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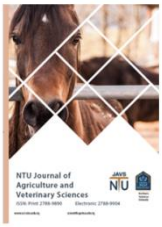

# The Spatial Analysis and Dispersal of the Greater Wax Moth *(Galleria Mellonella* L.) in Apiaries of Some Central and Southren Iraqi Provinces.

1st Raja malik khlaf [1] 2nd Muslim Ashor Al-etby [2]
1,2. Department of Plant Protection, College of Agriculture, University of Basrah, Iraq.

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**Corresponding author:**
Name: Muslim Ashor Al-etby
Affiliation : University of Basra
Email: muslim.abdel_wahed@uobasrah.edu.iq

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**A B S T R A C T**

This study was an attempt to investigate the prevalence of the greater wax worm, *Galleria mellonella* L., in some provinces of central and southern Iraq Study period from 23\11\2023 to 22\11\2024( Babylon, Karbala, Wasit, Qadisiyah, Maysan and Basra). The survey results showed that The pest prevalence was varied in the provinces, as the highest infection percentage in Basra province was reached 73.33%, and the lowest in Maysan province reached 10.67%. It is significant to mention that Maysan province was also distinguished by having strong hives at a percentage of 81.7%, while Basra had the lowest level of strong hives at 30.3%. The methods of controlling the insect also was differed in the provinces that were subject to the study. The effective methods of controlling the pest that proved their worth in reducing the numbers of the pest and eliminating it were burning frames and dusting frames , and also dusting warehouses with dusting discs every two weeks. Besides, the method of freezing frames for two days is a very successful method for eliminating the different insect roles of the pest. Daily follow-up is also one of the crucial practices for early detection of the pest, whether in the apiary or the storehouse, to take appropriate measures at the beginning of the insect's activity and before it spreads in the apiary and storehouse.

## Introduction

First of all, honey bees are one of the most significant living organisms in the environment, playing a crucial role in the global economy. Honey bees contribute to pollination and increase agricultural production.[1] Because they are one of the most effective means of natural pollination of plants. Honey is also considered one of the most outstanding food products because it is a natural source of sugars, vitamins, minerals and antibiotics. It is used in many food products and other industries, which leads to the generation of notable economic revenues. Honey bees have a reliable economic role through cross-pollination of trees to improve their physiological properties, as the increase in production is not less than 25% [1].

Besides, honey bees are exposed to non-infectious diseases such as poisoning and exposure to high temperatures or extreme cold, Moreover, they are vulnerable to serious dangers caused by agricultural pesticides that play a major role in reducing the number of honey bee colonies.[2] Honey bee colonies are also open to attack of many pests such as parasites and diseases. Among the diseases that affect honey bee hives that target brood and adults are viral diseases such as cysts and paralysis, or bacterial diseases such as American and European brood bacteria, and fungal diseases such as calcification and petrification.[2] There are parasites that affect honey bee hives and cause great damage, which is the Varroa parasite.[3] Honey bee adults are also exposed to predation by bee-eaters and red wasps. Among the Al-Samara, most important economically important insect pests that affect honey bee hives are the greater and lesser wax worms [2]

In addition, the greater wax worm *Galleria mellonella* L. (Pyralidae: Lepidopter) is one of the most prominent insect pests that infect honey bee colonies.[4] It causes great losses to stored beeswax, and causes the greatest damage to apiaries and material losses every year. Also, it brings damage to bee hives by feeding larvae and destroying frames and other wooden parts in the apiary. The adults and larvae of the greater wax worm transmit pathogens that cause serious diseases to bees, such as Foulbrood, which harms the bee colony [3], [4].

Furthermore, an insect attacks the empty wax frames containing pollen of the honey bee *Apis mellifera* L. inside the hives, especially the weak ones, in addition to digging into the wood from which the frames are made and the wax blocks inside the stores, along with the silk threads secreted by the larvae that hinder the movement of the bees inside the hive [5]. The wax worm infects the wax combs, as its larvae feed on the wax of the frames and the honey and pollen they contain, and the tissue they leave behind that destroys the honey, in addition to its remains of molting skins and waste that leads to the destruction of the honey bee hive. The damage caused by this insect hinders the process of raising honey bees, and it even leads to deterioration and the failure of any future vision to develop the apiaries for the better by increasing the number of its hive. It even leads to a reduction in the number of hive due to the migration of bees from them and leaving the hives infected with this insect and expelling the remaining bees in them [4],[6], [7].

It is significant to refer to the losses attributed to the pest invasion in the southern United States which were estimated at about $3-4 million in 1973 and 1976, respectively, which represents about 3.9% and 5.1% of the profits in the two years, respectively. In Florida and Texas, under tropical climatic conditions, approximately $5 and $1.5 per colony were recorded, respectively. In 1997, in Iran, the cumulative economic losses due to the greater wax moth were estimated at 38%. The greater wax moth was first discovered in colonies of the Asian honey bee *Apis cerana* and later spread to North Africa, Britain, parts of Europe, North America, and New Zealand. Williams and Shimanuki made it clear that the greater wax moth appears wherever there are honey bee hives, especially in areas with long summers [8] .The pest has been confirmed in 27 African countries, 9 Asian countries, 5 countries in North America, 3 countries in Latin America and Australia, 10 European countries and 5 islands. Although there are currently areas free of this pest, a recent case study conducted in Kenya predicted, using a model of software algorithms, its future spread. It is likely that areas where honey bee pests do not appear due to environmental factors that are unfavorable to their life will become a suitable geographical area for their spread once the appropriate environmental conditions are available for them [9].

**Figure 1**. International Distribution of *Galleria Mellonella* GBLF - 2023

Spatial distribution is a study of items by analyzing and examining their features and evaluating them by studying the locations, attributes and relationships that reveal the geographical features of the data. It uses a set of mathematical equations and analytical techniques to link geographical information together, and study the extent of its impact on individuals. The geographic coding of locations and their identification using modern technologies such as satellites and GPS services makes available a huge amount of digital information that can be used in scientific research to know the location of an organism [10] .It is notable to mention that natural geographical factors, vegetation cover, human factors and economic activities affect the distribution of honey bee hives and their associated pests, including the greater wax worm *Galleria mellonella* [11],[12].

## Materials and Methods

**field survey**

Data information was collected about the study areas represented by the provinces covered by the study period from 23\11\2023 to 22\11\2024 (Babylon, Karbala, Qadisiyah, Wasit, Maysan and Basra) by collecting research, reports and statistical data published in scientific journals. A questionnaire form was distributed to obtain the required data, as it was distributed to beekeepers in the provinces under the study with the help of the agricultural departments of those provinces by using the survey method for the most important apiaries in those provinces for the year 2023-2024 Which can be identified by the distinctive location that enjoys the presence of vegetation of perennial or annual flowering plants throughout the year.. The availability of a good breed of honey bees and the number of cells in the apiary also play an important role in the importance of the apiary, as does the beekeeper's experience and sufficient information in managing the apiary and his experience in dealing with the problems that he may encounter. The apiary, in addition to sufficient knowledge of the pests that affect bees and how to treat them. The survey procedures also reviewed the agricultural departments of the provinces designated for the study. The Internet was used to obtain spatial information for the locations of the apiaries. Personal interviews were carried out with beekeepers, direct observations and examination of hives to diagnose infected and healthy hives.

The questionnaire form for the infection with the greater wax worm *Galleria mellonella* was distributed to the agricultural departments, which in turn distributed to the most prominent apiaries infected with the wax worm and which were reported. It included the following information: Location of the apiary (Province, District and Quarter), the total number of hives, the number of infected hives and healthy hives, the strength of the hives, the date of infection, the apiary infection recurrence years , the infection type, whether it is in the apiary or the storage frames, and the procedures followed to combat it.

**Table 1.** shows the GPS location of the apiaries in the governorates included in the study**.**

| GPS | District | Province |
|---|---|---|
| "28.8'41°32N<br>44°25'01.6"E | Mahaweel | Babylon |
| "27.3'45°32N<br>44°14'06.2"E | musayiab | |
| 32°38'54.0"N<br>43°58'28.9"E | Al-hur | Karbala |
| 37.9'40°32\"N<br>44°09'52.9"E | Al-husainiya | |
| 32°09'50.2"N<br>44°55'48.3"E | Daghara | Qadisiya |
| 31°58'41.8"N<br>44°53'40.4"E | Diwaiya | |
| 31°49'44.3"N<br>44°56'41.6"E | Al-sidair | |
| 32°03'07.2"N<br>45°15'55.8"E | Afach | |
| 32°33'39.0"N<br>45°48'20.9"E | Al-ahrar | Wasit |
| 32°10'19.6"N<br>46°03'18.1"E | Al-hay | |
| 32°54'42.0"N<br>45°03'44.6"E | Al-aziziya | |
| 33°02'22.5"N<br>44°51'15.3"E | Al-siwaira | |
| 31°51'02.2"N<br>47°06'58.9"E | Al-emara | Maysan |
| 31°52'57.4"N<br>47°07'55.7"E | Kahla | |
| 31°30'47.5"N<br>46°46'08.8"E | Maymoona | |
| 30°25'58.6"N<br>47°52'58.5"E | Abi al-khaseeb | Basrah |
| 30°41'23.5"N<br>47°49'20.5"E | Shatt al-arab | |
| 30°42'17.6"N<br>47°44'29.1"E | Hartha | |
| 31°07'03.2"N<br>47°18'02.1"E | Mdaina | |
| 31°01'06.2"N<br>47°25'09.6"E | Qurna | |
| 30°48'02.7"N<br>47°34'33.1"E | Dair | |

The incidence percentage of the pest in the mentioned provinces was also calculated using the following equation**:**

$$\%\ \text{Infection} = \frac{\text{Number of infected hive}}{\text{Total number of hive}} X\ \%100$$

The strength of the hives was calculated according to the Kasper equation with some modifications.

$$\text{Overall Infection \%} = \frac{\text{umber of hive examined X Infection degree}}{\text{Total number of hive X Infection}} X\ \%100$$

A scale was created where the hives were classified within ranges as in the table below:

**Table 2.** displaying a scale for classifying hive within certain ranges.

| | Degree of Infection of Moth larvae Cells | Infection |
|---|---|---|
| 1 | Completely healthy hive (zero larvae) | 0 |
| 2 | Very weakly infected hive (1-3) larvae | 1 |
| 3 | Weakly infected hive (4-9) larvae | 2 |
| 4 | Mode percentage infected hive (10-15) larvae | 3 |
| 5 | Heavily infected hive (16-20) larvae | 4 |
| 6 | Very severely infected hive (21-30) larvae | 5 |

Sufficient information was also obtained for the control methods Table 3 followed by beekeepers, represented by preventive and therapeutic methods in each province to control the greater wax worm *Galleria mellonella*. The GENSTAT program was used in the statistical analysis at the 5% level.

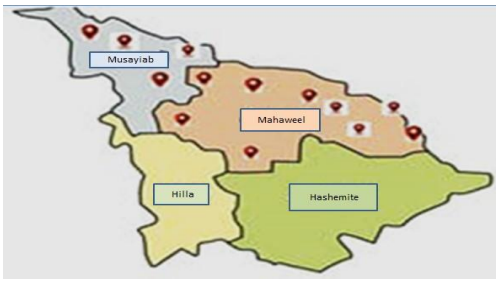
## Results and Discussion

Spatial Distribution of the Wax Worm

*G.mellonella*

The results of the spatial survey of the distribution of the greater wax worm *G. mellonella* in the provinces that were subject to the study and according to the following maps that reflect the concentration of infection in the apiaries in those Province s, where the location symbol indicates the areas of the pest's spread in the apiaries distributed in the districts and sub-districts of the Province s in addition to the Province centers, as follows:

The infection with *G. mellonella* in Babylon Province included Al-Mahawil and Al-Musayyab as in Map 1.




**Map 1.** Distribution of G. mellonella Infections in Babylon Province.

The infection with *G. mellonella* in Karbala Province included Al-Khairat District, Al-Hur District, Al-Hindiya District, and Al-Jadwal Al-Gharbi District, as displayed in Map 2.


**Map 2.** bring to light the spread of *G. mellonella* in Karbala Province

Figure 2 depicts that the highest infection rate in Ali Al-gharbi, as indicated in table was 87%, while the lowest infection rate in Al-Hur District was 22%. The reason may be due to the periodic follow-up by beekeepers and the attention paid to the hives, and the beekeepers following effective control methods to reduce the rates of infection with the pest and deter its harm, and getting rid of the infected frames by burning them and eliminating the various insect stages, or by the freezing method, which is effective in eliminating all stages as well.

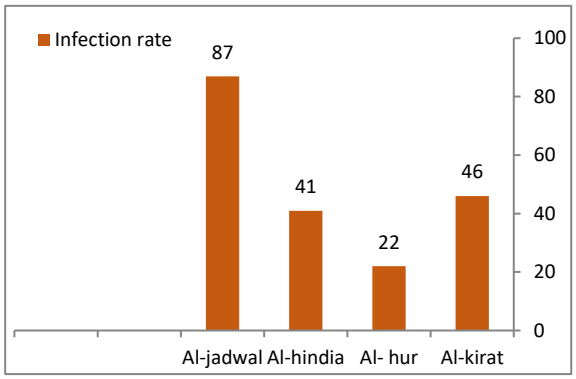
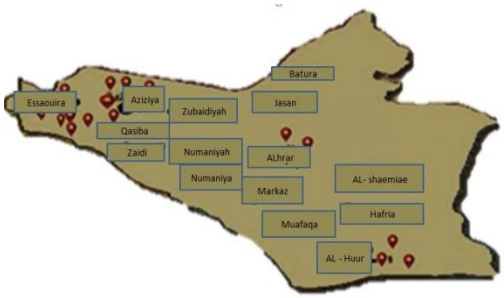



**Figure 2**. bring to light the spread of G. *mellonella* in Karbala Province.

Map 3. exhibited the locations of the spread of the G. mellonella insect in the apiaries of Wasit Province, with a large spread of the pest in Al-Ahrar District, Al-Hay District, Al-Suwaira District, Kasiba District, and Al-Aziziyah District. The percentages of infection with the pest varied from one district to another.

Figure 3. brought to light that the highest infection rate was in Al-Suwaira, 65%, while the lowest infection rate was in Al-Aziziyah, 24%. The reason may be due to the periodic follow-up by beekeepers and their attention to the hives, and the beekeepers' use of effective control methods to reduce the rates of infection with the pest and deter its damage, and getting rid of the infected frames by burning them and eliminating the various insect stages, or the freezing method, which is effective in eliminating all stages as well, or the method of replacing the infected frames with healthy frames.




**Map 3**. demonstpercentage the spread of *G. mellonella* in Wasit Province.

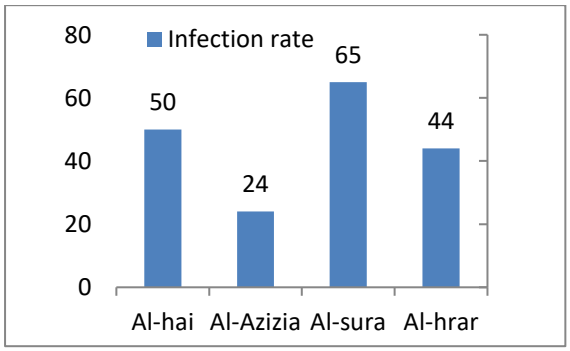
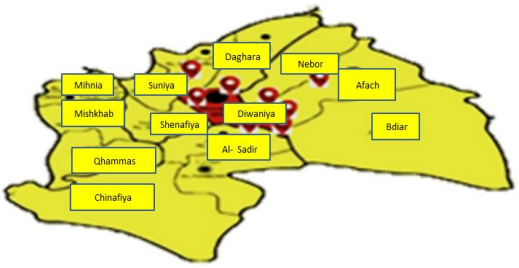



**Figure 3.** demonstpercentage the spread of *G. mellonella* in Wasit Province **.**

Map 4 presented the locations of the apiaries where the wax worm G. mellonella is spread in Al-Qadisiyah Province, including the city center of Diwaniyah, Afach District, and Al-Daghara District**.**

Figure 4 disclosed that the highest infection rate was in Diwaniyah Center, 77%, while the lowest infection rate was in Al-Daghara, 26%. The reason may be due to the methods used by beekeepers to reduce the rates of infection with the pest, deter its damage, and get rid of infected frames by freezing the frames to eliminate the various insect roles, or by the method of fumigating the frames and fumigating the stores with one of the fumigation discs, or replacing infected frames with healthy ones.




**Map 4.** reveal the spread of *G. mellonella* in Al-Qadisiyah Province**.**

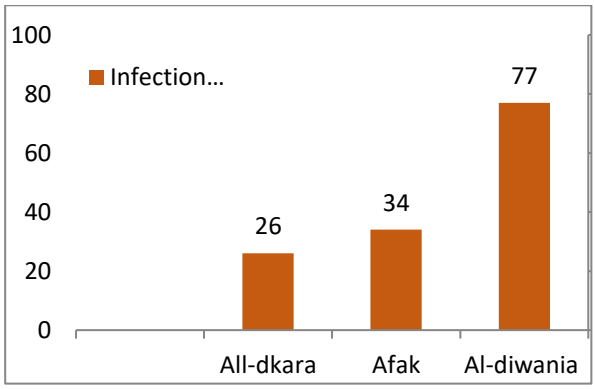
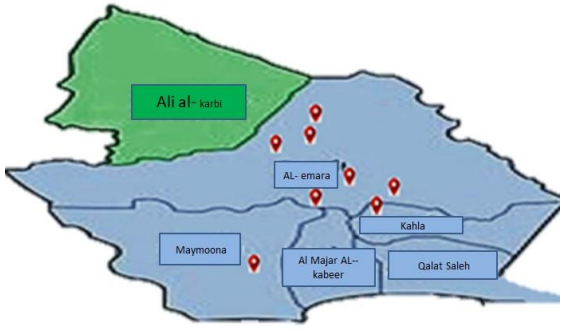



**Figure 4.** reveal the spread of *G. mellonella* in Al-Qadisiyah Province**.**

As for Maysan Province, Map 5 made it claer that the pest spread in the apiaries located in Al-Emara District, Al-Maymoona District, Kumait District, and Al-Kahla District.

As for Maysan Governorate, Map 5 revealed the spread of the pest in the apiaries located in Al-Amara District, Al-Maymouna District, Qumit District and Al-Kahla District. Figure 5 shows that the highest infection rate was in Al-Maymouna Center, 45%, while the lowest infection rate was in Qumit, 21%. The reason may be due to the methods followed by beekeepers to reduce the rates of infection with the pest, deter its harm, and get rid of infected frames by burning them to eliminate the various insect roles, or by fumigating frames and warehouses with one of the fumigation discs, or replacing infected frames with healthy ones.




**Map 5**. present the spread of *G. mellonella* in Maysan Province.

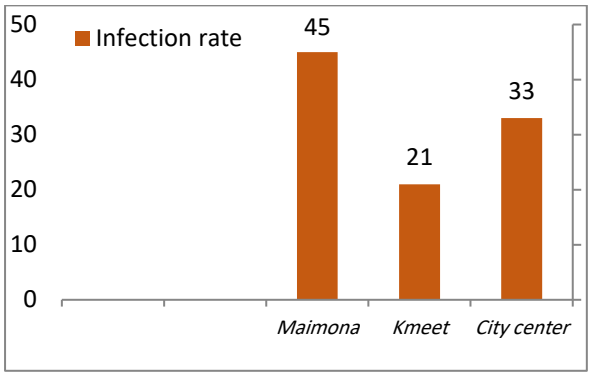
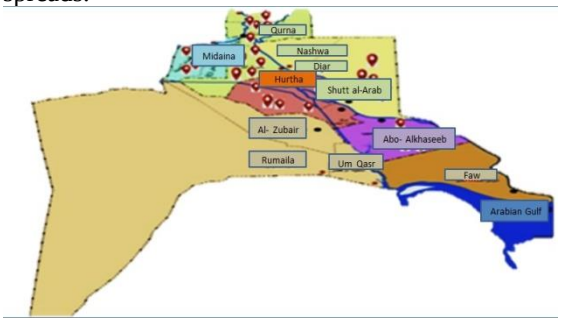



**Figure 5.** present the spread of *G. mellonella* in Maysan Province.

The results made it clear that the spread of the pest in Basra Province, as depicted in Map 6, was very wide, including the districts of Shatt al-Arab, Abi Al-Khaseeb, Al-Qurna, Al-Hartha, Al-Nashwa and Al-Madina.

Figure 6 shows that the highest infection rate in Shatt al-Arab district was 54%, while the lowest was in Al-Hartha 16. The reason may be due to the methods followed by beekeepers to reduce the rates of infection with the pest, deter its damage, and get rid of the infected frames by burning them to eliminate the various insect roles, or by dusting the frames with one of the dusting discs, or by freezing the frames to get rid of all insect roles, or by adopting the method of manually cleaning the frames from the pest larvae. Periodic follow-up of beekeepers is also one of the most important methods for early detection of infection and taking proactive measures to combat the insect before it spreads.




**Map 6.** show the spread of *G. mellonella* in Basrah Province.

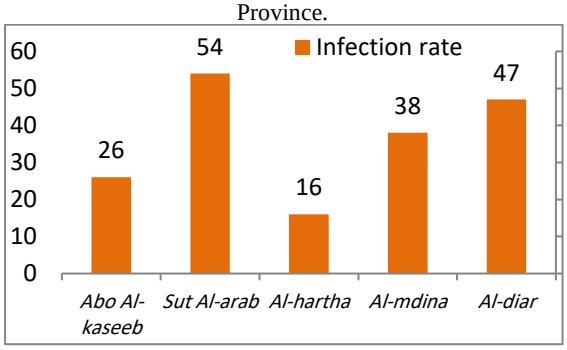



**Figure 6.** show the spread of *G. mellonella* in Basrah Province.

## Infection Percentage in Apiaries

The results of the Pearson Correlation between the strength of the hive and the infection percentage in the Provinces that were studied showed that it was 0.80 - that the relationship between them is a strong inverse relationship 0.80 - where the stronger the hive, the lower the infection percentage in it, as expressed in figure 7 that the infection percentage in Maysan Province was the lowest Province , reaching 10%, followed by Karbala, Qadisiya, Babylon, Wasit and Basrah Provinces, where the percentages were 38%, 42%, 50%, 63%, 70% respectively, and the strength of the hives also showed variations, where the strength of the hives in Maysan Province reached the highest percentage of 83%, then Karbala, Qadisiya, Babylon, Wasit and Basra, where it reached 44%, 37%, 33%, 32%, 26% respectively. The results showed that there are significant differences in the infection percentage between the Province s, as Basra Province topped the highest infection percentage of 73.33, followed by Wasit Province with 63, and the lowest infection percentage was in Maysan Province with 10.67. There were no significant differences between Babylon, Karbala and Qadisiya Provinces. The results also showed significant differences in the strength of the hive, as Maysan Province recorded the highest level of 81.7, and the lowest Province was Basra Province with a level of 30.3. There were also no significant differences between Qadisiyah, Wasit and Karbala Provinces. The reason may lie in the fact that Maysan Province apiaries have strong bee colonies, which provide a defensive force to protect them from infection with the greater wax worm *G.mellonella*. The strength of the hive depends on vital factors such as vegetation cover, food abundance, the presence of young queens, the number of frames filled with brood, the number of foraging bees, and non-vital factors such as temperature, as temperatures play a major role in the activity of bee colonies and the activity of foraging bees in collecting pollen and nectar. Rain is also a factor affecting the activity of bees and thus affects the strength of the hives, as it reduces the efficiency of foraging bees in collecting food. These factors combined affect the strength of the hive and the efficiency of the work of its members, as the ideal conditions for honey bee activity make the hive strong and able to protect itself from exposure to wax worm infection.

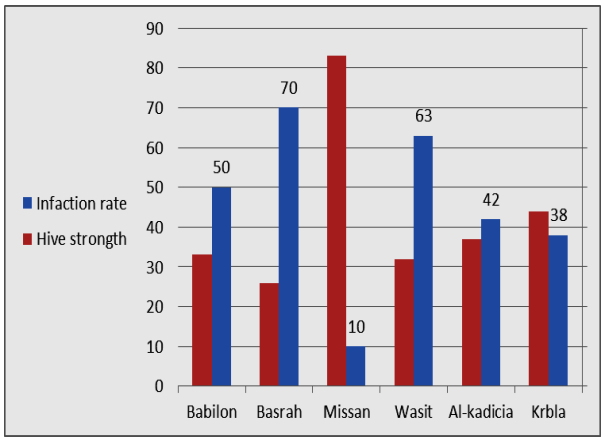



**Figure 7.** shows infection percentage and hive strength in provinces hives strength LSD = 8.56, Infection percentage LSD = 5.65**.**

Results of the study of methods used for controlling the wax worm *G. mellonella* and its impact on the infection percentage.

**Table 3.** Results of the study to investigate methods of controlling *G. mellonella* in provinces.

| Controlling Methods | | | | | | | Province |
|---|---|---|---|---|---|---|---|
| Periodical Follow up | Hand-cleaning | Using dusting discs for storehouses | Replacing frames | Using dusting discs for frames | Burning infected frames | Freezing affected frames | |
| - | + | + | - | + | - | - | Babylon |
| + | - | - | - | - | + | + | Karbala |
| - | - | - | + | + | - | + | Al - Qadisiya |
| - | - | + | + | - | - | + | Wasit |
| - | - | + | - | + | + | - | Maysan |
| + | + | - | - | + | + | + | Basra |

The methods used in combating the greater wax worm, *G. mellonella*, varied between the provinces that were subject to the study. Beekeepers in Babylon province relied on dusting the frames with dusting discs to combat it. This was done by placing the infected frames in thick plastic bags, and placing 3-4 dusting discs with them. The bag was tightly closed, as the discs would swell to emit toxic gases and kill the insect roles. Some beekeepers also dust the storehouses as a preventive control against the greater wax worm before depositing the frames inside the storehouses.

Some beekeepers also get rid of the wax worm infestation by manually removing the various insect roles of the pest from the infected frames, such as larvae, pupae, and adults, but this is an ineffective method for getting rid of the pest's eggs, as the eggs remain on the wax and are a new source of infection. As for the beekeepers of Karbala Province , some of them tend to freeze the frames, where the infected frames are placed inside a thick plastic bag, the bag is tightly closed and placed in the freezer at a temperature of (-15) Celsius Degree for 2-3 days, after which the frames are placed in the store. Other beekeepers use the method of burning infected frames to get rid of all insect roles, and some beekeepers fumigate the stores as a preventive control against the greater wax worm before depositing the frames inside the stores.

Some interested beekeepers also perform periodic follow-ups and continuous examinations of the hives and stores to avoid wax worm infections and also to detect the infection early to facilitate its control. In Qadisiya Province , some beekeepers freeze the frames, placing the infected frames inside a thick plastic bag, sealing the bag tightly and placing it in the freezer at a temperature of (-17) Celsius Degree for two days. Some beekeepers sterilize the frames when symptoms of infection appear, such as larvae, silk threads, feces, and dead and adult insects. The method of control is to dust the frames with dusting discs, by placing the infected frames in thick plastic bags and placing (3 – 4) dusting discs with them, and the bag is tightly closed, as the discs rise to emit toxic gases and kill the insect stages. Some beekeepers also replace the infected frames with new frames instead of those infected with wax worms, and the infected frames are destroyed. Some of the beekeepers in Wasit Province use the method of freezing frames, where the infected frames are placed inside a thick plastic bag, the bag is tightly closed and placed in the freezer at a temperature of (-17) Celsius Degree for two days. Some beekeepers also replace the infected frames with new frames instead of those infected with wax worms, and the infected frames are destroyed. Some beekeepers also resort to using the method of dusting the frames with dusting discs, by placing the infected frames in thick plastic bags and placing (3 – 4) dusting discs with them, and the bag is tightly closed, as the discs rise to emit toxic gases and kill the insect stages. Some of the beekeepers in Maysan province tend to burn the infected frames that show symptoms of the greater wax worm.

Some others use the method of dusting the frames with dusting discs, by placing the infected frames in thick plastic bags and placing (3 – 4) dusting discs with them, and the bag is tightly closed, as the discs rise to emit toxic gases and kill the insect stages. Other beekeepers also carry out preventive control by dusting the stores in which the frames are placed. In Basra Province , beekeepers resort to different methods, including freezing frames for (2 – 3) days to get rid of all insect roles. Some beekeepers tend to burn infested frames to get rid of the pest completely. Other beekeepers combat the wax worm by dusting the frames with dusting discs, by placing the infected frames in thick plastic bags and placing (3 – 4) dusting discs with them, and the bag is tightly closed, as the discs rise to emit toxic gases and kill the insect stages. Other beekeepers also combat it preventively by dusting the stores in which the frames are placed. Some beekeepers also get rid of wax worm infestation by

manually removing the various insect stages of the pest from the infested frames, such as larvae, pupae, and adults, but this is an ineffective method for getting rid of the pest's eggs, as the eggs remain on the wax and become a new source of infection. The low infection rate in Maysan Province may be due to the methods used to combat the pest, as methods of burning infected frames , dusting infected frames , and dusting warehouses are effective methods of combating the pest in the province.

The vegetation cover in the province provides a suitable food source for the continuity of the strength of the cells by giving pollen throughout the year, which leads to the strength of the hives. As for Basrah Province , which witnessed the highest infection rate with the pest, despite the beekeepers' reliance on many and varied methods to combat the pest, it may be becausethat the pest has been widely spread in the province for a long time and has adapted to Basra's environmental conditions. In addition, the weakness of the vegetation cover and its availability in certain seasons and the high temperatures in the province reduce the efficiency of bee colonies, weaken them, and make it a suitable environment for infection with pests.

## Conclusion

This study was a practical endeavor to investigate the extent of the spread of the greater waxworm, *G. mellonella* L., in some provinces of central and southern Iraq, namely Babylon, Karbala, Wasit, Al - Qadisiya, Maysan, and Basrah. The extent of the spread of the pest varied in the provinces, with the highest infection percentage in Basra reaching 73.33% and the lowest in Maysan province reaching 10.67%. It is significant to disclose that Maysan province was distinguished by having strong cells at a percentage of 81.7%, and Basrah had the lowest level of strong cells, reaching 30.3%. Methods of controlling the insect also differed in provinces that were subjected to the study. There were effective methods of pest control that proved their worth in reducing the number of the pest and eliminating it.

It is so through complete burning of frames and dusting frames with dusting discs. Also, dusting the warehouses with dusting disc every two weeks was another method used. The method of freezing frames for two days was a successful use for eliminating the various insect roles of the pest. Daily follow-up was taken into consideration as a practice for early detection of the pest, whether in the apiary or the warehouse, to take appropriate measures at the beginning of the insect's activity before being spread in the apiary and the warehouse.

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