper and lower surfaces of the leaf) and macro-distribution (spatial distribution in the cardinal or quadrant directions of the tree canopy) of the citrus leaf miner *P. citrella* on navel orange trees in Zagazig district during the two successive years of 2022 and 2023.

2. Material and Methods

Field specimens were collected to investigate the effect of cardinal directions and tree levels of the citrus leaf miner *P. citrella* infestation on navel orange (*Citrus sinensis* L. var. Navel) in Tal-Howien village (37.14`35º30 N, 3.02`26º31 E), Zagazig district, Sharkia governorate, Egypt. Navel orange trees (*Citrus sinensis* (L.) Osbeck variety Navel) more than 50 years old were cultivated in an orchard of about 10 feddans of clay soil and irrigated by a flooding system**.** Trees of about 2.5–3 meters in height were cultivated on 5×5 meters.

To study the micro-spatial distribution of citrus leaf miner individuals, *P. citrella*, on both the upper and lower surfaces of leaves as well as the macro-spatial distribution of the same insect within quadrants of the tree canopy that represent the cardinal directions (east, north, south, and west), five tender twigs of each quadrant from three trees (as replicates) were randomly collected in plastic bags. Five leaves of each twig (25 leaves in each direction) were inspected at random in the laboratory using a stereoscopic microscope.

All alive individuals (eggs, larvae, and pupae) of the tested insect were counted. The procedure was conducted during two seasons throughout the spring flushes, from 6/3/2022 and 13/3/2023 until 23/5/2022 and 30/5/2023, respectively. The obtained data were statistically analyzed as a randomized block design using ANOVA analysis, according to [24].

3. Results and Discussion

Data in Table 1 and Figure 1 showed the mean numbers of alive individuals of *P. citrella* on Navel orange, spatially distributed on upper and lower leaf surfaces, as well as those that occurred in the different quadrants of the tree canopy. Statistical analysis of variance revealed that the alive individuals of *P. citrella* showed on the upper surface of navel orange trees (10.25 individuals per sample) were highly significant than those observed on the lower surface (8.09 individuals per sample). But, in the case of the cardinal directions of tree quadrants, the investigated differences were insignificant. The macro-distribution of *P. citrella* between the different quadrants of the tree clarified as follows: 9.65, 9.33, 8.95, and 8.76 individuals per sample for the north, west, east, and south directions, respectively. In all quadrants, the highest mean numbers of individuals were observed on the upper surfaces of navel orange (Figure 1).

Table 1: Spatial distribution of alive, immature stages of *P. citrella* (Stainton) on spring flushes of Navel orange in Sharkia governorate during the first season of 2022

Direction	Mean no. of individuals/sample		
	Upper	Lower	Average
East	10.13	7.76	8.95
North	10.87	8.43	9.65
South	9.96	7.56	8.76
West	10.07	8.59	9.33
Average	10.25 A	8.09 B	-

F value of leaf surface 73.45 **
F value of cardinal direction 2.53 n.s.
F value of tree level × cardinal direction 0.59 n.s.

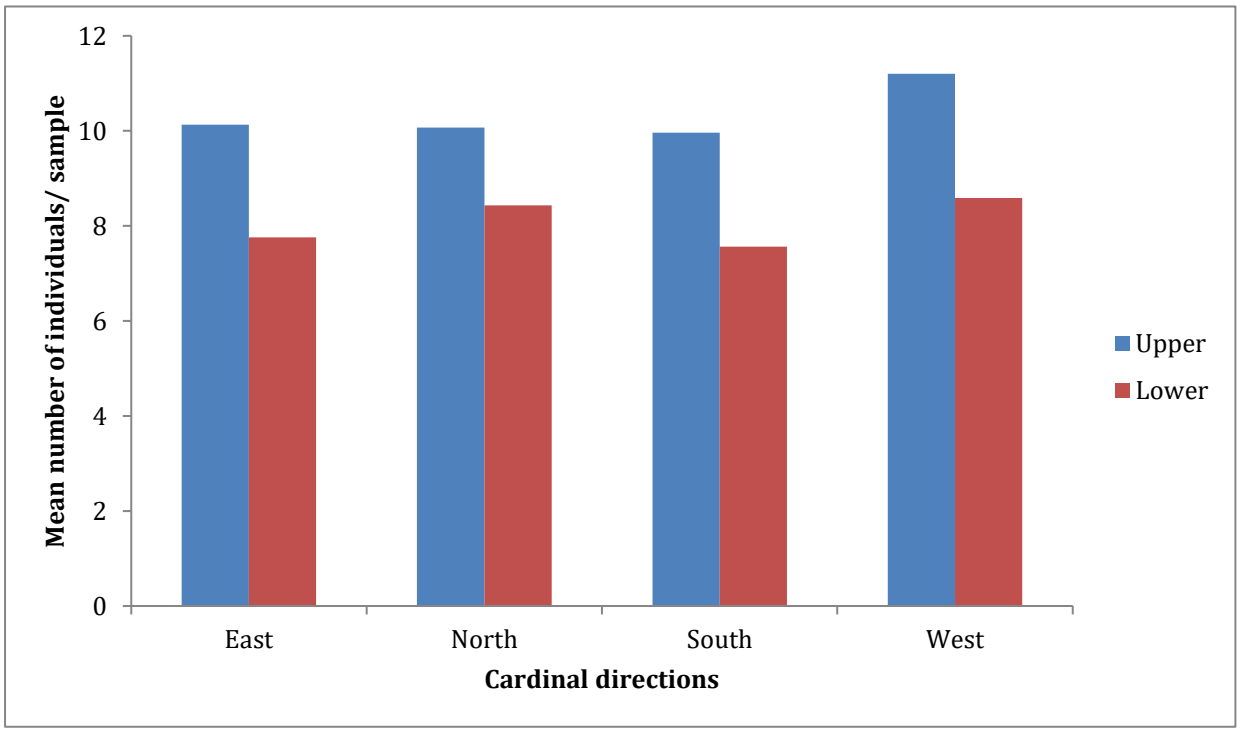

Figure 1: Macro- and micro-distribution of alive individuals of *P. citrella* on Navel orange trees during 2022 spring flushes

On the other hand, the individuals of the citrus leaf miner insignificantly preferred to occur on the lower surface the leaf (7.44 insects per sample) during the second season of 2023. The micro-habitable distribution of the pest on the upper surface of the navel orange leaf (7.36 insects per sample) was lower than that recorded on the lower surface. Also, the average of the macro-habitable distribution of *P. citrella* within the tree canopy was statistically insignificant. The results recorded 6.85, 7.31, 8.00, and 7.60 individuals per sample for east, north, south, and west, respectively (Table 2). Data in Figure 2 indicate that individuals of the citrus leaf miner occurred on the upper surface of navel orange in the east and west directions of the tree canopy, whereas the reverse took place in the north and south directions during the second season of 2023.

Table 2: Spatial distribution of alive, immature stages of *P. citrella* (Stainton) on spring flushes of Navel orange in Sharkia governorate during the second season of 2023

Direction	Mean no. of individuals/ sample		
	Upper	Lower	Average
East	6.90	6.48	6.85
North	7.29	7.33	7.31
South	7.50	8.50	8.00
West	7.76	7.43	7.60
Average	7.36	7.44	-

F value of leaf surface 0.07 n.s.
F value of cardinal direction 2.19 n.s.
F value of tree level × cardinal direction 1.44 n.s.

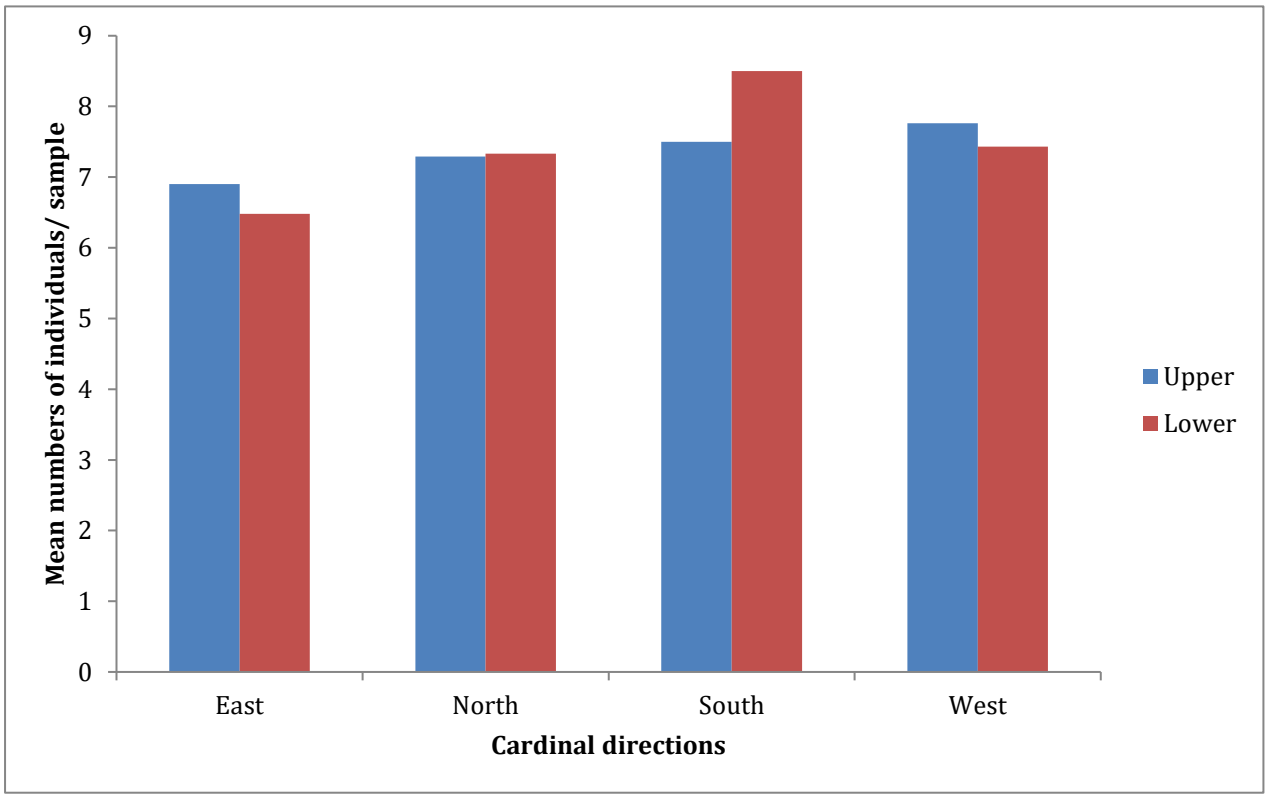

Figure 2: Macro- and micro-distribution of alive individuals of *P. citrella* on Navel orange trees during 2023 spring flushes

The obtained data are in harmony with those recorded by [3], who stated that the population of *P. citrella* preferred the eastern and southern directions over the western and northern directions of citrus trees in Egypt. [18] found that the center of the tree is the preferred direction, with 25% of the total egg number issued by the female of *P. citrella*. The larvae developed in greater numbers on the lower side of the leaf, with a rate of 61% against 39% on the upper surface. Also, [19] revealed that the south direction of the orange trees had the highest percentages of leaf damage by the citrus leaf miner. There were significant differences between the south direction (68.75%) and the west direction (64.42%), the north direction (60.58%), the east direction (54.58%), and the middle of orange trees (45.38%). The recorded predatory species were the highest in the south direction (70 individuals) compared to those in the north direction (54), the east direction (50), the west direction (37) and (20) for the middle of the orange trees. [20] studied the spatial distribution of the citrus leaf miner in a citrus orchard in Egypt and showed that individuals of *P. citrella were* highly distributed in the west direction more than in the other directions and centers of host trees during the spring season. [21] reported that the *P. citrella* damage increased from the lower to the upper canopy of the citrus trees.

The highest level of infestation was observed on the upper canopy of citrus plants, followed by a middle and lower canopy in the case of all citrus cultivars. [22] stated, in Algeria, that the leaf miner *P. citrella* was considered a potential serious pest of citrus and determined the relationship between the ecophases of the citrus leaf miner and the leaf surface of the Washington navel citrus variety. The authors found that more than 80% of the leaf miner ecophases were distributed on the lower surfaces of the leaves. [15,23] reported that the spatial distribution of *P. citrella* consistently indicated an aggregated pattern. However, temporal variation in distribution was observed on specific dates. But these results contradict those of [16], who identified the spatial distribution of *P. citrella* in two citrus orchards and found the highest average numbers of leaf miner pupae and parasitoids in the east quadrant ($\chi^2 = 11.81$; df = 3; $P < 0.05$), ($\chi^2 = 10.36$; df = 3; $P < 0.05$).

In the Murcott orchard, the highest number of parasitoids and of mines was registered in the north quadrant ($\chi^2 = 19.29$; df = 3; $P < 0.05$) and in the south quadrant ($\chi^2 = 4.39$; df = 3; $P < 0.05$). In both orchards, there was no difference between the numbers of shoots, either relative to the strata or to the quadrants. As the number of shoots did not vary much relative to the quadrants, it is possible that the higher number of miners and parasitoids in the East and West quadrants would be influenced by the higher solar exposure of these quadrants. [23] stated, also in Egypt, that *P. citrella* preferred the middle and east directions of its host trees.

References

[1] J.B. Heppner. (1993). Citrus leafminer, *Phyllocnistis citrella*, in Florida (Lepidoptera: Gracillariidae: Phyllocnistinae). Tropical Lepidoptera, 4(1): 49-64.

[2] S.L. Lapointe & W.S. Leal. (2007). Describing seasonal phenology of the leafminer *Phyllocnistis citrella* (Lepidoptera: Gracillariidae) with pheromone lures: controlling for lure degradation. Florida Entomologist, 90(4): 710-714.

[3] I.E. Abdel-Rhman. (2009). Population dynamics and distribution of the citrus leaf miner, *Phyllocnistis citrella* Stainton larvae on different Citrus species. J. Agric. Sci. Mansoura Univ., 34(6): 6737 - 6744.

[4] H. Khechna, H. Bendoumia, B. Doumandji-Mitiche & S. Doumandji. (2017). Population dynamics and parasitic complex of *Phyllocnistis citrella* Stainton, 1856 (Lepidoptera; Gracillariidae) on three varieties of citrus in Oued-El-Alleug of Mitidja (Algeria). Advances in Environmental Biology, 11(2): 1-11.

[5] A.M.A. Mohsen. (2019). Survey of insect pests infected Navel orange trees, population dynamic of some dominant insects and effect of cultivation and intercropping on population density. Current Science International, 8(1): 221-229.

[6] P.M. Prabhudev, M.H. Suchithra Kumari, M. Hanumanthappa, R. Girish, H.S. Yallesh Kumar & L. Hanumantharaya. (2021). Seasonal incidence of citrus leaf miner, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillaridae) in the hilly region of Chikkamagaluru district. Journal of Entomology and Zoology Studies, 9(1): 1152-1156.

[7] D. Dewangan, D. Kumar, A. Kerketta, U.B. Deshmukh, A.K. Awasthi, N.K. Chaure & S. M. Chandrakar. (2022). Seasonal incidence of citrus leaf miner (*Phyllocnistis citrella* Stainton) on acid lime (*Citrus aurantifolia* Swingle) and it's correlation with different abiotic factors. The Pharma Innovation Journal, SP-11(7): 3666-3668.

[8] A.F. Hashem (1996). CLM and its control in Egypt. Report of Workshop on Citrus Leafminer and its Control in the Near East, Sep. 30- Oct. 3. Safita (Tartous), Syria.

[9] S.A. Moustafa (2004). Studies on some natural enemies associated with the Citrus Leafminer, *Phyllocnistis citrella* (Stainton). Ph. D. Thesis, Fac. of Agric., Mansoura Univ., Egypt, 178 pp.

[10] H. Rahman, K. S. Islam & M. Jahan. (2005). Seasonal incidence and extent of damage caused by citrus leaf miner, *Phyllocnistis citrella* Stainton infesting lemon. Pak. J. Sci. Ind. Res., 48(6) 422-425.

[11] A.M. Hoy, R. A. Singh & M. E. Rogers. (2007). Citrus leafminer, *Phyllocnistis citrella* (Lepidoptera: Gracillariidae), and natural enemy dynamics in central Florida during 2005. Florida Entomologist, 90(2): 358-369.

[12] M. Chhetry, R. Gupta, J.S. Tara & P.C. Patha. (2012). Seasonal abundance of citrus leaf miner *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) from Jammu and Kashmir. Journal of Insect Science, 25(2): 144-149.

[13] M.M. El-Maghraby, Shimaa, E.M. Metwally, A.M.S. Hegab, A.M.A. Mohsen & A.M.Z. Mosallam. (2016). Effect of some physical properties and chemical contents of different citrus species and varieties on infestation with citrus leaf miner, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) in Egypt. Zagazig Journal of Agricultural Research, 43(1): 209-224.

[14] M. Arshad, M. I. Ullah, M. Afzal, S. Ali, Y. Iftikhar, S. Khalid & Z. Hussain. (2021). Seasonal abundance of *Phyllocnistis citrella* (Lepidoptera: Gracillariidae) on mandarin (Spindales: Rutaceae) groves in Pakistan. J. Agric. Res., 59(2): 165-170.

[15] G. Nguvu, B.S. Wudil & G.M. Rwegasira. (2023). Spatial distribution and damage severity of Citrus leafminer (*Phyllocnistis* spp. Stainton) in major Citrus producing regions of Tanzania. Asian Journal of Agricultural and Horticultural Research, 10(4): 593-605.

[16] S.M. Jahnke, L.R. Redaelli, L.M.G. Diefenbach & C.F. Efrom. (2008). Spatial distribution of parasitism on *Phyllocnistis citrella* Stainton, 1856 (Lepidoptera: Gracillariidae) in citrus orchards. Braz. J. Biol., 68(4): 813-817.

[17] C.R. Jesus & L.R. Redaelli. (2008). Spatial distribution of *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) larvae in three scales. Braz. J. Biol., 68(1): 205-210.

[18] N. Salhi & B. Doumandji-Mitiche. (2009). Population dynamics of the Citrus leaf miner, *Phyllocnistis citrella* (Lepidoptera: Gracillariidae) and its parasitoids on marsh seedless grapefruit in Algeria. J. Ent. Res. Soc., 11(1): 5-16.

[19] I.A. Bahy El-Din, M.A.M. Ali & M.A.M. El-Khawas. (2017). A study on the differentiation between orange trees directions on the citrus leafminer, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) and the common predatory species, in Qaluobiya governorate. Arab Univ. J. Agric. Sci., Ain Shams Univ., Cairo, 25(1), 213-224.

[20] A.H. El-Afify, R.M. Shreef, N.M. Ghanim1 & M.A. Hendawy. (2018). host preference, spatial distribution and chemical control of the citrus leafminer, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae). Zagazig J. Agric. Res., 45(1): 151-164.

[21] M.W. Abbas, A.M. Raza, A. Dageri, M. Arshad, M.A. Khan, M.I. Ullah & M. Afzal. (2020). Consequences of leaf biochemical characters for Citrus leafminer, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) along the microclimatic gradient of Citrus plants. Kuwait J. Sci., 47(4): 49-56.

[22] M. Dahmane & G. Chakali. (2020). Distribution pattern of developmental stages of *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) on the surface of citrus leaves. Polish Journal of Entomology, 89(1): 1-6.

[23] N.M. Youssef, S.Kh. Ragab & N.M. Ghanim. (2022). Host preference and distribution within the tree's canopy of some insect pests infesting citrus species with response to certain weather factors. International Journal of Entomology Research, 7(12): 70-77.

[24] G.H. Snedecor & W.G. Cochran. (1972). Statistical methods. Iowa State Univ. Press, Amer., Iowa.