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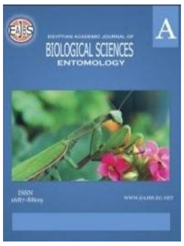

Spatial Distribution of *Deudorix livia* and Associated Predatory Insects on Pomegranate Manfaloty Cultivar at Assiut Governorate

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ABSTRACT

Deudorix livia (Klug) (Lepidoptera: Lycaenidae) causes substantial damage to pomegranate fruits, leading to significant yield losses. This damage directly impacts the economic viability of pomegranate farming. Studying the spatial distribution of *D. livia* and its predators is vital for developing effective, sustainable, and environmentally sound pest management strategies in pomegranate orchards. So, the present work aimed to study the spatial distribution patterns of *D. livia* eggs and predatory insects on the Manfaloty cultivar of pomegranate orchards at Assiut Governorate during 2020 and 2021 growing seasons.

Results indicate that a significantly higher average number of *D. livia* eggs was observed in the western direction across both seasons. The western-south side was the most preferred oviposition site. Statistical analysis reveals significant differences in egg distribution among cardinal directions. Predatory insects collected using yellow sticky traps exhibited varying spatial distributions between the two seasons. In 2020, the western direction showed the highest predator numbers, while in 2021, the northern direction was dominant. The preferred directions for predaceous insects were on the southwestern side and the eastern-northern side in 2020 and 2021, respectively.

The current study demonstrates the value of spatial distribution data in enabling precise pest management. Identifying areas of concentrated *D. livia* populations and the locations of their predatory insects facilitates targeted interventions, thereby enhancing the efficacy of Integrated Pest Management (IPM) programs and minimizing unnecessary pesticide use.

INTRODUCTION

Pomegranate (*Punica granatum* L.) is a valuable fruit crop, widely cultivated in tropical and subtropical regions, including Egypt, due to its nutritional and medicinal properties (Holland *et al*., 2009; Abdel-Galil *et al*., 2023a). Globally, pomegranate production is rising, driven by increasing consumer demand for healthy and exotic fruits. Countries like India, Iran, the United States, and Spain are the major producers and exporters, each contributing unique cultivars to the market (Saxena *et al*., 2023). Cultivar preferences vary by region, influenced by local tastes, agricultural practices, and market demands (Stover and Mercure, 2007). Egyptian pomegranate production surged by 47.9% to 995,477 tons in 2021/2022, comprising 8% of total fruit output. Domestic consumption accounts for 78% (7kg per capita), with 22% exported. Al-Nobaria leads production (725,000 tons, 73%), followed by Assiut (186,447 tons, 19%) and Beheira (22,179 tons) (MALR Egypt, 2022). In Upper Egypt, and notably within Assiut Governorate, pomegranate cultivation is a crucial economic activity for farmers, where it serves as a primary source of export income (Arafat *et al*., 2019; Mousa, 2023).

Pomegranate cultivation faces increasing challenges from various pests (Chandana *et al*., 2024). Its production is significantly threatened by several insect pests, among which the pomegranate fruit borer, *Deudorix livia* (Klug) (Lepidoptera: Lycaenidae), stands out as a major constraint (Abdel-Galil *et al*., 2023a). This lycaenid species inflicts substantial damage by boring into developing fruits, leading to premature fruit drop and reduced yield, ultimately impacting the economic viability of pomegranate cultivation (El-Husseini *et al*., 2018).

The conventional response has often involved the widespread and, unfortunately, unwise application of chemical pesticides. This practice, while potentially offering short-term relief, poses significant risks to environmental health, human safety, and the long-term sustainability of pomegranate production. Consequently, there is a critical need to explore and implement alternative, environmentally sound approaches for controlling serious pomegranate pests.

The indiscriminate use of pesticides in pomegranate orchards can lead to a cascade of adverse effects. Pesticide residues can persist in fruits, posing direct health risks to consumers (Gormez *et al*., 2025). Also, these chemicals can contaminate soil and water resources, disrupting ecological balance and harming non-target organisms, including beneficial insects and pollinators (Onwudiegwu and Izah, 2024). As biodiversity decreases, target pests are increasingly developing resistance to pesticides. This creates a negative feedback loop, forcing greater dependence on these chemicals (Belgacem *et al*., 2021).

Recognizing these detrimental consequences, the agricultural community is increasingly advocating for IPM strategies. Also, IPM emphasizes a holistic approach, combining cultural practices, biological control, and targeted pesticide applications only when necessary. This approach aims to minimize environmental impact while maintaining effective pest control.

Research into natural enemies, biopesticides, and innovative monitoring techniques is crucial for developing sustainable IPM programs tailored to the specific needs of pomegranate orchards. The growing awareness of environmental sustainability and consumer demand for residue-free produce underscore the urgency to shift away from excessive pesticide use. Developing and implementing effective, environmentally friendly pest control strategies is not only an ecological imperative but also a crucial step toward ensuring the long-term viability of pomegranate cultivation.

The Manfaloty cultivar, widespread in Assiut Governorate, Upper Egypt, does not possess resistance to *D. livia* infestation. Understanding the spatial distribution of this pest within orchards is crucial for developing effective pest management strategies. Spatial distribution patterns, such as aggregated (clustered), random, or uniform, provide insights into the ecological factors influencing pest populations and guide the implementation of targeted control measures (Ibrahim *et al*., 2021).

Furthermore, natural enemies play a vital role in regulating insect populations and are essential components of IPM programs (DeBach and Rosen, 1991; Rebek *et al*., 2012). Identifying and characterizing the natural enemies of *D. livia* in pomegranate orchards, including parasitoids and predators, are critical for assessing their potential as naturally occurring biological control agents (NOBCA) **(**Aboulnasr *et al.*, 2024**)**. The effectiveness of these natural enemies is often influenced by their spatial distribution, which may be linked to the distribution of their host or prey (Mousa, 2023).

In Assiut Governorate, where pomegranate cultivation is significant, detailed studies on the spatial distribution of *D. livia*, and its natural enemies are limited. Therefore, the present work aimed to study the spatial distribution patterns of *D. livia* and its associated predatory insects on the Manfaloty cultivar of pomegranate at Assiut Governorate. The findings of this research will contribute to better understanding the ecological dynamics of this pest and its predatory insects, and to provide valuable information for developing sustainable and effective IPM strategies for pomegranate orchards in Northern Upper Egypt.

MATERIALS AND METHODS

1-Experimental Site:

This study was carried out at the Experimental Farm, Faculty of Agriculture, Assiut University, Egypt (31° 11' 21.4188" E, 27° 10' 48.4824" N) over the 2020 and 2021 growing seasons. A total of 130 trees (12 years old) of the Manfaloty cultivar in pomegranate orchards were chosen for the present study. The other host plants, sweet acacia and date palm trees, were distributed in clusters around pomegranate orchards.

2-Spatial Distribution Patterns of *Deudorix livia* and Predatory Insects Inhabiting Pomegranate Trees:

2.1-Counting the *D. livia* Eggs:

Using cardinal directions-based sampling strategy (north, south, east, west, and centre), five sites within a pomegranate orchard were selected. Weekly, from the fruit set onward, *D. livia* eggs were counted on five branches from ten randomly selected trees at each site, as per El-Sheikh and El-Kenway (2020).

2.2-Counting Predatory Insects:

Yellow sticky traps (30 × 20 cm), constructed from environmentally safe and non-toxic materials, were used to capture insects. One trap was hung on each of five pomegranate trees, positioned to represent the cardinal directions (north, south, east, west, and center). Traps were replaced weekly and were taken to the laboratory at Assiut University Biological Control Unit (AUBCU) for identifying and counting predatory insects.

2.3-Spatial distribution pattern equation:

The cardinal direction preference of *D. livia* eggs and predatory insects within the pomegranate orchard was estimated using an established mathematical formula (Mahmoud, 1981; Hassan, 1998; El-Sheikh and El-Kenway, 2020).

$$H= \sqrt{\boldsymbol{F1^2 + F2^2 + 2(F1 \,.\, F2\, Cos.Q}})$$

Where:

H = powers summation.

F1 = The population in the north direction minus the population in the south direction, if the former is higher, and the reverse is applied if the population in the south direction is higher.

F2 = The population in the east direction minus the population in the west direction, if the former is higher, and is reversed if the latter is higher.

F1= N-S ، F2= E-W

Tan (Cosine of the angle between the two directions) Q = F2/F1

3-Data Analysis:

Data were statistically analyzed using SAS 9.1 software (SAS, 2008).

RESULTS

To pinpoint where the pomegranate butterfly (*Deudorix livia*) deposits its eggs for studying spatial distribution, the study of Abdel-Galil *et al*. (2023a) rigorously observed this agricultural pest across different host plants like pomegranate and sweet acacia. This observation involved recording infestation dates. Furthermore, accurate identification of this pest, including its egg stage, was achieved through both morphological features and molecular techniques, as detailed in Abdel-Galil *et al*. (2023b).

1. Spatial Distribution Patterns of *Deudorix livia* on Pomegranate Manfaloty Cultivar During 2020 and 2021 Growing Seasons:

1.1. Distribution of *Deudorix livia* Eggs in Cardinal Directions and Center:

The monthly average of *Deudorix livia* egg numbers on Manfaloty pomegranate, as shown in Table 1, varied by cardinal directions and orchard center over the 2020 and 2021 growing seasons. analysis of Data reveals that the maximum average of egg counted 35.33 and 25.78 in the west during the 2020 and 2021 growing seasons, respectively, followed by east (26.25 and 22.78), south (19.33 and 15.33), and north (15.11 and 10.97 eggs) directions. The orchard center consistently showed the lowest counts (9.97 and 5.75). Also, significant differences in *D. livia* egg distribution were observed across cardinal directions in both 2020 and 2021 ($F = 10.69^{**}$, 9.22^{**}, respectively). The western direction appears to have the highest egg percentages (33% and 31%), followed by east (25% and 27%), south (19% in both seasons), and north (14% and 13%). The center of the field showed the lowest egg percentages (9% and 10%) in both seasons **(**Fig. 1**)**. Analysis across the two seasons showed a significantly higher average *D. livia* egg count in 2020 compared to 2021 (F = 19.11**). In both years, the western direction exhibited the highest average egg count (30.56), followed by the eastern (24.51), southern (17.33), northern (13.04), and central (7.86) directions.

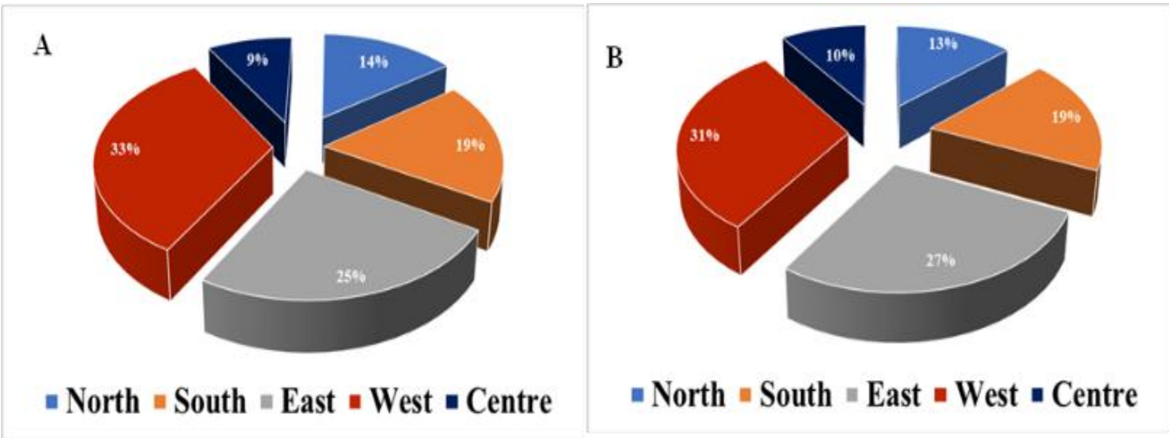


Fig. 1: The distribution of *D. livia* eggs across cardinal directions on Manfaloty pomegranate trees in 2020 (A) and 2021 (B).

1.2. Preferred Spatial Distribution In Cardinal Directions for *Deudorix livia* Eggs on Pomegranate Manfaloty Cultivar:

The western direction showed a higher *D. livia* egg population, with 1252 eggs in 2020 and 928 in 2021 (Table 2). Also, Fig. 2, demonstrates that the western-south side was the most favored for egg deposition over both seasons, where pomegranate plants displayed angles of 27°10'58" (2020) and 27°11'01" (2021) **.**

Table 1: Monthly average number of *Deudorix livia* eggs in cardinal directions and center on Manfaloty pomegranate cultivar during 2020 and 2021 growing seasons**.**

Inspection Date	**Avg. Egg No.(per 5 branches/ ten trees/direction /week)**									
	2020					**2021**				
	North	**South**	**Est**	**West**	**Centre**	**North**	**South**	**Est**	**West**	**Centre**
April	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May	0.50	3.00	5.00	11.25	0.25	3.25	4.50	7.50	12.00	1.00
June	15.50	20.50	15.50	33.50	8.75	10.00	15.00	25.25	24.50	4.50
July	7.50	7.50	6.25	7.50	3.75	0.00	0.00	0.00	0.00	0.00
Auguste	4.75	4.25	9.00	10.75	2.00	0.00	0.00	0.00	0.00	0.00
September	21.75	27.25	34.25	41.50	12.75	4.75	6.75	9.25	10.00	0.00
October	41.25	55.25	70.75	87.25	27.50	56.50	73.25	108.25	129.75	27.75
November	35.00	40.25	63.50	88.00	27.25	24.25	38.50	54.75	55.75	18.50
December	9.75	16.00	32.00	38.25	7.50	0.00	0.00	0.00	0.00	0.00
Average Year	**15.11** $^{cd\#}$	**19.33** ^{bc}	**26.25** ^{b}	**35.33** ^{a}	**9.97** ^{d}	**10.97** ^{cd}	**15.33** ^{bc}	**22.78** ^{ab}	**25.78** ^{a}	**5.75** ^{d}
F value	**10.69** **					**9.22** **				
Two seasons Average	**N=13.04** ^{cd}		**S=17.33** ^{c}			**E=24.51** ^{b}	**W=30.56** ^{a}		**C=7.86** ^{d}	
F value of Two seasons	**19.11** **									

*= significant at 0.05 level of probability, **= highly significant at 0.01 level of probability, and ns= Nonsignificant
#Averages that have the same letter in each row are not significant at 0.05 level of probability, according to Duncan's multiple range test.

Table 2: Expected eggs at cardinal directions preferred in pomegranate Manfaloty cultivar.

Season	**North**	**South**	**East**	**West**	**Total**	**Mean**	**F1**	**F2**	**Cos**	**Tan. Q**	**H**	**Site***
2020	544	696	945	1252	3437	859.25	152	307	0.96	1.94	548.0	27º10´58"
2021	395	552	820	928	2695	673.75	108	157	0.97	1.41	290.0	27º11´01"

***Site= The angle of site was obtained by using Google Earth app.,:** Google Earth

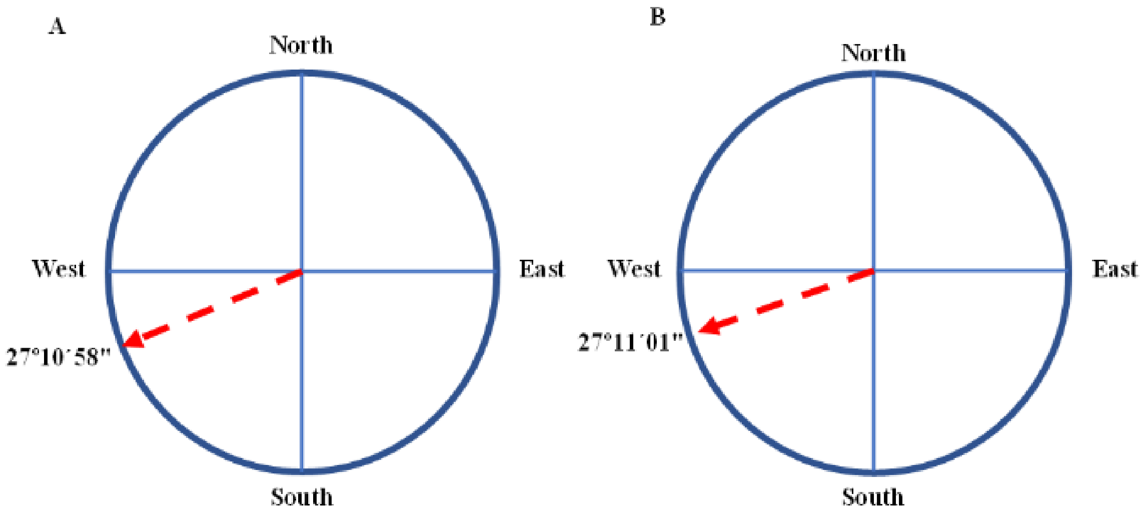


Fig. 2: Directional preference of *D. livia* eggs on Manfaloty pomegranate, 2020 (A) and 2021 (B), cultivated in Assiut University Experimental Farm of Faculty of Agriculture, Assiut University, Assiut, Northern Upper Egypt**.**

2. Spatial distribution patterns of predatory insects collected by a yellow sticky trap on the pomegranate Manfaloty cultivar:

The predatory insect's data showed the presence of 11 insect species categorized into 8 genera, 5 families, and 5 orders, including: *Austrocnemis maccullochi* (Tillyard), *Coccinella undecimpunctata* (Linnaeus), *Cydonia vicina isis* Crotch, *C. vicina nilotica* (Mulsant), *Rodolia cardinalis* (Mulsant), *Scymnus interruptus*(Goeze), *S. suturalis* Thunberg, *S. syriacus* Marseul, *Chrysoperla carnea* (Stephens), *Camponotus maculatus* Fabricius, and *Syrphus corollae* Fabricius.

2.1. Distribution of Predatory Insects Collected by Yellow Sticky Traps at Cardinal Directions and Center:

Table 3, presents the monthly average predatory insect counts collected via yellow sticky traps at cardinal and central sites on Manfaloty pomegranate trees during the 2020 and 2021 growing seasons. Statistical analysis reveals no significant directional differences in predator numbers ($F = 1.68^{ns}$). The highest average count (5.06 predators) occurred in the west direction during 2020, followed by east (4.78), south (4.17), centre (4.00), and north (3.72). While the 2021 growing season, showed statistically significant variation in the predator abundance average across different directions (F = 6.14**). The north had the highest average (14.58), while the center, east, south, and west recorded 13.00, 12.69, 11.39, and 6.69, respectively.In Figure 3A, the predator collection percentages in 2020 peaked at 23% in the west, followed by 22% (east), 19.2% (south), 18.4% (center), and 17.1% (north). In contrast, the highest predator percentage in 2021 was 25% in the north. Followed by the center (22.3%), east (21.8%), south (19.5%), and west (11.2%) (Fig. 3 B).

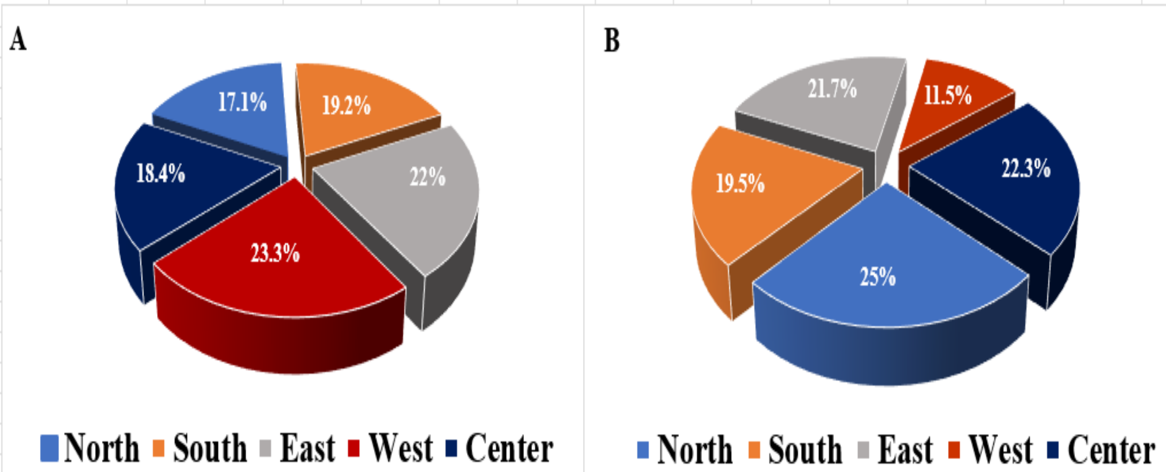
Analysis across the two seasons showed a significantly higher average predator count in 2021 compared to 2020 (F = 2.37*). In both years, the highest average predator numbers were observed in the north, followed by the east, center, south, and west, with respective averages of 8.81, 8.49, 8.21, 7.53, and 5.81 Table 3).

Table 3: Monthly average number of predatory insects collected by yellow stick traps in cardinal directions and center on Manfaloty pomegranate cultivar during 2020 and 2021 growing seasons.

Inspection Date	Avg. Predatory Insects No. (one trap/ one trees/direction/week)									
	2020					2021				
	North	South	Est	West	Center	North	South	Est	West	Center
April	1.50	6.00	6.00	5.00	2.75	15.75	9.44	6.50	6.25	5.00
May	3.00	4.50	5.75	5.50	3.25	5.25	3.25	4.50	5.75	5.50
June	1.50	3.00	2.50	3.75	3.00	2.75	4.00	3.00	2.50	3.75
July	2.75	1.75	3.25	3.00	1.50	1.00	1.25	2.19	3.81	2.75
August	6.00	6.00	10.50	7.25	10.50	13.50	15.50	6.00	10.50	7.25
September	5.75	5.00	4.75	6.50	6.00	25.00	42.25	5.00	4.75	6.50
October	9.00	5.25	5.00	7.00	4.50	45.25	16.00	5.25	5.00	7.00
November	4.00	6.00	5.25	7.50	4.25	21.75	8.25	6.00	5.25	7.50
December	0.00	0.00	0.00	0.00	0.25	0.75	3.50	0.00	0.00	0.00
Average Year #	**3.72$^{b\ \#}$**	**4.17^{ab}**	**4.78^{ab}**	**5.06^{a}**	**4.00^{ab}**	**14.58^{a}**	**11.39^{b}**	**12.69^{a}**	**6.69^{a}**	**13.00^{a}**
F value	**1.68^{ns}**					**6.14****				
Two seasons Average	**N=8.81^{ab}**		**S=7.53^{ab}**		**E=8.49^{a}**		**W=5.81^{b}**		**C=8.21^{a}**	
F value	**2.37***									

*= significant at 0.05 level of probability, **= highly significant at 0.01 level of probability, and ns= Nonsignificant

#Averages that have the same letter in each row are not significant at the 0.05level of probability, according to Duncan’s multiple range test.



Fi g. 3: The directional contribution of predatory insects captured via yellow sticky traps in the Manfaloty pomegranate cultivar during 2020 (A) and 2021 (B).

2.2. Preferred Spatial Distribution in Cardinal Directions for Predatory Insects Collected by Yellow Sticky Traps on the Pomegranate Manfaloty Cultivar:

Table 4, reveals that the western direction recorded the highest predator count in 2020 (182 predators), whereas the northern direction had the highest count in 2021 (525 predators). Figures 4A and B show that predator preference shifted from the southwestern side in 2020 to the northeastern side in 2021, corresponding to the angles of 27°10'54" and 27°11'02", respectively. Predator density varied spatially across the two growing seasons, potentially influenced by abiotic or other unidentified factors.

Table 4: Expected predatory insect collected by yellow sticky traps at cardinal points preferred in pomegranate Manfaloty cultivar.

Season	North	South	East	West	Total	Mean	F1	F2	Cos.	Tan Q	H	Site*
2020	134	150	172	182	638	159.5	16	10	0.87	0.625	23.02	27°10´54"
2021	525	410	457	241	1633	408.25	115	216	0.98	1.88	389.12	27°11´02"

*Site= The angle of site was obtained by using Google Earth app.,: Google Earth

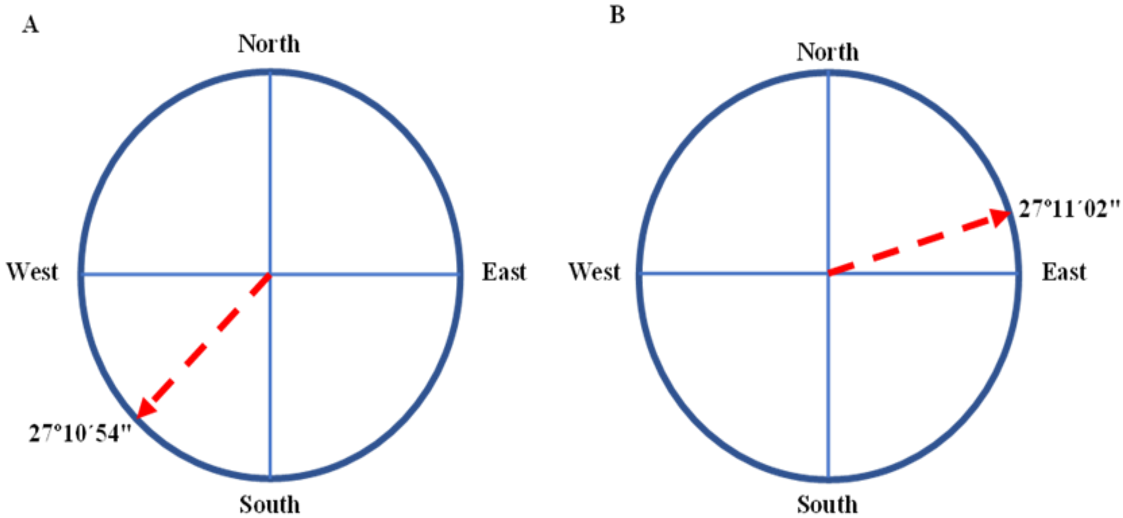


Fig. 4: Directional preference of predatory insects collected by yellow sticky traps on Manfaloty pomegranate cultivar during the 2020 (A) and 2021 (B) growing seasons at the Assiut University Experimental Farm in Northern Upper Egypt.

DISCUSSION

Globally, numerous studies have explored insecticide-based management strategies for the pomegranate butterfly *Deudorix livia* (Klug) in pomegranate orchards. Due to the extensive and irrational use of pesticides in pomegranate orchards, fruits contain residual levels exceeding international safety standards, and the lack of natural biological control agents, especially predatory insects, destabilizes pest populations.

By elucidating the spatial dynamics of *D. livia* and its predatory insects, this can provide a foundation for developing integrated pest management (IPM) strategies that minimize reliance on chemical pesticides. Thus, the present study contributes to deep understanding the ecological interactions within pomegranate insect pests in Upper Egypt. The results indicate a clear spatial distribution pattern for *D. livia* eggs on the Manfaloty pomegranate cultivar, with a significant preference for the western and western-south sides of the orchard. This spatial preference could be attributed to variations in agroclimatic factors, as suggested by **Mahmoud (1981), Hassan (1998), and El-Sheikh and El-Kenway (2020)**.

The lower egg counts in the northern and central areas may be related to fruit characteristics and oviposition site selection, aligning with the findings of Mokhtar and Al Nabhani (2016), who reported that *D. livia* egg distribution depends on the ovipositing females' site selection decisions.

The significant differences in egg counts between the two seasons suggest that environmental factors play a crucial role in *D. livia* population dynamics.

The spatial distribution of predatory insects collected by yellow sticky traps varied between the two seasons. In 2020, there were no significant differences in predator distribution among the directions, while in 2021, the north direction had a significantly higher predator count. This variation may be due to differences in abiotic factors or other unknown variables. The preferred location for predators also varied between the two seasons, with the southwestern side being preferred in 2020 and the northern-east side in 2021. The spatial distribution patterns of both *D. livia* eggs and predatory insects have significant implications for pest management. Targeted control measures, particularly in the western and western-south areas for *D. livia* and depending on the year for predators, could improve the efficacy of integrated pest management (IPM) strategies. This knowledge meliorates the decision-making in applying the best integrated management strategy to combat such a dangerous pest, *D. livia*. Inconclusion, this information about the spatial distribution of predatory insects in pomegranate orchards is the first studied and considered in the present work .

CONCLUSION

This study offers valuable spatial insights into *Deudorix livia* egg distribution and predatory insects within Manfaloty pomegranate orchards in Assiut Governorate across two growing seasons. The consistent preference of *D. livia* for western and particularly southwestern oviposition sites, likely driven by environmental factors like sunlight or wind, highlights the importance of oviposition direction sites for targeted pest management. The inter-annual variation in egg counts suggests climatic influence on pest pressure. These spatial patterns underscore the potential of concentrating IPM efforts in western orchard areas to reduce pesticide use and environmental impact. Future research should quantify the effects of specific natural enemies and evaluate the IPM tactics, like habitat manipulation and biological control, on the target insect pest. Advanced spatial analysis can further refine our understanding of pest and natural enemy distributions to achieve high-quality pomegranate production.

List of Abbreviations

Abbreviation	Full name
AUBCU	Assiut University Biological Control Unit
IPM	Integrated Pest Management
NOBCA	Naturally Occurring Biological Control Agents

Declarations:

Ethics Approval and Consent to Participate: This study has been granted by the Research Ethics Committee of Faculty of Agriculture at Assiut University in accordance with Egyptian laws and university guidelines for the care of animals (approval no. 03-2025-0026).

Authors Contributions: Conceptualization, Farouk A. Abdel-Galil, Gaber H. Abou-Elhagag, Mohammad Allam and Ahmed M. M. Ahmed; Methodology, Sara E. Mousa; Formal analysis and investigation, Ahmed M. M. Ahmed and Sara E. Mousa; Software, Farouk A. Abdel-Galil, Mohammad Allam, and Sara E. Mousa; writing, review and editing, Gaber H. Abou-Elhagag, Mervat A. B. Mahmoud, Gehad N. Aboulnasr, and Sara E. Mousa; All authors have read and agreed to the published version of the manuscript.

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ARABIC SUMMARY

التوزيع المكاني لحشرة *Deudorix livia* والحشرات المفترسة المصاحبة لها على صنف الرمان المنفلوطي بمحافظة أسيوط

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تسبب حشرة أبي دقيق الرمان، *Deudorix livia* (Klug) (Lepidoptera: Lycaenidae) أضرارًا جسيمة لثمار الرمان، مما يؤدي إلى خسائر كبيرة في المحصول. يؤثر ذلك بشكل مباشر على الجدوى الاقتصادية لزراعة الرمان. يعد دراسة التوزيع المكاني لتلك الآفة والحشرات المفترسة لها أمرًا حيويًا لتطوير استراتيجيات إدارة الآفات الفعالة والمستدامة والصديقة للبيئة في بساتين الرمان. لذلك، هدف العمل الحالي إلى دراسة أنماط التوزيع المكاني لبيض الآفة والحشرات المفترسة في بساتين رمان صنف منفلوطي بمحافظة أسيوط خلال موسمي النمو (2020 و2021م).

أشارت النتائج إلى أنه بالنسبة لبيض الآفة، لوحظ أن متوسط الأعداد أعلى بشكل ملحوظ في الاتجاه الغربي عبر كلا الموسمين. بينما كان الجانب الغربي الجنوبي هو موقع وضع البيض الأكثر تفضيلاً. كشف التحليل الإحصائي عن اختلافات كبيرة في توزيع البيض بين الاتجاهات الأصلية. أظهرت الحشرات المفترسة، التي تم جمعها باستخدام المصائد اللاصقة الصفراء، توزيعات مكانية متباينة بين الموسمين. في عام 2020، أظهر الاتجاه الغربي أعلى الأعداد من المفترسات، بينما في عام 2021، كان الاتجاه الشمالي هو المهيمن. كانت الاتجاهات المفضلة للحشرات المفترسة هي الجانب الجنوبي الغربي والجانب الشرقي الشمالي في عامي 2020 و2021م على التوالي.

لذا فإن الدراسة الحالية توضح أهمية بيانات التوزيع المكاني في تمكين إدارة الآفات بدقة عالية. وتحديد مناطق تركيز تجمعات الآفة ومواقع الحشرات المفترسة لها، ويسهل التدخلات الهادفة، وبالتالي تعزيز فعالية برامج الإدارة المتكاملة للآفات (IPM) وتقليل استخدام المبيدات الحشرية غير الضرورية.

الكلمات المفتاحية :أبي دقيق الرمان، الحشرات المفترسة، التوزيع المكاني