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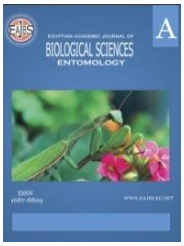

Reducing Attacks of the Oriental Hornet, *Vespa orientalis* L. (Hymenoptera: Vespidae) on Apiaries Using Targeted Attractant Baits

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ABSTRACT

This study focused on evaluating strategies to manage *Vespa orientalis* L., a social hornet species known for causing significant harm to apiaries. The efficacy of three bait types: citronella oil solution, pollen solution, and a pollen substitute solution, sugar solution as a control was assessed. The experiments were conducted in two apiaries located in Kafr El-Sheikh and Giza governorates, Egypt from October to December. Trapped hornets were collected twice weekly, and baits were replaced accordingly. The findings revealed that hornet populations peaked in October, decreased in November, and diminished completely by December. Citronella oil solution emerged as the most effective bait, capturing averages of 97 and 60.44 hornets in Kafr El-Sheikh and Giza, respectively. Pollen solution ranked second, attracting 58.56 and 32.11 hornets, while the sugar solution captured 30.44 and 16.44 hornets. The pollen substitute solution was the least effective, attracting only 27.56 and 10.67 hornets. The results highlight Citronella oil solution as a highly effective method for attracting *Vespa orientalis* inside the traps, offering a promising approach for protecting bee colonies.

INTRODUCTION

The oriental hornet (*Vespa orientalis*) known for its aggressive predatory behavior, which often disrupts the natural balance of pollinator populations especially honey bee colonies (Mihai and Adrian, 2021; Paolo *et al*., 2024; Smith-Pardo *et al*., 2024 and Fouad *et al*., 2021). They catch honeybee foragers, capture bee guards at hive entrances, and may even enter honeybee hives to carry off larvae, pupae, honey, pollen, and adults. This weakens the hives and reduces the bees' productivity (Matsuura, 1988). Due to its ecological and agricultural impact, researchers have focused on understanding the population dynamics of *Vespa orientalis* across different seasons to develop effective management strategies. Nests of *V. orientalis* may be located subterraneously or in crevices of rocks or walls, or beneath the roofs of manmade buildings (Smith-Pardo *et al*., 2020). *V. orientalis*, similar to other species within its genus, exhibits strong social behavior. Colonies began with a mated queen emerging from hibernation, following a colony cycle in North Africa and the Middle East

that typically spans from mid to late April until the end of November, but a few workers and males may occasionally last into December. Mating flights occur from October to November, with fertilized queens entering hibernation sites by the end of November (Archer, 1998; Taha, 2014).

The use of baited traps with specific attractants has emerged as a crucial tool for monitoring and controlling hornet populations. These traps rely on the hornet's attraction to chemical cues such as pheromones, food odors, or sugar-based baits. Several studies have demonstrated the efficacy of these traps in capturing hornets and reducing their numbers, especially during periods of high activity. According to Leza *et al*. (2018) highlighted the importance of attractants that mimic natural food sources in increasing trap efficiency, particularly during the hornet's active foraging season. The seasonal abundance of *Vespa orientalis* populations is influenced by various environmental factors, primarily temperature, humidity, and the availability of food resources. Studies have shown that hornet activity peaks during the warmer months, coinciding with increased foraging and reproductive behaviors. For instance, Mahfouz & Abd Alfattah, (2022) reported a positive correlation between high temperatures and the activity levels of *Vespa orientalis*, emphasizing that temperature thresholds play a critical role in governing the hornet's lifecycle. On the other hand, low temperatures in winter months significantly reduce activity, leading to a decline in trap captures during this period. Humidity also plays a substantial role in influencing hornet populations. Research by Monceau *et al*. (2015) indicated that optimal humidity levels enhance the effectiveness of baited traps by maintaining the attractants' potency and appealing to hornets in search of water or sugary substances. Additionally, the availability of food resources, such as ripening fruits or exposed food waste, contributes to seasonal variations in hornet abundance. Baited traps have proven invaluable for analyzing population trends of *Vespa orientalis* and their relationship with environmental factors. Studies have utilized these traps to assess the effectiveness of attractants and monitor seasonal fluctuations.

This study aims to evaluate strategies to manage *Vespa orientalis* L., which known for causing significant harm to apiaries. The efficacy of four bait types: citronella oil solution, pollen solution, and a pollen substitute solution, sugar solution as a control was assessed. The experiments were conducted in two apiaries located in Kafr El-Sheikh and Giza governorates, Egypt from October to December .

MATERIALS AND METHODS

Experimental Sites:

The current study's sites were located in Bee Research Department, Plant Protection Research Institute, Agricultural Research Center, Egypt, in Kafr El-Sheikh (Sakha branch) and Giza (Dokki branch) governorates, during Autumn season from October to December.

Hornet Traps:

The traps consisted of a wooden body with dimensions 36×28×10 cm covered by a wire screen (33×16 cm) that allows bees to pass through. The baits are placed in a drawer at the bottom of the trap as shown in Figure 1.

Fig. 1: The hornet trap.

Attractant Baits:

Four attractant baits were used as follows:

1- Citronella oil solution (250 µl + 50 mL sugar solution (1:1 sugar: water) /trap)
2- Pollen solution (5 grams + 50 mL sugar solution /trap)
3- Pollen substitute solution (5 grams + 50 mL sugar solution /trap). The ingredients ratio for Pollen substitute were chickpea flour (154g), wheat germ (154g), dried brewer's yeast (62g), sugar powder (315g), bees honey (251 mL) and water (64 mL), according to **(**Younis, 2019).
4- Sugar solution (50 mL sugar solution (1:1 sugar: water)/trap) as a control.

Field Experiments:

Each sampling site had twelve monitoring traps and four types of baits (three for each trap-bait combination). The traps were randomly placed around the experimental apiary in each site from the first week of October to the last week of December. The traps and baits were all set on the same day (October 1st). The baits were placed in the morning and replaced twice a week, and the captured hornets were counted before emptying the traps.

Statistical Analyses:

Obtained data was analyzed using Proc. ANOVA in SAS computer program (Anonymous. 2003). Means separation was conducted using LSD in the same statistical program at $P \leq 0.05$.

RESULTS

Results obtained in Table 1 & Figure 2, provide insights into the trapped hornets by using four attractant baits in Kafr El-Shiekh region. Mean numbers of trapped hornets were 97, 58.56, 27.56 and 30.44 hornets for citronella oil solution, pollen solution, pollen substitute solution and sugar solution, respectively. The data clearly showed that the Citronella Oil traps significantly captured the highest number of hornets, followed by pollen traps. While the sugar solution and pollen substitute traps captured the lowest number of hornets without significant differences between them. Also, the results illustrated that highly significant differences among the hornet population peaked with an average of 92.08 in October, followed by 59.08 and 9 in November and December, respectively.

Table 1. Mean numbers of trapped hornets in Kafr El-Shiekh region by using different attractant baits during experimental period.

Month	Citronella oil solution	Pollen solution	Pollen substitute solution	Sugar solution	Average
Oct	149±8.14	93.67±4.81	60.67±4.8	65±2.65	92.08a
Nov	127±5.51	67.67±3.28	19.33±2.3	22.33±2.96	59.08b
Dec	15±1.15	14.33±1.45	2.67±0.33	4±0.58	9c
Average	97a	58.56b	27.56c	30.44c	

Means followed by the same letter don't differ significantly at the 5% level of probability.

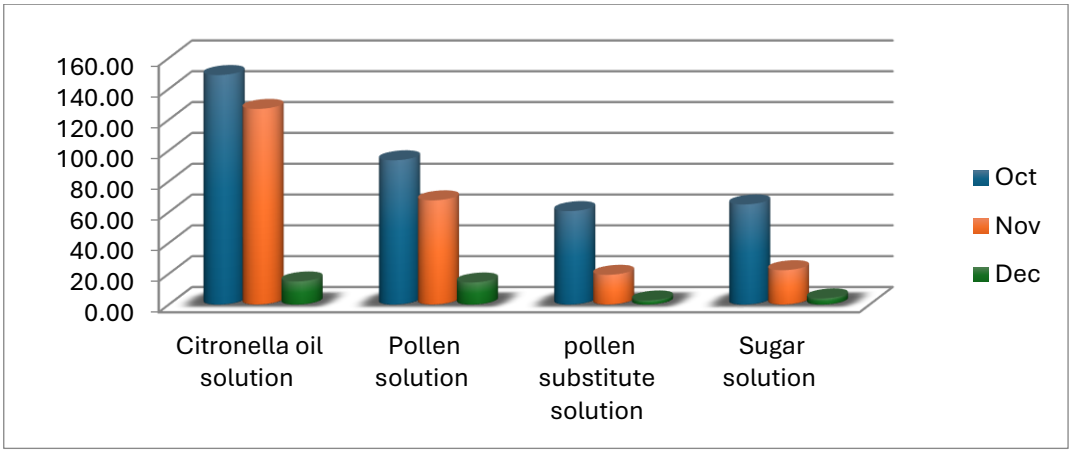

Fig 2. Mean numbers of trapped hornets in Kafr El-Shiekh region with different baits.

Data obtained in Table 2 & Figure 3, showed that, the mean numbers of the captured hornets by using four attractant baits in Giza region, which were 60.44, 32.11, 10.67 and 16.44 hornets for citronella oil solution, pollen solution, pollen substitute solution and sugar solution, respectively. The data confirmed that Citronella Oil traps were significantly captured the highest number of hornets, followed by pollen solution traps. While, the sugar solution and pollen substitute solution traps were captured the lowest number of hornets without significant differences between them. Also, the results illustrated that, highly significant differences among hornet population peaked with an average of 55.67 in October, followed by 32.42 and 1.67 in November and December, respectively.

Table 2. Mean numbers of trapped hornets in Giza region by using different attractant baits during experimental period.

Month	Citronella oil solution	Pollen solution	Pollen substitute solution	Sugar solution	Average
Oct	100.67±5.78	63.67±3.67	21.67±1.20	36.67±2.33	55.67a
Nov	77.33±2.96	31±3.79	9.67±1.45	11.67±1.20	32.42b
Dec	3.33±0.88	1.67±0.67	0.67±0.33	1±0.58	1.67c
Average	60.44a	32.11b	10.67c	16.44c	

Means followed by the same letter don't differ significantly at the 5% level of probability.

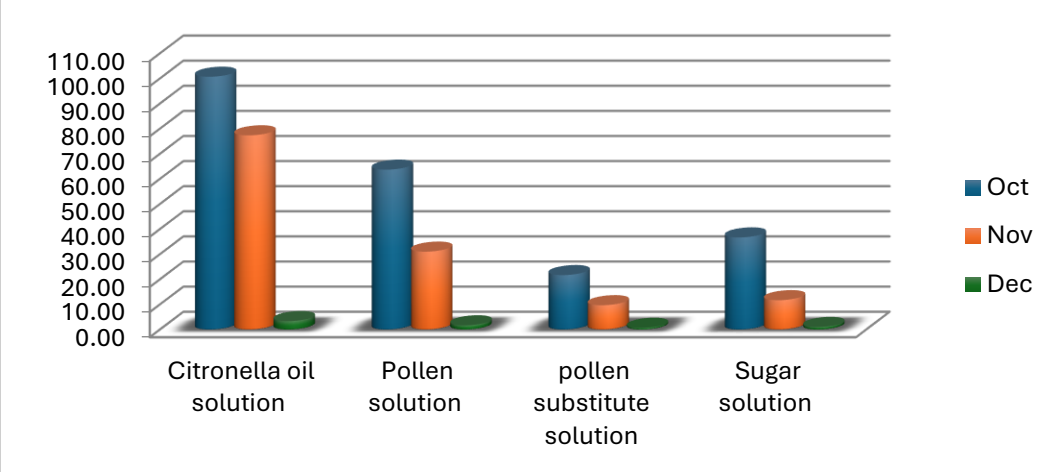

Fig. 3: Mean numbers of trapped hornets in Giza region with different baits**.**

DISCUSSION

From these results we found that the highest hornet population captured inside the traps was in October followed by November in the two regions, In December we found that the hornet gradually decreased until disappeared completely (Gomaa and Abd Elwahab, 2006; Khodairy and Awad, 2013; Taha, 2014; Younis *et al*, 2016). The highest population of hornets was collected from Kafr-Elsheikh region, while Giza region was the lowest one, this can be explained by the difference in climatic changes between them, which indicated that there was a positive correlation between the population dynamic of oriental hornet and the climatic changes (Mahfouz and Abd Alfattah, 2022). Galushko *et al*. (2005) mentioned that oriental hornets are most active during the hottest part of the day. Furthermore, because *V. orientalis* is the only hornet species capable of using sun radiation to produce energy, its activity behavior is different from what occurs in the other hornet species. Due to their pigments' ability to absorb and convert sunlight into energy.

On the other hand, it is clear from the previous results that the Citronella oil solution was the best to attract the oriental hornets followed by the pollen solution, while the pollen substitute solution and sugar solution gave the lowest results. To explain the high attraction rate of hornets to citronella oil, perhaps it’s because citronella oil contains Citral substance (Nakahara *et al.*, 2013), which is also found in Nassanoff pheromone secreted by foraging honeybee workers (Shearer & Boch, 1966). It is obvious that the hornets were attracted to the traps searching for bees inside them. While, the least attractant bait was the pollen substitute solution which recorded the lowest mean numbers of captured hornets, because it is fermented rapidly than other baits. In conclusion, the use of baited traps not only offers insights into the fluctuations of the population dynamics of *Vespa orientalis* but also serves as a cornerstone for integrated pest management strategies. Further research is necessary to refine attractant formulations, optimize trap designs, and explore the interaction between environmental variables and hornet behavior. By integrating scientific findings with practical applications, sustainable solutions for managing *Vespa orientalis* populations can be developed to protect honey bee colonies and maintain ecological balance.

Finally, the study concluded that citronella oil is effective bait for controlling oriental hornet populations in apiaries.

Declarations:

Ethical Approval: Not applicable.

Authors Contributions: Mohamed Younis (Conceptualization, Methodology, Data curation, Writing – review & editing, submission for publication), and Amro Taha

(Conceptualization, Methodology, Writing – review & editing). All authors reviewed drafts of the article and approved the final draft.

Competing Interests: The authors declare that they have no competing interests.

Availability of Data and Materials: The data supporting the study are included in the manuscript.

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ARABIC SUMMARY

تقليل هجمات الدبور الشرقي *Vespa orientalis* L. (Hymenoptera: Vespidae) على المناحل بإستخدام طعوم جاذبة مستهدفة.

محمد سمير يونس*[1] وعمرو احمد طه [2،1]

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[2]: محطة الأبحاث والتدريب، جامعة الملك فيصل، ص.ب 400، الأحساء 31982، المملكة العربية السعودية.

ركزت هذه الدراسة على تقييم إستراتيجيات إدارة الدبور الشرقي، وهو نوع من الدبابير الاجتماعية المعروفة بإحداث ضرر كبير للمناحل. تم تقييم فعالية ثلاثة أنواع من الطعوم : محلول زيت السترونيلا، ومحلول حبوب اللقاح، ومحلول بديل حبوب اللقاح، والمحلول السكري للمقارنة. أُجريت التجارب في منحلين يقعان في محافظتي كفر الشيخ والجيزة بمصر في الفترة من أكتوبر إلى ديسمبر. وتم جمع الدبابيرمرتين أسبوعيًا مع استبدال الطعوم وفقًا لذلك. وكشفت النتائج أن أعداد الدبابير بلغت ذروتها في أكتوبر ثم انخفضت في نوفمبر ثم تضاءلت تمامًا بحلول ديسمبر. وبرز محلول زيت السترونيلا باعتباره الطُعم الأكثر فعالية، حيث اصطاد في المتوسط 97 و60,44 دبورا في كفر الشيخ والجيزة على التوالي، واحتل محلول حبوب اللقاح المركز الثاني حيث اجتذب 58.56 و32.11 دبورا، بينما اجتذب المحلول السكري 30.44 و16.44 دبورا. كان محلول بديل حبوب اللقاح هو الأقل فعالية، حيث اجتذب 27,56 و10,67 دبورا فقط. تسلط النتائج الضوء على محلول زيت السترونيلا باعتباره وسيلة فعالة للغاية للسيطرة على مجموعات الدبور الشرقي في المناحل مما يوفر نهجا واعدا لحماية طوائف النحل.

الكلمات المفتاحية: الدبور الشرقي، المصيدة، الطعوم الجاذبة، نحل العسل.