



## Effect of Bee Population and Bee Venom Milking on Bee Worker's Daily Mortality and Some Physiological Characters

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**Abstract.** The current study was conducted in the apiary of the College of Agriculture & Forestry/ University of Mosul during the year results that showed the highest mean amount of bee venom for the interaction reading 0.1207 mg/colony in the treatment of milking bee population of 10 frames (TMV2) during the period from 7-12/8/2021 compared with the lowest mean interaction of 0.0067 mg/colony which was recorded during the period from 16-21/10/2021 for the same treatment. However, the highest mean interaction for the treatment of milking bee venom population was 5 frames (TMV1) during the period from 21-26/8/2021 which was 0.0810 mg /colony compared with the lowest mean of 0.0023 mg/colony during the period from 16-21/10/2021 for the same treatment. As for the treatments general mean, the highest mean was recorded in the TMV2 treatment which amounted to 0.0644 mg/colony compared with the lowest general mean of zero mg/colony in the TCM2 treatment. As for the milking treatment of TMV1, the highest mean was recorded 0.0305 mg/colony in the TMV1 treatment compared with the lowest average of zero mg/colony in the TCM1 treatment. As for the process effect of the bee venom milking on daily mortality of workers, the daily mortality was increased by 3.47 worker/day in TMV2 which recorded a mean of 6.99 worker/day compared with the TCM2 treatment which, in turn, recorded a mean of 3.52 worker/day. As for the treatments with a bee population of five frames, the daily mortality of workers was increased by 3.2 worker/day in the treatment of TMV1 treatment which recorded the lowest mean of 5.78 worker/day compared with the TCM1 treatment which recorded a mean of 2.58 worker/day. Regarding the general mean of the fat content, the statistical analysis did not show any significant differences between the two treatments TMV2 and TCM2 whose means reached 21.10 and 20.93 % respectively. As for the treatments with fat content of five frames, the highest mean was recorded in a treatment TMV1 amounting to 17.50 % compared with the lowest mean which was 15.38 % recorded in TCM1 treatment. As for the Nitrogen content in treatments with a bee population of 10 frames, the highest mean was recorded in the TMV2 treatment which amounted to 9.37 % compared with the lowest mean in the TCM2 treatment which amounted to 8.11%. The statistical analysis did not show any significant differences for the effect of milking bee venom in the Nitrogen content for the treatments with a bee population of five frames, and the highest mean was recorded in the TMV1 treatment which amounted to 7.77 % compared with the lowest mean of 7.75% which was recorded in the TCM1 treatment. As for the acidity (pH) in workers abdomen, the statistical analysis did not show any significant differences for the effect of milking bee venom in the acidity (pH) in workers abdomen for the treatments with a bee population of ten frames.

**Keywords:** bee venom, bee population, daily mortality of workers, fat content, Nitrogen content, Acidity (pH).

**Note:** The current study is a part of the PhD thesis of the researcher.

### Introduction

Honey bees have an important role in raising agricultural production. They are the best pollinating insects for field crops, vegetables and fruits, especially mixed pollinators. They also represent 67% of the total other pollinating insects and work to increase the crop yield by 30% Ashman et al. (2004). Gupta et al. (2014) & FAO (2020) declared that bee products are of great economic and medical importance, as honey and

other bee products such as wax, bee venom, propolis, royal jelly, pollen and others have great importance in the field of medicine. In addition, bees contribute in pollinating various agricultural crops by collecting pollen which helps in solving the problems of food shortages on the earth. Also, Bhalotia (2016) and Szabat et al. (2019) explained that bee venom is colorless, with a bitter taste, and a pungent aromatic odor. Its specific weight is 1.13 and its pH is 4.5-5.5. However, when exposed to air, it dries up and crystallizes at a high speed

and turns into a white powder. Sanad & Mohanny (2013) declared that the process of milking bee venom was affected by various factors including the months of the year and the time of the milking process during the day, as the best period was between four and six in the evening. Bogdanov (2016) explained that the worker bees whose ages ranged between 15-21 days are the most productive of venom, and that in one sting, about 100 micrograms of dry bee venom are released. He showed that the bees were not affected by the process of milking the venom which lasted for 3 hours a day and was repeated 3-4 times per month. Also, he showed that 1g of dry bee venom needs to be milked by 10,000 bees. Kurek-Górecka et al. (2021) and Khalil et al. (2021) added that bee venom has been widely used against infections, especially rheumatoid arthritis and multiple sclerosis, and has an effective effect against fungi, viruses and various micro-organisms. The amount of total bee venom was 0.17 and 0.20 g/colony in the month of June and for both years respectively, and that the highest quantities of milked bee venom were at 7-9 pm and that the average number of bees. The dead-day amounted to 18.7 workers in October 2014 and 24.0 workers-day was in August 2015. El-Bahnasy and others (2017) found that the factors that could be the cause of the increase in bee venom production; viz. the increase in bee population within the colonies, the degree of aggressiveness and the extent to which bees are able to benefit from food to produce venom. Sayegh (2000) explained that the highest average acidity of the rectum was in winter bees which amounted to 6.431 pH, while the lowest average acidity was 6.964 pH in spring bees. Al-Jubouri (2005) recorded that the percentage of fat content in the bodies of workers was 7.40%, and that it was raised on a sugar solution mixed with vitamins. Sanad & Mohanny (2013) found that the general mean of daily mortality of workers was 24.74 workers/day during summer. Al-Hamdani (2014) recorded that the highest average of the year for daily death workers was 40.20 workers/trap when read on 4/5/2013 with superiority of all averages during the season. AL-Abedi (2021) found that the highest Nitrogen content of the treatments was 20.77% in the Fumagill in the treatment followed by 16.88 and 13.92% in the control and menthol treatment respectively compared with the lowest average recorded in the Artemisia treatment.

## Materials and Methods

At the beginning of spring 2021, fourteen divisions of local hybrid bees were purchased from

one of the licensed beekeepers. Each swarm contained five pressurized bee population frame, and all swarms had a queen age of one year reared in 2020. After transferring the swarms to Lancasterth wooden hives, a balancing of the colonies was carried out up to obtaining two sets of balanced colonies in all biological characters. The first group contained 5 bee population frames, and the second group contained 10 bee population frames. Each groups was divided into two parts representing the treatments designated for the study to form four treatments. In addition, each treatment included 3 replicates (i.e. three colonies) as follows: 1- the milking control treatment given the code (TCM1) and containing five frames of bee population, 2- the treatment; viz. bee venom milking given the code (TMV1) and containing five frames of bee population to place the milking device inside each colony during the period of bee venom milking, 3- the milking control treatment given the code (TCM2) and containing ten frames of bee population, and 4- the treatment of bee venom milking given the code (TMV1) and containing ten frames of bee population to place the milking device inside each colony during the period of bee venom milking. All experiments were designed according to the randomized complete block design of factorial trials (RCBD), and the results were analyzed according to Anova table by the computer with the SAS program and the means were tested by Duncan's test.

Manufacturing of an electric bee venom milking device was done in cooperation with the Technical Center of the Electronics Company. Locally, the bee venom milking system was manufactured consists of the following:

A- Electrical transformer: it is a box containing a number of electrical devices connected to each other to control the conversion of electrical current from continuous to alternating mode and to control the electrical impulses that result in electric shock to honey bee workers that move on wires during the process of milking bee venom and also through which control was done during the time period for milking ( See Fig. 1).

B- Milking bee venom frame: it is a wooden frame similar to the Hoffman frame used in a Lancasterth hive whose measurements are 48 cm in length, 23 cm in width and 2.6 m in thickness. Several modifications were made to make it capable of milking venom as it was perforated from the

middle and a channel made for the passage of the glass plate from the middle. It was also been perforated for the passage of parallel positive and negative electrical wires without meeting each other where the distance between each was 4 mm. Also, the distance between the wires and the glass plate was only 3-4 mm approximately representing the length of the workers' abdomen. The glass plate is a transparent smooth glass plate of 4 mm thickness, 37 cm length and 22 cm wideness, The glass plate was inserted inside a special channel located in the wooden frame to receive the secreted venom from the venom gland, which, in turn, quickly dries on it to turn into a white powder and then later collected by a sharp iron scraper designated for this purpose. Before inserting the glass plate, it must be well cleaned and wiped and then covered with a thin layer of transparent nylon paper (selufan) in order to ensure not breaking the workers' stings who, in turn, inserted them in the nylon during the process of stunting. Besides, it is easy for the worker to withdraw it; thus, obtaining the highest degree of pure venom.

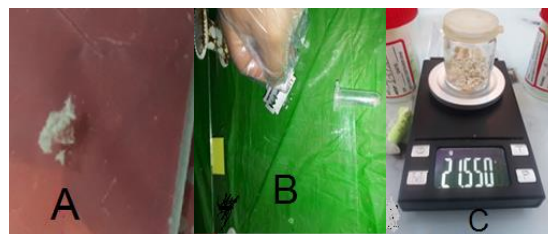


**Fig 1.** Components of the bee venom milking device  
A - the electrical transformer B - the wooden frame.

The stage of extracting the poison after the process of milking and electric shock:

Six frames were manufactured for milking bee venom; three of which were designated for the five frame population treatment of milking bee venom, and the other three were designated for the ten frame population treatment of bee venom. In order to ensure obtaining the largest amount of bee venom during milking, the frames had been put in various treatment replicates in the evening to ensure the return of all the foraging bees into the hive, thus achieving the goal by milking bee venom from the forager bees and the brooder bees inside the hive. The milking frames were inserted and placed in the center of the brood nest frame in the colonies designated for milking. Then the transformer was turned on with the timer installed at a time of 30 minutes, as well as the electric pulse on the amount of one second, an electrical pulse was followed by a stop of 3 seconds and finally the voltage was fixed at 14

volts. The process of milking the bee venom daily lasted for two hours starting from 5-7 o'clock in the evening for a week of milking, and starting from Saturday and ending on Thursday for a week of rest all during the period of conducting the current study. All necessary precautions were taken including wearing plastic gloves, as well as glasses for eye protection, and wearing medical masks to prevent inhalation of venom, especially after beginning the process of scraping bee venom from glass plates using a razor (See Fig. 2). After skimming and collecting the bee venom from the glass plate, the collected quantity was weighed by a sensitive Tn-Series balance. After that, the weighed venom was kept in a dark jar scored on it the weight, the date of the week of collection, the treatment number and the replicates, after completing the scraping and the packing processes, all jars were transferred and placed in a large dark glass container and placed in the freezer for preservation.



**Fig 2.** A - Dry bee venom B - Scraping venom method C - The sensitive balance used.

### Physiological Characteristics:

1- Daily mortality of workers: Wooden trays designed for this study were placed with dimensions of 40 x 100 cm covered with a wire mesh interface containing graduated wood at the bottom to confine the dead workers and fixing the entrance to each cell (duplicate) below each treatment as in Fig. (3) shows. This was done to receive the dead and fallen workers from the cells and to record the numbers of daily mortality of workers at seven in the evening throughout the two semesters of the study. Then, the monthly averages were calculated.



**Fig 3.** Wooden trays for collecting dead workers.

2- Nitrogen content: The nitrogen content in the workers' bodies was estimated using the (Microkjeldahl) device. The resulting nitrogen value was multiplied by the constant (6.25) according to both Al-Sayegh's (1988) and Al-Obaidi's (2022) methods.

3-Fat content: The total fat content in the body of worker bees subjected to different treatments was estimated using the Soxhelt fat extractor according to Al-Sayegh (1988) and Al-Obaidi (2022).

4- Acidity in workers abdomen: Five workers were taken representing each treatment in the experiment where their stomachs were cut with scissors without using any chemicals in the killing operations and then transferred to a ceramic mortar and grinded well. Each operation was separately repeated from each treatment with a continual addition of an amount of distilled water until it became to its final size 5 ml. For the purpose of reading the acidity pH, the pH meter was adjusted using two types of buffer solutions which are pH number (7) and pH number (9) in order to adjust the reading of the device. After the adjustment process, the acidity number of the prepared solution was read according to Goldsmith's method (1988) and Al-Obaidi's (2022) as shown in the Fig (4).

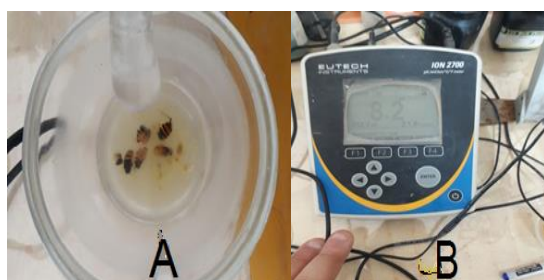


Fig 4. A. Severed abdomen of workers B. pH meter.

## Results and discussion

The results of Table (1) showed that the highest amount mean of bee venom for the interaction reading was 0.1207 mg / colony in bee venom collection treatment with 10 frames (TMV2) during the period 7-12/8/2021 compared with the lowest mean of interaction which was 0.006 mg /colony which was recorded during the period 16-21/10/2021 for the same treatment at a mean temperature and relative humidity of 36.03 ° C and 25.88% respectively (See Fig.5 & Fig. 6). However, the highest mean readings of the interaction in the treatment bee venom collection treatment with 5 frames (TMV1) during the period from 21-26/8/2021 amounted to 0.0810 mg / colony at an average temperature and relative humidity of 34.76°C and 23.19% respectively (See Fig.5 & Fig.

6) compared with the lowest mean of the recording during the period 16-21/10 and amounting to 0.0023 mg/colony for the same treatment. As for the treatments general mean, the highest mean was recorded in the TMV2 treatment which amounted to 0.0644 mg/colony, compared with the lowest general mean of zero mg/colony in the TCM2 treatment. As for the general mean of the effect of readings, the highest general mean was recorded on reading 7-12/8 and 21-26/8/2021 which amounted to 0.0925 and 0.0995 mg/colony respectively compared with the lowest mean at the date of reading on 16-21/10/2021 which amounted to 0.0030mg/colony. The reason for this significant decrease was due to low temperatures, high relative humidity and lack of food represented by pollen and nectar which supply the workers with the materials needed to produce venom as a result of the lack of pastures during this period. Thus, the study concluded the following results shown in this table; viz. the clear effect of the population bees on the production of bee venom, the weight of the milked mean also affected by the progression of the weeks of milking towards the autumn and the amount of venom significantly decreased compared with summer. Sanad & Mohanny (2013) recorded that the best time to collect the largest amount of bee venom was during August, while the least amount collected was in March. Hussein et al. (2019) recorded that the lowest mean amount of bee venom collected was 11.1 mg/colony collected in October. Badawy (2022) found that collecting bee venom every 30 days from Carniolan and Italian hybrid bees in different seasons during the years 2017 and 2018. The mean was 1.937 and 3.817 mg/colony for the year 2017, and 2.412 and 3.426 mg/community for the year 2018 respectively. The best time to collect the largest amount of bee venom was in July, then June, and then August in the Italian bee breed.

Effect of Bee Venom Milking on Physiological Characteristics of Honey Bees

1- Fat content : The results of Table (3) showed that the highest mean of interference readings in treatments with bee population of 10 frames in TMV2 at the first experiment in 22/6/2021 which amounted to 28.00% compared with the lowest in the third experiment which averaged 16.30% and for the same treatment. As for the interaction readings for treatments with bee population of 5 bee frames, the highest mean was recorded in the TMV1 during the third experiment on 30/8, which amounted to 23.50% compared with the lowest mean recorded at the second experiment 5/7 which amounted to 11.00% for the same treatment.

**Table 1.** The effect of reading date and bee venom collection treatments and their interactions on the amount of bee venom for the two seasons (late summer and autumn) 2021.

reading date of readings	Treatments				Total mean
	TCM1	TMV1	TCM2	TMV2	
10-5 /7	0	0.0190 f-h	0	0.0333e-g	0.0255 bc
24-29 /7	0	0.0173gh	0	0.0443 e	0.0305 bc
7-12 /8	0	0.0637 d	0	0.1207 a	0.0925a
21-26 /8	0	0.0810 c	0	0.1183 a	0.0995a
4-9 /9	0	0.0347 ef	0	0.1027 ab	0.0680 ab
23-18 /9	0	0.0190f-h	0	0.0757 cd	0.0635 ab
2-7 /10	0	0.0077cd	0	0.0133 h	0.0100bc
16-21 /10	0	0.0023h	0	0.0067 h	0.0030 c
Average	0	0.0305 b	0	0.0644a	0.0548

\* Numbers with similar letters do not significantly differ according to Duncan's multiple test for mean below 5% significance level. TMV1 and TMV2: Bee venom collection treatment 5 and 10 frames respectively. TCM1 and TCM2 : Control Treatments 5 and 10 frames respectively.

Effect of Bee Venom Milking on Daily Mortality of Workers of Honey Bees During late Summer and Autumn.

The results of Table (2) show that the highest mean of interference readings in treatments with bee population of 10 frames the date 12/7/2021 in TMV2, which amounted to 15.22 workers/day at a mean temperature and relative humidity of 35.57 °C and 26.06%, respectively (refer to Fig. 5 & Fig. 6) compared with the lowest mean in the TCM2 treatment at the date of reading 24/10/2021 which amounted to 0.16 worker/day. However, the highest mean readings of the interaction in the treatment of bee venom milking of bee population was 5 frames TMV1 at the date 12/7/ 2021 amounting to 12.64 worker/day compared with the lowest mean of the recordings during the period which amounted to 0.28 worker/day during the period 24/10/2021. The reason behind the gradual decrease in the number of daily mortality was due to the gradual decrease in the temperatures and the availability of some sources of nectar and pollen for some annual plants and weeds during this period of a year beside the

gradual decrease in the quantities of bee venom generally dissolved from milking treatments (See Table 1). As for the general mean of the treatments, it was noticeable that the treatment of TMV2 amounted to 6.99 worker/day compared with the lowest mean of recorded in TCM2 which amounted to 3.52 worker/day. As for the general mean of readings, Duncan's multiple test at the 5% probability level showed the significant superiority of reading on the date in 12/7/2021 in all readings and the general mean which amounted to 10.84 worker/day compared with the lowest mean of recording in 24/10/2021 which amounted to 0.34 worker/day. Al-Sayegh & Muhammad (2002) recorded that the highest average daily death rate for workers was 68.6 worker/day in the control treatment compared with the lowest recorded average of 47.9 worker/day in the treatment of the hive winter crossing within wooden and double-decker boxes. Nowar (2016) recorded between 2014 and 2015 that the average number of dead bees was 18.7 bees / colony during November.

**Table 2.** The effect of reading date and bee venom collection treatments and their interactions on the Daily death workers of honey bees during late summer and autumn 2021.

History of readings	Treatments				Total mean
	TCM1	TMV1	TCM2	TMV2	
7 / 12	6.45 f	12.64 b	9.06 cd	15.22 a	10.84a
7 / 25	5.87 fg	9.76 c	6.61 f	12.12 b	8.66b
8 / 7	3.51 j	6.22 f	4.12 ij	8.77 d	5.66c
8 / 20	2.25 kl	6.55 f	3.36 j	7.62 e	4.94cd
9 / 2	1.37 l- m	5.19 gh	2.41 k	6.61 f	3.48d e
9 / 15	1.43 l- o	5.86 fg	3.64 ij	5.88 fg	4.20c -e
9 / 28	0.95 m - p	4.42 hi	1.55k-n	4.13 ij	2.76 ef
10 / 11	0.93 m - p	1.11 m- o	0.74n-p	1.74 k - m	1.13fg
10 / 24	0.42 op	0.28 op	0.16 p	0.86 m - p	0.34g
Average	2.58 d	5.78 b	3.52 c	6.99 a	4.71

\* Numbers with similar letters do not differ significantly according to Duncan's multiple test for mean below 5% significance level.

As for the general mean of the transactions, the statistical analysis showed that there were no significant differences for the treatments with bee population of 10 bee frames in the TCM2 and TMV2 where their general mean reached 20.93 and 21.10% respectively. As for the TMV1, the highest general mean was 17.50% compared with the lowest general mean in the TCM1 which amounted to 15.38%. As for the general mean of readings, Duncan's multiple test at the 5% probability level showed that the highest mean in fourth experiment on 12/9/2021 amounted to 22.45% in all readings compared with the lowest general mean at the second experiment in 5/7/2021 which, in turn, amounted to 16.25%. It was observed that the fat content values increased in the treatments with a bee population of 10 bee frames compared with a low population of 5 frames during the four experiments because of the high population of bees which positively affected the fat content of the worker bees in which the effort on the workers was doubled and thus the consumption of stored fats and a decrease in the general fat content of the workers' bodies. Al-Sayegh (2000) noted that the highest mean fat content was 58.7% for bees on 1/7/1999 and the lowest fat content was 36.3% for bees on 21/3/1999. Al-Jubouri (2005) recorded that the percentage of fat content in the bodies of the workers was 7.40% and those were raised on the sugar solution mixed with vitamins.

2- Nitrogen content :The results of Table (3) showed the highest mean of interference readings in treatments with bee population of 10 frames in TMV2 in the material. There is one experiment with different reading date on 22/6/2021 which amounted to 12.25% compared with the lowest mean in the TCM2 at the second experiment on 5/7 which amounted to 6.20%. Whereas, in the treatments with the bee population of 5 bee frames, it recorded the highest mean in the TMV1 in the first experiment on 22/6 which amounted to 9.18% compared with the lowest mean in the TCM1 in the second experiment on 5/7 which amounted to 6.10%. As for the general mean of the treatments, the statistical analysis showed the moral superiority in the TMV2 and its general mean was 9.37% compared with the lowest mean in the TCM2 which amounted to 8.11%. As for the treatment with low bee population, there were no significant differences between the two treatments with their mean of 7.75 and 7.77% respectively. As for the general mean of the readings, there were no significant differences among all the readings. As for their general means, they were 8.72, 7.81, 7.93 and 7.64, respectively. The reason for the high Nitrogen content in the colonies of 10 frames was due to the colonies

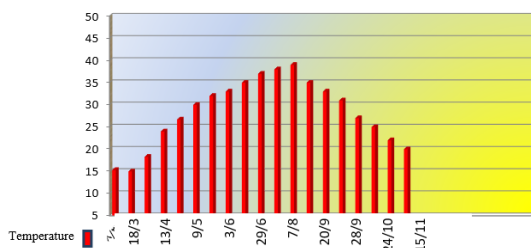
benefiting from the high of population workers which led to the collection of large quantities of pollen that, in turn, provided a large percentage of protein as well as the lack of effort made by the workers in the field activity and the completion of tasks inside and outside the colonies. This led to the accumulation of protein in their bodies as well as the distribution of the process of milking the venom on a large number of workers in contrast with the 5 tire colonies with low bee population. The reason for the high Nitrogen content in the colonies of 10 frames was due to the colonies benefiting from the high of population workers which led to the collection of large quantities of pollen that, in turn, provided a large percentage of protein, as well as the lack of effort made by the workers in the field activity and the completion of tasks inside and outside the colonies. this led to the accumulation of protein in their bodies as well as the distribution of the process of milking the venom on a large number of workers in contrast with the 5 tire colonies with low bee population. Al-Sayegh (2000) noted that the highest mean protein of worker bodies was 60% in winter bees compared with the lowest protein percentage which amounted to 36.1% for hatched bees 10/18/1999. Metwally (2016) found that honey bee workers excrete protein from their bodies through the solution of venom which required compensation by feeding on pollen

3- Acidity (pH) in workers' abdomens: The results of Table (3) showed that the highest mean of interference readings in treatments with bee population of 10 frames in TMV2 in the first experiment on 22/6/2021 amounted to 6.73 pH compared with the lowest mean in TCM2 at the second experiment in 5/7/2021 which was 6.30 pH. In treatments with a bee population of 5 bee frames, the highest mean of interference was recorded in TCM1 during the first and third experiments, and in TMV1 during the second experiment where they all averaged 6.60 pH compared with the lowest mean in TCM1 at the fourth experiment on 12/9 which amounted to 6.20 pH. As for the general mean of the transactions, the statistical analysis showed that there were no significant difference among the treatments at a probability of 5%, and the general mean of the four treatments of 6.45, 6.45, 6.40 and 6.57 pH respectively. As for the general mean of the readings, Duncan's multiple test showed that there was no significant difference during the four experiments, and their general averages were 6.55, 6.50, 6.50 and 6.30 pH respectively. Al-Sayegh (2000) found that the highest acidity of the contents of the abdomen workers was 6.431 pH in winter bees, while the lowest acidity was 6.964 pH recorded for hatching bees on 28/4/1999.

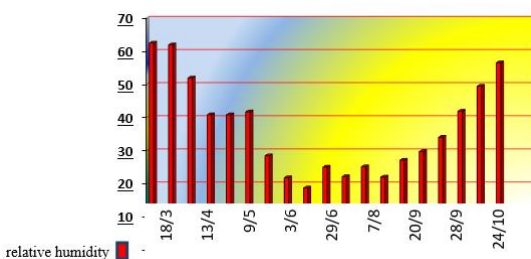
**Table 3.** The effect of reading date and bee venom collection treatments and their interactions on the some physiological characteristics

Physiological Characteristics	Reading date	Treatments				Total mean
		TCM1	TMV1	TCM2	TMV2	
Fat content	22/6	17.70 g	14.50 j	22.40 c	23.30 b	19.45ab
	5/7	14.30 l	11.00 j	18.90 f	20.80 d	16.25b
	30/8	10.50 j	23.50 b	20.23 e	16.30 h	17.30ab
	12/9	18.80 f	21.00 d	22.20 c	28.00 a	22.45a
	Average	15.38 c	17.50 b	20.93 a	21.10 a	19.07
Nitrogen content	22/6	6.12h	9.18 c	7.31 f	12.25 a	8.72a
	5/7	6.10 h	8.55 d	6.20 h	10.64 b	7.81a
	30/8	6.12 h	6.68 g	11.00 b	7.93 e	7.93a
	12/9	8.69 d	6.68 g	7.93 e	6.68 g	7.46a
	Average	7.75c	7.77c	8.11 b	9.37 a	8.00
Acidity (pH) in workers abdomen	22/6	.660 ab	6.40 b– d	6.60 ab	6.73 a	6.55a
	5/7	6.50 bc	6.60 ab	6.30 cd	6.60 ab	6.50a
	30/8	6.60 ab	6.50 bc	6.40 b–d	6.60 ab	6.50a
	12/9	6.20 d	6.30 cd	6.30 cd	6.40 b–d	6.30b
	Average	6.45 a	6.45 a	6.40 a	6.57 a	6.46

\* Numbers with similar letters do not differ significantly according to Duncan's multiple test for mean below 5% significance level.



**Fig 5.** The Celsius temperature of Nineveh Governorate for the year 2021.



**Fig 6.** The degrees of relative humidity in Nineveh Governorate for the year 2021.

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