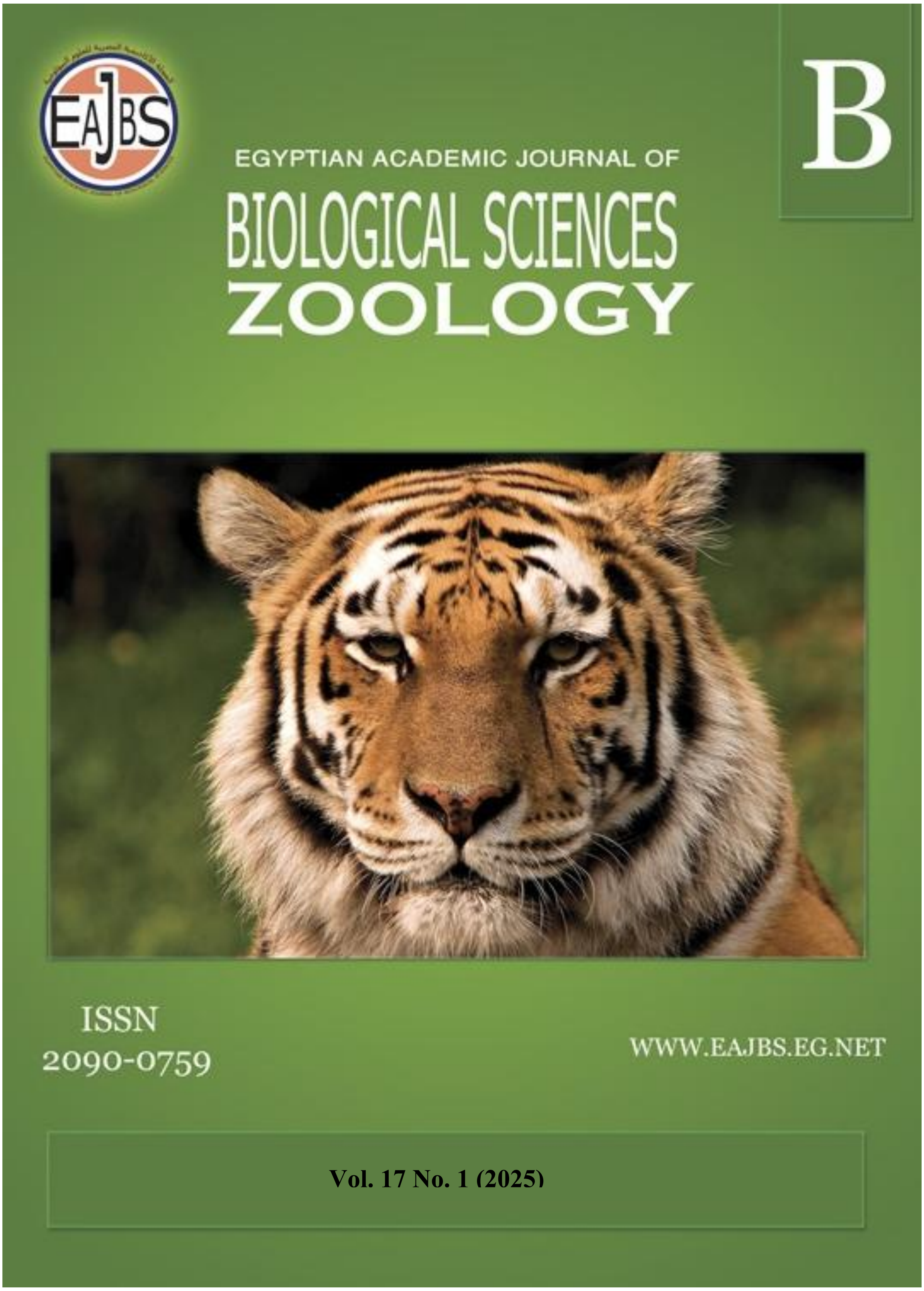

Citation: *Egypt. Acad. J. Biolog. Sci. (B. Zoology) Vol. 17(1) pp:281-287 (2025)*
DOI: 10.21608/EAJBSZ.2025.426417

Egypt. Acad. J. Biolog. Sci., 17(1):281-287(2025)
Egyptian Academic Journal of Biological Sciences
B. Zoology
ISSN: 2090 – 0759

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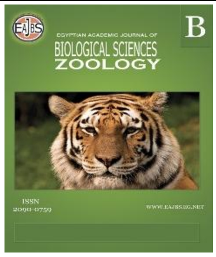

Field Evaluation of Certain Chemicals against the White-Bellied Rat, *Rattus rattus frugivorus* in Mango Orchards (*Mangifera indica*) at Qena Governorate, Egypt

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ARTICLE INFO

Article History
Received:3/4/2025
Accepted:7/5/2025
Available:11/5/2025

Keywords:
White-bellied rat, *Rattus rattus frugivorus*, Rodent control, mango orchards, Qena.

ABSTRACT

The white-bellied rat (*Rattus rattus frugivorus*) poses a significant threat to mango orchards, causing substantial damage to fruits, bark, and branches throughout the growing season. Effective rodent control measures are essential to minimize economic losses and maintain crop health. This study evaluated the efficacy of three compounds Zinc Phosphide, Methomyl, and Bromadiolone by analyzing their impact on bait consumption and rodent population reduction in mango orchards located in El-Nagahia village, Nag Hammadi district, Qena Governorate. Weekly bait consumption, both plain and poisoned, was recorded before and after treatment to assess the effectiveness of each rodenticide. Results indicated that before treatment, the highest weekly plain bait consumption was observed in the Zinc Phosphide group (305.68 g/week), followed by Methomyl (288.12 g/week), the untreated control (265.52 g/week), and Bromadiolone (235.53 g/week). After treatment, the untreated control group exhibited the highest weekly plain bait consumption (412.50 g/week), while treated groups showed a significant decline. Methomyl recorded the highest weekly poisoned bait intake (219.60 g/week in the second week and 145.77 g/week in the third week), followed by Zinc Phosphide and Bromadiolone. Population reduction rates were highest with Zinc Phosphide (81.24%), followed by Methomyl (74.13%) and Bromadiolone (44.90%). The findings highlight the severe impact of *R. rattus frugivorus* on mango production and underscore the effectiveness of Zinc Phosphide and Methomyl in controlling rodent populations. The highest bait consumption occurred in the first treatment week, suggesting that early intervention is critical for effective control.

INTRODUCTION

Fruits play a crucial role in the human diet by providing essential nutrients, including vitamins, minerals, complex carbohydrates, proteins, lipids ،and antioxidants, all of which are necessary for maintaining overall health (Hayes, 2005; Rossato *et al*., 2009). Mango (*Mangifera indica* L.) is India's most prominent fruit crop and is often referred to as the "king of fruits." In addition to its delightful taste, appealing flavor, and pleasant aroma, mango is a rich source of Vitamin A and Vitamin C. Moreover, the tree is known for its resilience and requires relatively low maintenance costs (Verma *et al*., 2021). Rodents considered as one the most important pest in Egypt. That caused great economic loss to farmers, damage in the orange and mandarin orchards. (Dongol *et al*. 2021). In addition, they can transmit zoonotic pathogens responsible for significant human morbidity and mortality around the world (Feng and Himsworth, 2013). Rats (Genus: *Rattus*) are among the most widespread and successful invasive species, found on all continents except Antarctica

(Morand *et al*., 2015). In urban environments, their presence is often linked to poor socioeconomic conditions, inadequate waste disposal, open sewage systems, overcrowding, and other structural factors that provide food and shelter opportunities (Langton, 2001). The roof rat (*Rattus rattus*), also known as the citrus rat, fruit rat, black rat, or gray rat, is considered one of the most destructive rodent pests. It consumes and contaminates stored food supplies, damages fruit crops, and frequently nests in attics, soffits, hollow walls, and outbuildings. When infesting buildings, these rats can chew through electrical wires posing a fire hazard gnaw on plastic and lead water pipes, create holes in walls, and inflict structural damage (Kern, William H. Jr., 2012). Managing roof rats is challenging and requires an integrated pest management (IPM) approach. This strategy involves various methods, including inspection, cultural control (habitat management and prevention), physical control (trapping and exclusion), biological control (using predators), and, when necessary, chemical control through rodenticides and repellents (Kern, William H. Jr., 1997). The most widely used method for rodent control is poison baiting, as rodenticides are widely accessible, relatively simple to use, and can provide an effective and cost-efficient solution. Acute toxicants like zinc phosphide have proven successful in mitigating rat damage. However, challenges such as bait avoidance, the need for extensive pre-baiting procedures, and risks to non-target species may limit their continued use. Conversely, chronic poisons, specifically anticoagulants, have gained widespread adoption due to their effectiveness and relatively lower risk. This strategy has been instrumental in reducing and managing rodent populations. Nevertheless, resistance to anticoagulants has been observed in regions such as Europe and the United States due to prolonged and improper application (Jackson *et al*., 1988). Therefore, it is essential to determine the optimal toxicant dosage and the most effective delivery method for efficient rodent control. Rodenticides are expected to remain a key component in managing rodent-related agricultural damage (Buckle, 1999; Wood & Fee, 2003). Ensuring the effective management of pests that damage mango fruits is crucial for producing marketable yields. Consequently, this study aims to identify successful strategies for controlling major mango fruit pests, including rodents.

MATERIALS AND METHODS

Study Area:

This study was carried out in four fields cultivated with mango the experimental in EL-Nagahia village, Nag Hammadi district, Qena Governorate. Qena Governorate is one of the governorates of Upper Egypt, located approximately 600 kilometers south of the capital, Cairo. EL-Nagahia village is located in Nag Hammadi district, Qena Governorate, at latitude 26.0496°N and longitude 32.2412°E. It lies on the western bank of the Nile River, between the cities of Nag Hammadi and Farshut (Fig. 1). The rodents captured during the study were carefully transferred to the laboratory for further examination and species identification. The identification process was conducted following the classification criteria described by Osborn and Helmy (1980), ensuring accurate determination of the rodent species present in the mango orchards.

The Chemicals Used in The Current Study:

1-Acute Poison (Zinc Phosphide ®):

Active ingredient (Common name): Zinc phosphide.
Molecular Formula: Zn_3P_2
Compound type: Rodenticide
Chemical group: Inorganic compound

2-Chronic Poison (Super caid 0.005% ®):

Active ingredient (Common name): Bromadiolone
Molecular Formula: $C_{30}H_{23}BrO_4$
Compound type: Rodenticide
Chemical group: Anticoagulant

3-Insecticide (Lannate 90 % ®)

Active ingredient (Common name): Methomyl
Chemical structure: $C_5H_{10}N_2O_2S$
Compound type: Insecticide
Chemical group: Carbamate

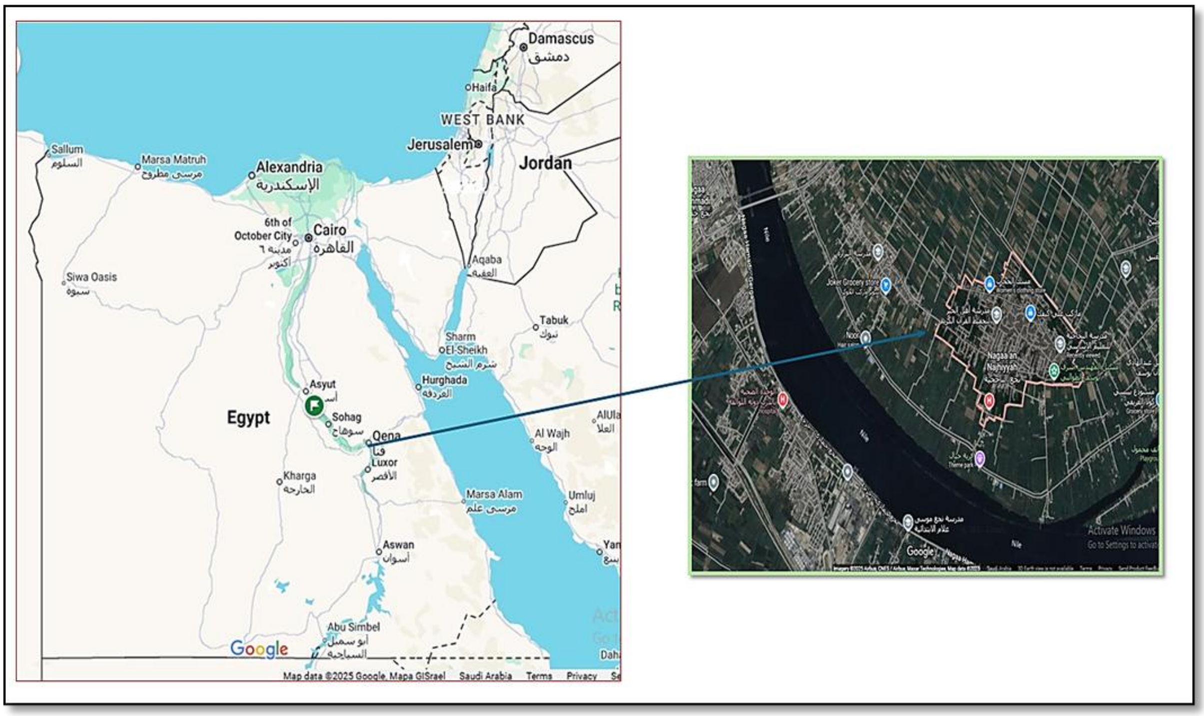

Fig. 1. shows the field experiment area.

Study of the Effect of Certain Compounds Against the Climbing Rat in The Field:

The efficacy of two rodenticides (zinc phosphide at a 2% concentration and Super Caid ready-made bait with sound wheat at 0.005%) and one insecticide (Lannate 90% at a 2% concentration) was evaluated based on food consumption (using wheat bait) before and after treatment. Each rodenticide was tested in an area of 2 feddans, where twenty plastic stations were used for four consecutive weeks—the first and fourth weeks were untreated, while the second and third weeks were treated. The stations were placed at 10-meter intervals along rodents' pathways. Meanwhile, another 2-feddan area was left untreated as a control. The reduction in rodent food consumption was estimated according to Pelz and Klemann (2004) by using the following equations:

$$\text{Reduction (\%)} = \frac{\text{W1} - \text{W2}}{\text{W1}} x100$$

Where:
W1= weight of the food consumption pre- treatments.
W2= weight of the food consumption post- treatments.
Data were analyzed according to standard procedures for analysis of variance Duncan's (1955) and (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Significant damage to mango orchards was observed, including severe destruction of bark stripping, and branch deterioration caused by rodent activity. Upon laboratory identification, the dominant rodent species responsible for these damages was confirmed to be *R. rattus frugivorus*, which belongs to the family Muridae, suborder Myomorpha, and order Rodentia (Fig. 2.). The data presented in Table (1) indicate that the highest weekly consumption of plain bait before treatment was recorded for Zinc Phosphide (305.68 g/week), followed by Methomyl (288.12 g/week), the untreated control group (265.52 g/week), and Bromadiolone (235.53 g/week). After treatment, the highest weekly consumption of plain bait was observed in the untreated control group (412.50 g/week), followed by Bromadiolone (129.78 g/week), Methomyl (74.55 g/week), and Zinc Phosphide (57.34 g/week). Regarding poisoned bait consumption, Methomyl recorded the highest weekly intake (219.60 g/week and 145.77 g/week in the second and third weeks, respectively), followed by Zinc Phosphide (211.08 g/week and 130.65 g/week) and Bromadiolone (175.61 g/week and 156.32 g/week) (Figs. 3 and 4). The results demonstrate that the highest reduction in rodent populations was achieved using Zinc Phosphide (81.24%), followed by Methomyl (74.13%) and Bromadiolone (44.90%).

Fig. 2. *Rattus rattus frugivorus* captured in a mango orchard, identified as the primary rodent species causing damage during the study.

Table 1. Effectiveness of certain chemical compounds against *Rattus rattus frugivorus* and reduction percentage based on food consumption before and after treatment.

Chemical controls	Before treatments	Time of treatments		After treatments	Reduction %
		1st week	2nd week		
Untreated (control)	265.52	302.61	360.02	412.50 a	–
Zinc phosphide	305.68	211.08	130.65	57.34 d	81.24**
Methomyl	288.12	219.60	145.77	74.55 c	74.13**
Bromadiolone	235.53	175.61	156.32	129.78 b	44.90*

Means within each column followed by the same letter are not significantly different (P = 0.05) according to Duncan's multiple range test.

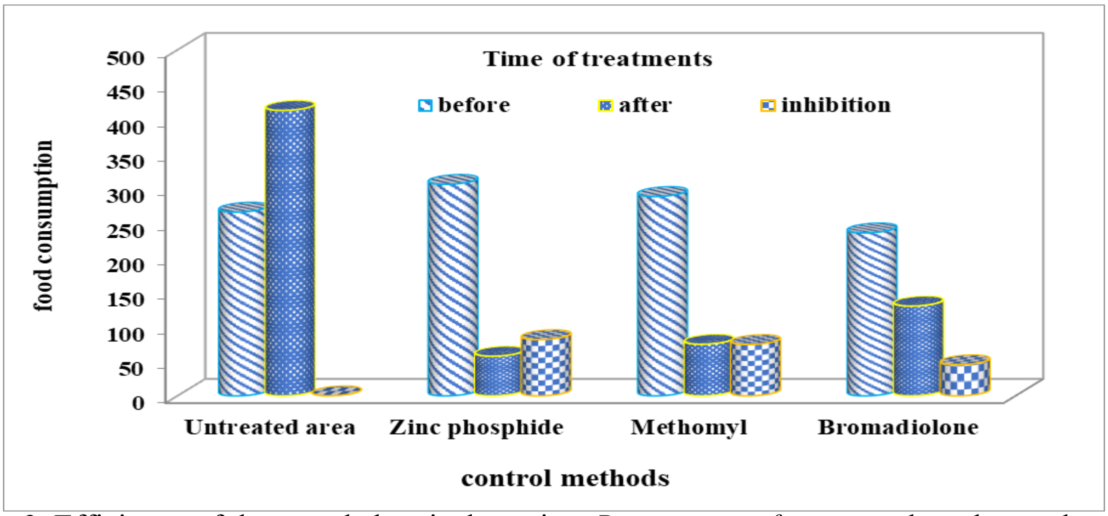

Fig. 3. Efficiency of the tested chemicals against *Rattus rattus frugivorus* based on reduction in food consumption before and after treatment.

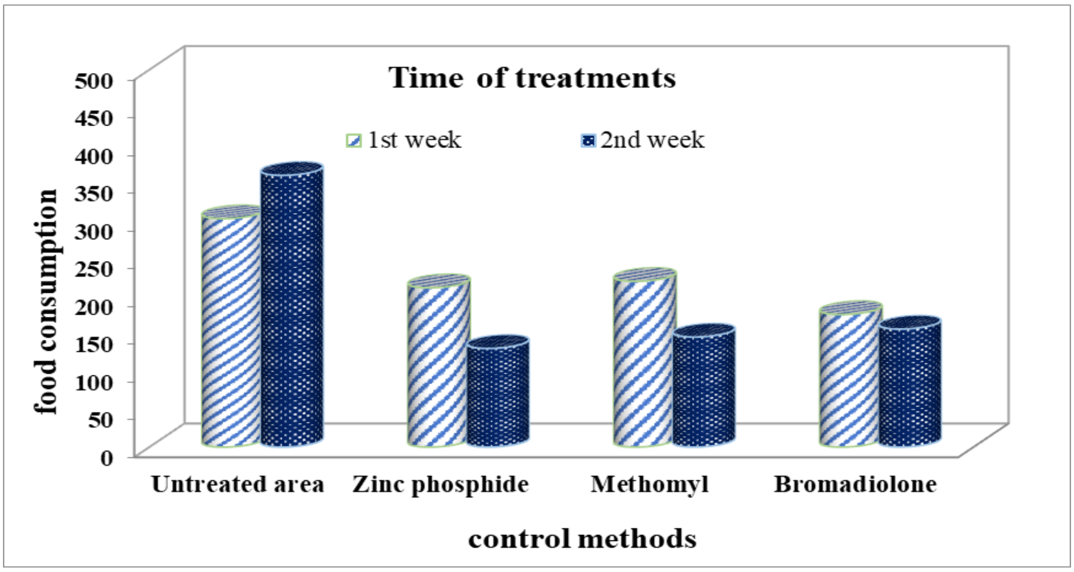

Fig. 4. Weekly bait consumption of various compounds under field conditions in a mango orchard at Qena governorate.

These findings align with those of Baghdadi (2012), who reported that the estimated protection indices for rodenticides indicated a statistically significant reduction when using Zinc Phosphide (67%), followed by PPD (63%), while Super Caid achieved an intermediate reduction rate of 52%. These results are consistent with the findings of Baghdadi and Desoky (2021), Elrawy (2021), Metwally *et al*. (2011), Desoky (2013), Baldwin *et al*. (2014), Kandil and Ahmed (2017), and Ahmed *et al*. (2019). These results, however, conflict with those of Saber (2017), who found that the most significant decrease in Rattus norvegicus populations occurred when Super Caid 0.005% was used (79.98% and 46.04%), followed by Zinc Phosphide 2% (51.85% and 36.51%) and Zinc Phosphide 3% (67.6% and 32.15%) both inside and outside buildings, respectively. These findings also differ from those reported by Maher and Abdel-Gawad (1982).

Conclusion

Considerable harm inflicted by the white-bellied rat (*Rattus rattus frugivorus*) was noted in mango orchards in El-Nagahia village, Nag Hammadi district, Qena Governorate. The rats targeted mango fruits, bark, and branches during the entire growth cycle, from planting to harvest. The use of zinc phosphide and methomyl demonstrated high efficacy in suppressing the white-bellied rat population in the study area. Notably, the rats consumed a higher amount of bait during the first week of treatment compared to subsequent weeks. Rodent control effectiveness depends on factors such as locality, neighboring environments, and food availability. Therefore, integrating these control measures into an Integrated Pest Management (IPM) program can effectively regulate rodent population density.

Declarations:

Ethical Approval: This study follows the ethics guidelines of Al-Azhar University, Assiut Branch, Egypt.

Competing interests: The author states that there are no competing interests to declare.

Author's Contributions: AE conceived and carried out the experiments, wrote the draft of the manuscript, and analyzed the data. HI, SA and NA organized the data, supervised, and reviewed the manuscript. The final manuscript was read and approved by both Authors.

Funding: No funding was received from any agency.

Availability of Data and Materials: The datasets utilized and analyzed during this investigation are available upon reasonable request from the corresponding author.

Acknowledgements: This work was supported by the Faculty of Agriculture, Al-Azhar University and Agricultural Research Center, Plant Protection Research Institute, Giza, Egypt.

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