



Seasonal incidence of pomegranate butterfly, *Deudorix livia* (Klug) (Lepidoptera: Lycaenidae) on pomegranate and evaluation of susceptibility degrees of pomegranate varieties to infestation by the pest

El-Solimany, E.A.¹ and Amira A.K.H. Negm ^{2*}

¹ Department of Vegetable, Medicinal, Aromatic and Ornamental pests Researches, Plant Protection Research Institute, Agricultural Research Center A.R.C., Dokki, 12511 Giza, Egypt.

² Horticulture Pests Department, Plant Protection Research Institute, Agricultural Research Center A.R.C., Dokki, 12511 Giza, Egypt.

Abstract

pomegranate butterfly, *Deudorix livia* is a dangerous pest that attacks pomegranate orchards in Egypt, causing severe damage and a great loss in yield. The seasonal population dynamics of pomegranate butterfly were investigated on five pomegranate varieties (Wonderfull, Manfaloty, Araby, Nab Al-Jaml, and Wardy) in this study during the seasons of 2021 and 2022 at Sohag Governorate. Results indicated that *D. livia* started to appear in pomegranate orchards in late May and continued to the early part of October in the five tested varieties in both seasons. Eggs, entrance holes, and emergence holes of the pest showed 4, 3, and 3 peaks of numbers, respectively, in both seasons of the study. The lowest numbers of eggs and entrance holes were observed during May, while the highest numbers were recorded during September and October, in both seasons. For emergence holes, the lowest and highest numbers were observed during June and September, in both seasons. The five pomegranate varieties varied significantly with regard to the number of eggs, entrance holes, and emergence holes in the two seasons. All tested pomegranate cultivars showed varied susceptibility degrees against *D. livia*. Manfaloty and Wonderful recorded the highest and the lowest attractive variety for infestation by the pest during the two seasons of study.

Keywords: *D. livia*; pomegranate; seasonal population dynamics; susceptibility.

1. Introduction

Pomegranate (*Punica granatum* L.) has been cultivated and naturalized over the whole Mediterranean region. It is one of the most important crops grown in Assiut, Sohag, the Sinai governorates and in many world countries. It considered as one of important exporting crops (Negm *et al.*, 2018). Pomegranate has a lot of nutritional and medicinal benefits, including antidiabetic, antimicrobial, antiallergic, and antioxidant, fruit also contains a considerable amount of protein, sugar, and minerals (Hamad *et al.*, 2021).

Pomegranates contain several bioactive compounds such as alkaloids, ellagic acid, punicalagin among other ellagitannins, anthocyanins, flavonoids, tannins, and other phytochemicals that may play a vital role in human health and in the prevention and treatment of several illnesses (Setiadhi and Sufiawati, 2017). Different varieties normally have diverse physicochemical characteristics and may, for that reason, differ in the amount and type of bioactive compounds (Hmid *et al.*, 2020).

Pomegranate cultivation and its potential yield and quality are affected by infestation by many pests. The most challenging pests that attack pomegranates are aphids, fruit flies, and leaf-footed bugs. The pomegranate butterfly, *Deudorix*

*Corresponding author: Amira A.K.H. Negm

Email: amiranegm2000@gmail.com

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(*Virachola livia*) (Lepidoptera: Lycaenidae), and the carob moth, *Ectomyelois ceratoniae* (Lepidoptera: Pyralidae), are major Lepidopteran insects attacking pomegranate. Their larvae feed on the seeds, causing severe damage in many countries, such as Egypt, Iran, Saudi Arabia, Jordan, and Oman (Alotaibi *et al.*, 2022).

The infestation of many pests, especially the pomegranate fruit butterfly, *V. livia*, is one of the main causes of the decrease in pomegranate yield. The most severe and possibly persistent pest that attacks pomegranates bores holes into the fruit, feeds on the berries, and draws other insects and fungi to the fruit to do their damage. The percentage of infestation by *Virachola* sp. may reach over 50% (Balikai *et al.*, 2009). Pomegranate fruits become unpalatable to customers when infected with *D. livia*, which reduces their marketability. Due to the aggressiveness of *D. livia* infestations, many Egyptian growers switched to other crops (Abu Omira, 2022).

Information concerning the occurrence of pomegranate butterfly and their infestation rates on pomegranate orchards in Egypt, is still in lack; hence, this study was conducted for determination the seasonal population fluctuations and estimation the damage rates of pomegranate butterfly on pomegranate at Sohag governorate and determination the susceptibility degrees of five pomegranate varieties for infestation by pomegranate butterfly.

2. Materials and methods

2.1. Experimental design and orchard

The experiment was conducted in a pomegranate orchard of one feddan at the Experimental Farm of Shandweel Agricultural Research Station, Sohag Governorate, Egypt, during 2021 and 2022 seasons to determine the seasonal population of the pomegranate butterfly, *D. livia*, on five pomegranate varieties. The soil of the experimental site was heavy loam, and the trees, which were 25 years old, were 5 m apart from each other and had uniform vigor and size.

Conventional agricultural practices were performed, and insecticidal treatments were completely prevented. Five pomegranate varieties (Wonderfull, Manfaloty, Araby, Nab Al-Jaml, and Wardy) were used in a complete randomized block design with four replicates. Each replication consisted of 16 rows of trees.

2.2. Investigation of seasonal population of pomegranate butterfly

To investigate the seasonal population of pomegranate butterfly on the five tested varieties, weekly samples of 10 fruits were chosen randomly and collected from different directions on the trees. Samples started after fruit holding in 2nd May until the crop collection in 3rd October. The number of eggs, the number of entrance holes, and the number of emergence holes are counted and recorded.

2.3. Relative susceptibility of pomegranate cultivars to be infested with pomegranate butterfly

The relative susceptibility of different pomegranate varieties to be infested by pomegranate butterfly is tested using the following varieties (Wonderfull, Manfaloty and, Araby, Nab Al-Jaml and Wardy). 10 fruits were randomly chosen from different varieties of pomegranate trees. The mean numbers of eggs, entrance holes, and emergence holes all over the two seasons for each cultivar were used to determine the effect of variety on the infestation by the pomegranate butterfly.

2.4. Statistical analysis

Data were analyzed using one-way ANOVA using SPSS version 24. 'F' test used for determination the susceptibility of the five pomegranate varieties and mean separation was conducted using the least significant difference (L.S.D.) procedure at $P \leq 0.05$. Results are presented as mean \pm SD.

3. Results

3.1. Seasonal population dynamics of pomegranate butter fly, *D. livia*

3.1.1. Eggs

Data in Figures (1) and (2) shows the seasonal abundance of *D. livia* eggs on five pomegranate varieties during 2021 and 2022 seasons. Eggs of pomegranate butter fly were firstly observed during 23rd and 30th May for Wonderful and Manfaloty during the two seasons, and in 30th and

23rd May for Araby, Nab El-gamal and Wardy in the two seasons, respectively. Four peaks were recorded during the two seasons. The first peak was recorded on 13th June for all tested varieties, with a mean number of eggs of 4.67, 5.00, 2.33, 2.67, and 5.33 eggs per 10 fruits for Wonderful, Manfaloty, Araby, Nab El-gamal, and Wardy, respectively, in the first season and 7.00, 6.67, 4.00, 1.67, and 7.33 eggs / 10 fruits, respectively, in the second season.

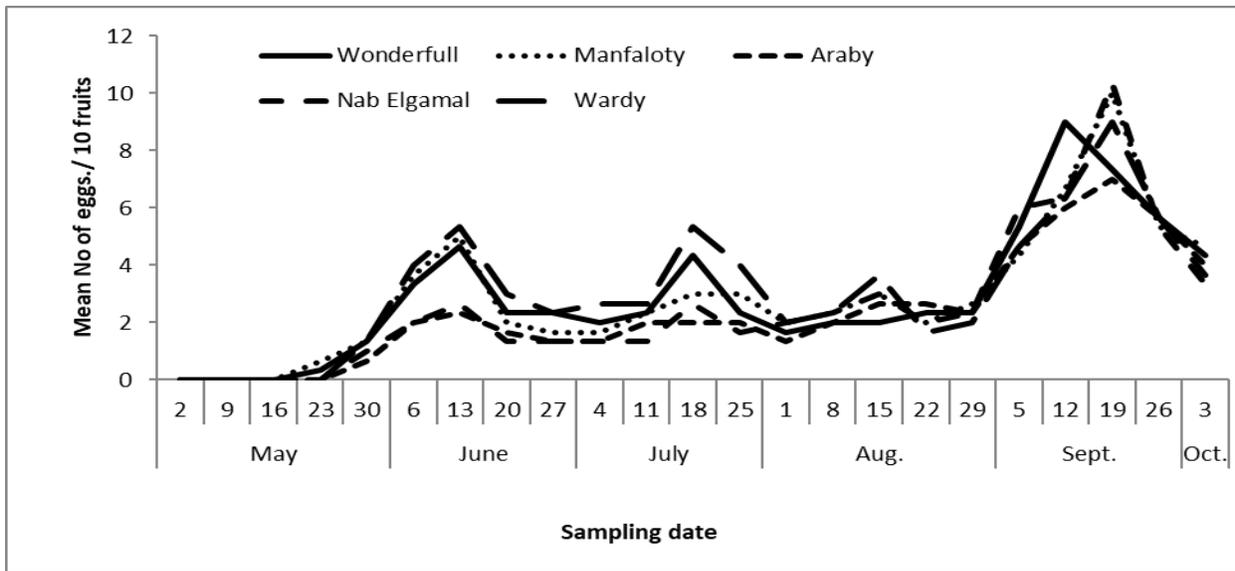


Figure 1. Mean number of eggs laid by *D. livia* adults on five pomegranate varieties at Sohag governorate during 2021 season.

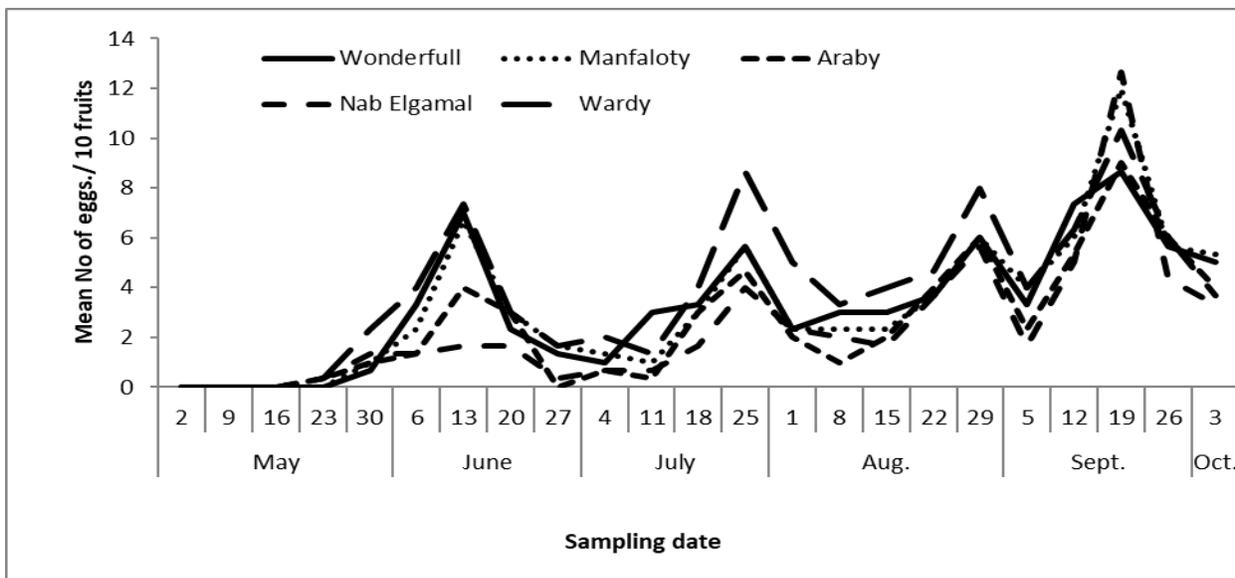


Figure 2. Mean number of eggs laid by *D. livia* adults on five pomegranate varieties at Sohag governorate during 2022 season.

The second peak was on 18th and 25th July in the two seasons, with 4.33, 3.00, 2.00, 2.67, and 5.33 eggs per 10 fruits for Wonderfull, Manfaloty, Araby, Nab Al-Jaml, and Wardy, respectively, in the first season, and 5.67, 5.67, 4.67, 4.00, and 8.67 eggs / 10 fruits for the previous varieties, respectively, in the second season. The third peak was observed on 15th and 29th July respectively, in 2021 and 2022 seasons. The mean numbers of 2.00, 3.00, 2.67 3.00, and 3.67 eggs per 10 fruits were recorded on Wonderful, Manfaloty, Araby, Nab Al-Jaml, and Wardy, respectively, in 2021 season, and the same varieties recorded 6.00, 6.00, 6.00, 5.67 3.00, and 8.00 eggs / 10 fruits, respectively, during 2022 season. The fourth peak is the highest which was detected on 19th September in both seasons. Wonderfull, Manfaloty, and Araby, Nab Al-Jaml, and Wardy recorded 7.33, 10.00, 7.00, 10.33, and 9.00 eggs / 10 fruits, respectively, in the first season, and 8.67, 12.00, 9.00, 12.67, and 10.33 eggs and 10 fruits, respectively, in the second season. The lowest number of eggs was observed during May; however, the highest one was recorded during September in both seasons.

3.1.2. Entrance holes

Illustrated data in Figures (3) and (4) shows the seasonal abundance of *D. livia* entrance holes on

the five pomegranate varieties during 2021 and 2022 seasons. The entrance holes of *D. livia* were observed almost one week after the first detection of eggs on 30th May, after that, the numbers fluctuated to form three peaks for all tested varieties during the two seasons. The first and lowest peaks were observed on 13th June with average numbers of 3.67, 3.33, 3.00, 2.33 and 1.67 holes/ 10 fruits for Wonderfull, Manfaloty, Araby, Nab Al-Jaml, and Wardy, respectively, in the first season, and 3.00, 3.00, 3.00, 2.67, and 1.33 holes / 10 fruits for the previous, respectively, in the second season. The second peak was detected on 25th July, Wonderfull, Manfaloty, Araby, Nab Al-Jaml, and Wardy recorded 4.00, 4.67, 3.67, and 2.67 holes and 10 fruits, respectively, in the first season and 5.33, 6.00, 5.00, 3.00, and 4.67 holes / 10 fruits, respectively, in the second season. However, the third and highest peak was observed on 26th September with average numbers of 5.67, 5.33, 5.33, 3.67, and 6.33 holes / 10 fruits for Wonderfull, Manfaloty, Araby, Nab Al-Jaml, and Wardy, respectively, in the first season, and 7.67, 6.00, 7.33, 5.33, and 5.00 holes / 10 fruits for the previous, respectively, in the second season. The lowest number of entrance holes was observed during May, however, the highest one was recorded during October in both seasons.

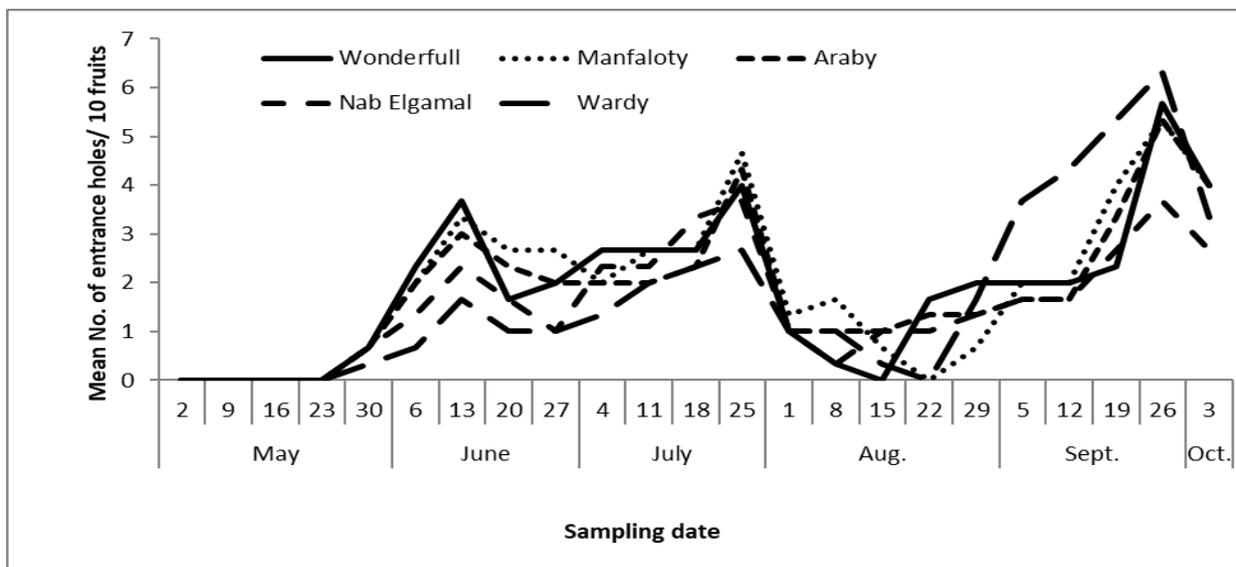


Figure 3. Mean number of entrance holes caused by *D. livia* larvae on five pomegranate varieties at Sohag governorate during 2021 season.

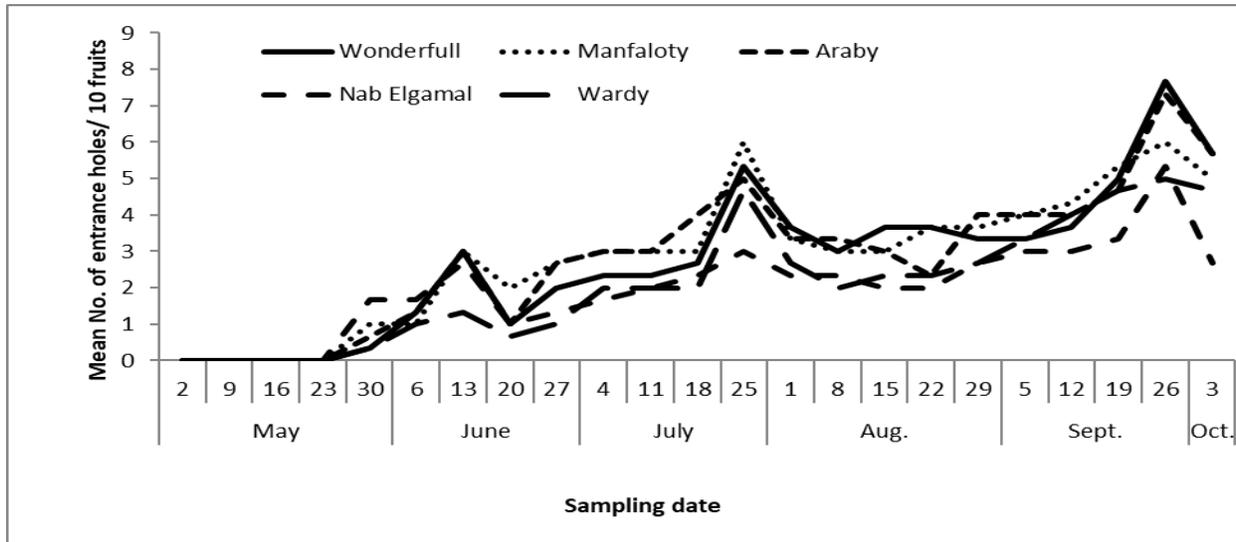


Figure 4. Mean number of entrance holes caused by *D. livia* larvae on five pomegranate varieties at Sohag governorate during 2022 season.

3.1.3. Emergence holes

Results in Figures 5 and 6 shows the mean number of emergence holes for the pomegranate butterfly on five pomegranate varieties during the 2021 and 2022 seasons. The emergence holes started to appear in 6th and 13th June for all tested varieties in the 2021 and 2022 seasons, after 1 and 2 weeks from the detection of the entrance holes in the two seasons. In regardless to pomegranate varieties, the number of emergence holes formed 3 peaks in both seasons. The first and the lowest peak was recorded in 20th June in both seasons. Wonderfull, Manfaloty and, Araby, Nab Al-Jaml and Wardy recorded 1.00, 2.00, 2.00, 0.67 and 2.33 holes/ 10

fruits, respectively in 2021 season, and 2.00, 2.67, 2.33, 2.33 and 3.00 holes/ 10 fruits, respectively in 2022 season. The second peak was recorded after 8 and 7 weeks from the first one on 15th and 8th August in the two seasons, respectively. Wonderfull, Manfaloty and, Araby, Nab Al-Jaml and Wardy recorded 2.67, 2.33, 2.00, 2.00 and 3.00 holes/ 10 fruits, respectively in 2021 season, and 3.00, 3.00, 3.00, 2.67 and 2.33 holes/ 10 fruits, respectively in 2022 season. The lowest number of emergence holes was observed during June; however, the highest one was recorded during September in both seasons.

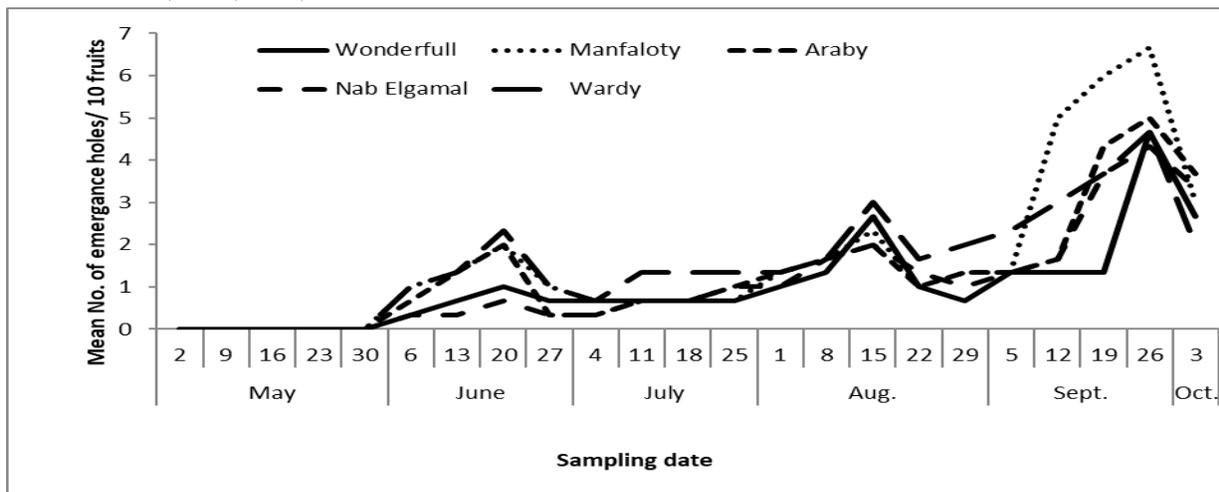


Figure 5. Mean number of emergence holes caused by *D. livia* larvae on five pomegranate varieties at Sohag governorate during 2021 season.

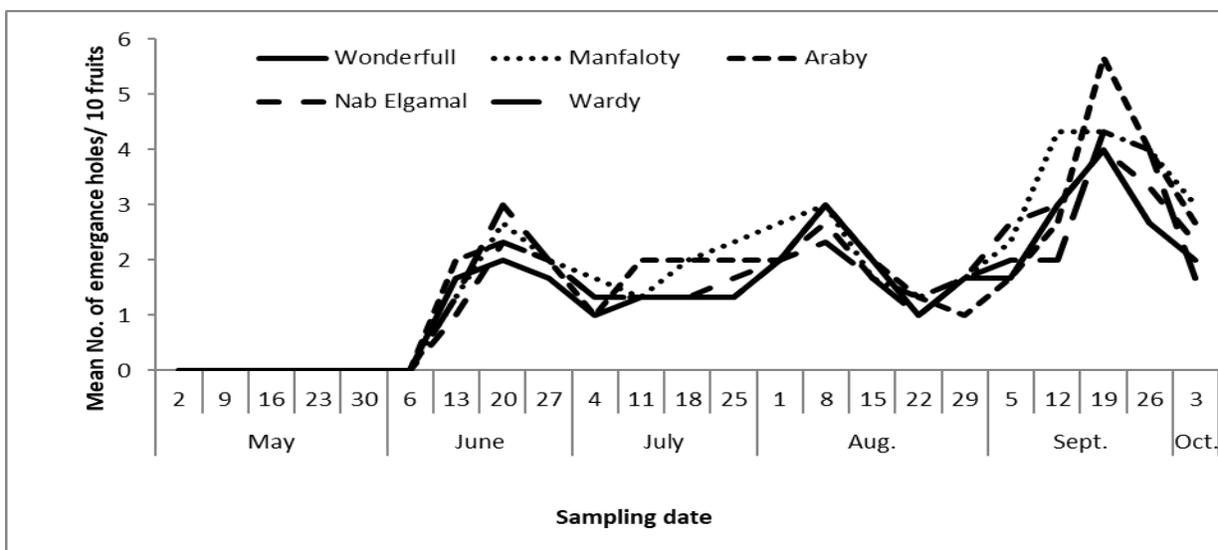


Figure 6. Mean number of emergence holes caused by *D. livia* larvae on five pomegranate varieties at Sohag governorate during 2022 season.

3.2. Susceptibility of pomegranate varieties for infestation by *D. livia*

The susceptibility of pomegranate's varieties to be infested with pomegranate butterfly was evaluated on five varieties of Manfaloty, Wonderful, Araby, Nab Al-Jaml and Wardy (Table 1) during the two successive seasons of study (2021 and 2022). It is clear that no variety was completely free of infestation in both seasons of the study. In general, the five pomegranate varieties varied significantly in regard to numbers of eggs, entrance holes and emergence holes in the two seasons.

For the mean number of eggs, Wardy was observed as the most attractive variety to egg

laying by the pomegranate butterfly, with a mean number of eggs of 3.12 and 3.91 eggs / 10 fruits in the two seasons, followed insignificantly by Wonderful (2.93) and Manfaloty (2.93) in the first season. On the other hand, Araby and Nab El Gamal recorded the lowest mean number of eggs in the two seasons, with insignificant differences between them in both seasons of the study. The two previous varieties showed a mean number of eggs of 2.33 and 2.54 eggs / 10 fruits, respectively, in 2021 season and 2.61 and 2.43 eggs / 10 fruits, in 2022 season.

Table 1. Susceptibility of five pomegranate varieties to infestation by *D. livia* at Sohag Governorate during 2021 and 2022 seasons.

Pomegranate varieties	Mean no. of laid eggs \pm SD		Mean no. of entrance holes \pm SD		Mean no. of emergence holes \pm SD	
	2021	2022	2021	2022	2021	2022
Wonderfull	2.93 \pm 1.00 a	3.29 \pm 0.20 b	1.88 \pm 1.00 ab	2.74 \pm 0.28 a	1.01 \pm 1.00 b	1.45 \pm 0.09 c
Manfaloty	2.93 \pm 1.53 a	3.28 \pm 0.09b	1.96 \pm 1.53 a	2.87 \pm 0.23 a	1.64 \pm 1.00 a	1.81 \pm 0.19 a
Araby	2.33 \pm 1.00 b	2.61 \pm 0.31 c	1.84 \pm 0.58 ab	2.46 \pm 0.59 ab	1.32 \pm 1.73 ab	1.71 \pm 0.18 ab
Nab Elgamal	2.54 \pm 2.08 b	2.43 \pm 0.27 c	1.55 \pm 1.15 c	2.00 \pm 0.12 b	1.12 \pm 1.53 b	1.55 \pm 0.03 bc
Wardy	3.12 \pm 0.06 a	3.91 \pm 0.24 a	1.74 \pm 3.21 b	2.12 \pm 0.07 b	1.55 \pm 1.53 a	1.49 \pm 0.17 bc
F. value	19.42*	22.99*	8.42*	4.12*	6.42*	4.82*
L.S.D.	0.2382	0.4040	0.1771	0.6096	0.3464	0.2272

In regard to entrance holes, data analysis showed that Manfaloty recorded the highest mean numbers of 1.96 and 2.87 holes / 10 fruits in the

two seasons, followed insignificantly by Wonderful and Wardy varieties in both seasons, with 1.88 and 1.84 holes / 10 fruits in the first

season, and with 2.74 and 2.4 holes per 10 fruits in the second season. Nab Elgamal recorded the lowest mean number of entrance holes with 1.55 and 2.00 holes in the two seasons, followed insignificantly by Araby and Wardy (2.12) in the second season only.

From the mean number of emergence holes, we can determine the susceptibility of tested pomegranate varieties to being infested by the pomegranate butterfly. Manfaloty recorded the highest mean numbers of 1.64 and 1.81 holes / 10 fruits in the two seasons, followed insignificantly by Araby in both seasons with 1.32 and 1.71 holes / 10 fruits in the two seasons, respectively, and Wardy (1.55) in the first season. Wonderful recorded the lowest mean number of emergence holes with 1.01 and 1.45 holes in the two seasons, respectively, followed insignificantly by Nab Elgamal in both seasons with 1.12 and 1.55 holes in the two seasons. Also, there was no significant difference between Wonderful and Araby in both seasons, and between Wardy (1.49) and Araby (1.49) in the second season only.

4. Discussion

The pomegranate butterfly is one of the most severe pests attacking pomegranate cultivation in Egypt, so it must be monitored constantly to make management decisions at the right time and place. The weekly numbers of eggs proved the presence of four peaks for *D. livia* during the two successive seasons of study (2021 and 2022); however, three peaks were detected for entrance holes and emergence holes in both seasons. Also, the activity of the pest was noticed during the period from May to October of the two seasons. In agreement with Abazaid *et al.* (2021) observed in Giza governorate during the seasons 2016 and 2017 the presence of four peaks of eggs on Wonderful on 3rd week of June, 2nd week of July, 4th week of September and 1st week of November. These data in agreement with Murugan and Thirumurugan (2001) who noted that the severity of damage was between April to August months.

Also, these results are similar to those obtained by Elsayed and Bazaid (2011), who observed that pomegranate fruits are attacked by *D. livia* during the period of pomegranate production (May to October) in Taif, Saudi Arabia. It has four overlapping generations in a year Khandare *et al.* (2018). Abu Omira (2022) reported that fruit infestation by *V. livia* appeared around 5th May and in 5th June in all cultivars, and continued to increase in 7th September in both two seasons.

Pomegranate variety of Manfaloty was the highest susceptible variety for infestation by pomegranate butterfly among the other tested varieties. Similar results were obtained by Abazaid *et al.* (2021), who evaluated the rate of infestation by *D. livia* on four varieties of pomegranate (Manfaloty, H116, Wonderful, and H118). It was determined that Manfaloti was the highest variety to be infested by *D. livia*. Also, these results agree with Negm *et al.* (2018) when measuring the firmness of pomegranate varieties (Manfaloty, Baladi, Nab El-Jaml, Taifi, and Wonderfull). The varieties were arranged in descending order according to fruit firmness as follows: Wonderfull, Manfaloty, Nab El-Jaml, Taifi, and Baladi. The differences in fruit firmness between Manfaloty and Nab El-Jaml are insignificant, while differences in firmness were significant between Wonderful and the other varieties; this might be the cause of the resistance of the Wonderful variety to infestation by *D. livia*. Also, Abu Omira, (2022) found that the average percent infestations at harvest were 60.0, 54.5 and 63.0 % in Manfaloty, Higazy and Araby cultivars, respectively, in the first season, and 58.00, 56.50, and 58.00%, respectively.

The variation in the tested varieties may be due to the chemical composition of their fruits. (Soliman, 2020) mentioned that phytochemical polyphenolic compounds and tannins play a great role in the susceptibility or resistance of fruits to infestation. Elbeltagy (2020) tested some chemical prosperities for Manfaloty and Woderfull varieties of pomegranate in different four governorates and it was found that the percentage of tannins in Manfaloty recorded

0.081% while in Wonderfull recorded 0.099 % as well the percentage of phenolic compounds recorded 0.028 and 0.041%, respectively for Manfaloty and Wonderfull. (Ageu et al., 2018) mentioned that polyphenolic compounds and tannins have toxic effects on the egg hatchability of *Aedes aegypti*. Also, Soliman (2020) found higher concentrations of phenolic compounds and tannins in the pomegranate variety of Baladi (67.60 and 314.4) than those found in the Wonderfull variety (27.55 and 68.09), and this may explain why Baladi is more resistant to infestation by *B.zonata* and *C.capitata* than Wonderfull. Abd-Ella et al. (2022) demonstrated that pomegranate cultivars differed in the percentages of total soluble solids, TSS/acidity ratio, total sugars, and total reducing sugars. Also, the effects of pomegranate butterfly infestation on chemical composition varied between cultivars.

5. Conclusion

D. livia is a dangerous pest that attacks pomegranate orchards in Egypt, causing severe damage and a great loss in yield. The seasonal population dynamics of pomegranate butterfly and the susceptibility of the varieties for infestation were investigated on five pomegranate varieties (Wonderfull, Manfaloty, Araby, Nab Al-Jaml, and Wardy). The start of *D. livia*'s activity over the two subsequent research years is in late May. (2021 and 2022). For *D. livia*, eggs, entrance holes, and emergence holes recorded 4, 3, and 3 peaks during the course of the two years, respectively. Of the studied types, Wardy was the one most prone to *D. livia* infestation. Availability of data about this pest is very rare, and therefore we cared that we study the times of its annual activity and its preference for different varieties of pomegranate in preparation for future biological and control studies on this pest.

Authors' Contributions

All authors are contributed in this research.

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Institutional Review Board Statement

All Institutional Review Board Statements are confirmed and approved.

Data Availability Statement

Data presented in this study are available on fair request from the respective author.

Ethics Approval and Consent to Participate

Not applicable

Consent for Publication

Not applicable.

Conflicts of Interest

The authors disclosed no conflict of interest starting from the conduct of the study, data analysis, and writing until the publication of this research work.

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