

Effect of climate and radiation on the behavior of honey bee *Apis mellifera* workers

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ABSTRACT

The honey bee *Apis mellifera* workers used in the present study were from colonies headed with open mated local Carnica queens. The foraging activity of honeybee workers was monitored in a strong, moderate and weak colony from dawn and up to the hour of sunset in the four annual seasons. The highest peak of worker bee activity was between 11.00 - 11.30 am, 8.30 - 9.00 am, 8.00 - 8.30 am and 10.00 - 10.30 am in the winter, spring, summer and autumn season, respectively. However, in the spring and summer season there was a second peak in honeybee activity, but lower in magnitude, between 4.00 to 4.30 pm. In all cases the honeybee workers activity as affected to temperature was positive, as for light intensity it was observed that a certain light level was required to initiate the honeybee workers activity, but not necessary when it was at its highest lux. Honeybee workers were gamma irradiated by 20, 50, 100, 150 or 200 rads. Under conditions of the current laboratory experiment, Isozyme system was estimated for identification in honey bee workers and as affected by gamma irradiation. The zymogen reveals that Malic dehydrogenase 1, (Mdh1) had the same degree of intensity in irradiated and non-irradiated honeybee workers. Band Mdh2 and Mdh 4 appeared to be affected in honeybee workers irradiated with 40 or 200 rads. Meanwhile, a unique band Mdh 0.5 was expressed only in honeybee workers irradiated with 20 rads.

Key words: Honeybee, foraging, weather factors, gamma radiation and isoenzyme.

INTRODUCTION

Meteorological elements i.e. temperature, humidity, light intensity, wind velocity and atmospheric pressure may influence honey bee activity and flight frequencies or behavior. Uptake of sugar solution by individual honey bees in relation to meteorological phenomena was reported by Burrill and Dietz⁽¹⁾. Corbet *et al.*⁽²⁾ stated that among several abiotic factors, temperature has been seen to be the most important factor that affect honeybee activity. High temperature has been reported to affects negatively on bee foraging activity as well as queen's egg laying (3).

The present study was undertaken to investigate the honey bee *Apis mellifera* (L.) foraging behavior responses to some weather factors, e.g. temperature, humidity, dew point and light intensity in the annual four seasons under the environmental conditions of Egypt during the different times of the day. Furthermore, since the synthesis of various enzyme forms were under genetic control it was of interest to investigate the activity of some isoenzymes as affected by the different doses of gamma radiation. Malate dehydrogenase was chosen as a general indicator of aerobic metabolism.

MATERIALS AND METHODS

The foraging activity of honey bee worker was monitored for a day from initial sunlight until last light beam presented by a day expressing the typical weather conditions of each of the four seasons (winter, spring, summer and autumn), i.e. mid January, mid April, mid July and mid October. The weather factors considered were ambient temperature ($^{\circ}\text{C}$), relative humidity (RH %), dew point ($^{\circ}\text{C}$) and light intensity (Lux). Bee foraging activity was monitored at a 10 minute interval during the first hour of dawn before the sun rises and also the last hour of sun set before the dusk but in between this time, measurement was carried out at a 30 minute interval. The initial light (dawn) and last light beam (dusk) varied in the four seasons and was therefore carefully taken into consideration. The foraging activity was carried out by counting the number of forager bees leaving the hive during the selected previously mentioned times of the day. For this reason the effect of gamma irradiation was studied on isoenzyme by means of electrophoresis. The isoenzyme was malate dehydrogenase. F-value was calculated using SAS⁽⁴⁾.

RESULTS

As seen in Table (1) in the month of January, expressing a mid- winter day, first light was at 5.40 h at which time very few bees departed from their hive being 3, 2 and 1 bee / minute in a colony of a strong, medium or weak strength, respectively. Afterwards, the numbers of bees leaving their hive in the strong colony gradually increase to reach a peak of 37 bee /minute by 11.00 h. Meanwhile, in both the medium and weak colonies the highest number of departing bees reached 21 and 13 bee / minute, respectively, which occurred at 11.30 h and which were at a slightly later time than those recorded in a strong colony. At this time of the day, i.e. between 11 and 11.30 am, the recorded temperature was the highest recorded for that day, ranging between 18.5 – 19.8 $^{\circ}\text{C}$. Light intensity was not at its peak as it ranged between 24700- 46300 Lux. However, the highest light intensity was in the range of 61500 – 60300 Lux depicted between the hour of 12.30 – 13.00 h, but as seen in Table 1 the honeybees activity although slightly declined but was still in the high range being 30-27, 20-21 and 12-10 bee / minute in the strong, medium and weak colony, respectively. At this mentioned time (i.e. 12.30- 13.00 h) humidity was at an average level in the range of 48-57 % RH and dew point was 11 $^{\circ}\text{C}$, which was the highest recorded during that day.

As exhibited in Table (2), similar to the previous winter season the first exit of bees from their hives was at 5.00 h, at dawn and at first light, in both the strong and medium strength colony, being 2 bees / minute. The first bee leaving the weak colony was at 5.10 h. At this time of the day, the temperature, light intensity and relative humidity were at the lowest recorded in that day, i.e. 19.8 $^{\circ}\text{C}$, 12 Lux and 57% RH, respectively. Subsequently, there was a gradual increase in the number of foraging bees, which were in proportion to the strength of the three colonies, to reach a maximum of 95, 58 and 40 bees / minute, for that day, in the strong, medium and weak colony, respectively, by 8.30 – 9.00 h. The temperature was 21.4 – 22.8 $^{\circ}\text{C}$ which was still in the low range for the day; meanwhile the relative humidity the highest recorded i.e. 59 – 61 %, light intensity was 6960 – 15500 Lux and dew point 12-15 $^{\circ}\text{C}$.

In the summer season, Table (3) foraging activity of a few honeybee workers started at 5.00 to 5.30 h in the three colonies of different strengths. By 6.00 h, their numbers were 28, 10 and 5 bees / minute in strong, medium and weak colonies, respectively. This number was increased to 71, 42 and 35 bees / minute in the respective mentioned colonies in the next hour (i.e. 8.00 h) and was the maximum recorded during that summer day. The temperature at these

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two periods (i.e. 6.00 to 8.00 h) was between 25.5 – 26.7 °C, RH% ranged between 86 - 78%, a stable dew point of 22.7 °C and a marked increase in light intensity from 4650 to 11977 Lux. Hence forth, foraging activity of bees decline gradually up to mid- afternoon (i.e. 15.00 h) as the number of exiting bees were 30, 24 and 22 honeybees / minute in the strong, medium and weak colony, respectively. At this time of the day, the considered weather factors were at their maximum, the ambient temperature was very high (43.1 °C), as well as light intensity (81450 Lux) but moderate humidity (25%).

Table 1: Number of foraging honeybee workers / minute as affected by some weather factors during day-time period in winter 2009 (mid January).

Hour of day	Temperature °C	Humidity RH%	Dew point °C	Light Intensity Lux	N°. foraging bee / minute		
					strong colony	medium colony	weak colony
05:00	16	55	7	0	0	0	0
05:10	15.8	56	6	0	0	0	0
05:20	15.8	67	10	0	0	0	0
05:30	15.3	70	10	0	2	1	0
05:40	15.3	71	10	2	3	2	1
05:50	15.2	70	10	10	5	3	2
06:00	15.3	69	9	21	8	4	3
06:30	15.2	69	9	48	10	6	3
07:00	15.1	69	9	103	15	9	5
07:30	15.4	67	9	472	17	9	6
08:00	15.1	68	9	1116	20	11	7
08:30	15.2	68	9	1980	25	14	10
09:00	15.3	67	9	3000	26	13	9
09:30	15.2	64	8	4260	27	15	9
10:00	15.2	62	8	6720	29	17	10
10:30	15.7	57	7	10300	30	14	10
11:00	18.5	56	7	24700	37	18	12
11:30	19.8	52	10	46300	30	21	13
12:00	18.4	57	11	51120	31	22	12
12:30	17.7	57	11	60300	30	20	12
13:00	20.1	48	9	61500	27	21	10
13:30	19.1	53	10	50700	25	18	11
14:00	19.1	52	10	39900	18	16	9
14:30	19.2	59	12	21000	12	10	5
15:00	21.8	51	11	17250	13	9	4
15:30	22.3	41	8	12100	12	8	5
16:00	22.4	36	6	5640	11	8	4
16:10	22	39	7	3250	8	5	4
16:20	20.8	35	5	1027	6	3	2
16:30	20.3	35	5	440	4	3	2
16:40	19	37	4	162	3	2	1
16:50	18.2	41	4	98	3	1	0
17:00	18.1	41	4	10	2	1	0
F value					10.87		

Table 2: Number of foraging honeybee workers / minute as affected by some weather factors during day-time period in spring 2009 (mid April).

Hour of day	Temperature °C	Humidity RH%	Dew point °C	Light Intensity Lux	N ^o . foraging bee / minute		
					strong colony	medium colony	weak colony
05:00	19.8	57	11	12	2	2	0
05:10	20.3	59	12	51	4	2	1
05:20	21	61	13	110	5	4	3
05:30	20.8	60	13	177	11	7	3
05:40	21	56	12	193	17	9	5
05:50	21	54	11	201	29	11	7
06:00	21	52	10	221	38	18	10
06:30	20.8	61	13	330	48	24	16
07:00	21.2	59	13	1606	61	30	20
07:30	22	54	12	2310	83	47	25
08:00	22.8	52	12	3110	95	53	35
08:30	21.4	61	15	6960	95	58	36
09:00	22.8	59	15	15500	95	55	40
09:30	24.3	55	14	16310	90	49	34
10:00	25.2	50	14	17490	88	47	25
10:30	28.6	48	16	39100	85	43	24
11:00	31.6	39	15	49500	82	45	25
11:30	31.7	40	16	53200	77	40	15
12:00	33.1	39	17	61600	74	36	14
12:30	36.7	32	17	70900	64	30	15
13:00	39.4	31	19	59000	63	28	14
13:30	39.4	20	12	52600	45	21	13
14:00	44.8	26	21	46600	42	20	12
14:30	42.3	28	20	45100	40	20	14
15:00	36.3	26	14	33000	40	21	13
15:30	34.4	23	10	12260	44	22	15
16:00	33.1	26	11	6210	48	26	18
16:30	32	48	16	5800	51	32	21
17:00	30	56	14	3420	47	30	21
17:10	28.3	62	15	1622	49	27	18
17:20	27.5	55	14	1531	45	20	17
17:30	26.5	53	16	311	38	17	17
17:40	26	54	16	231	30	16	10
17:50	26	51	15	210	22	15	8
18:00	20	50	14	86	19	11	6
F value	28.66						

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Table 3 : Number of foraging honeybee workers / minute as affected by some weather factors during day-time period in summer 2009 (mid August).

Hour of day	Temperature °C	Humidity RH%	Dew point °C	Light Intensity Lux	N°. foraging bee / minute		
					strong colony	medium colony	weak colony
05:00	22	77	17.8	37	3	1	0
05:10	24	79	20	110	3	3	0
05:20	24.5	87	22.2	186	7	5	1
05:30	25.2	88	22.7	498	12	6	2
05:40	25.2	89	22.8	1570	17	8	4
05:50	25.5	88	23.3	2930	22	10	5
06:00	25.5	86	22.7	4650	28	10	5
06:30	25.7	84	22.8	6010	40	13	8
07:00	25.8	82	22.2	6820	53	18	10
07:30	26.3	80	22.2	8430	67	33	20
08:00	26.7	78	22.8	11977	71	42	35
08:30	27.3	75	22.2	16115	70	41	35
09:00	28.5	60	20	23025	66	31	22
09:30	28	60	19.4	24000	66	30	22
10:00	28	55	17.8	30100	56	25	17
10:30	29	56	19.4	31200	56	20	15
11:00	30	51	18.9	44560	55	18	10
11:30	33	49	20.5	59750	41	42	34
12:00	38.5	38	21.7	69150	39	30	22
12:30	41.1	27	18.9	69800	39	28	14
13:00	41.7	23	16.7	72300	35	27	16
13:30	43.1	21	16.1	81450	35	27	17
14:00	41.1	22	16.1	70600	32	25	20
14:30	41	23	16.2	68955	30	26	20
15:00	39.5	25	16.1	47665	30	24	22
15:30	39	25	16.8	26970	33	22	25
16:00	42.5	23	17	14700	41	33	30
16:30	42.5	22	16	12680	48	35	32
17:00	43.1	20	16.2	11300	54	36	33
17:30	37.7	32	19.3	7300	60	39	30
18:00	35.9	35	18.2	3680	50	35	28
18:30	34.7	42	20.2	2855	47	27	21
19:00	33.7	48	21.7	2620	33	21	17
19:10	33.5	48	21.3	2050	28	19	11
19:20	33	47	20	1460	23	15	9
19:30	32.7	49	21.3	745	20	13	7
19:40	32.5	51	22.8	195	16	9	5
19:50	32	55	22	52	11	8	2
20:00	31.1	48	19.2	37	3	2	0
F value				20.89			

As shown in Table (4), in the autumn season during mid October at first light and dawn, amid 5.10 to 5.30 h, the start of honey bee workers foraging activity was first recorded, beginning with very few individuals, the temperature was 17.8- 20°C, very low light intensity of 28 - 640 Lux and 74% RH. Similar to the previous three mentioned seasons, foraging bee activity gradually intensifies. In autumn the highest number of foraging honeybee workers was recorded by 10.00 - 10.30 h being 68 - 69, 45 - 47 and 20 - 22 bees / minute in the strong, moderate and weak strength colonies, respectively, at which period the temperature ranged 31-

33°C, 56 - 67 % RH and light intensity 25200 - 40200 Lux. Hereafter, foraging bees in the strong colony remain relatively active up to late afternoon (i.e. 16.00 to 16.30 h) as their number ranged between 66- 52 bees / minute.

Table 4 : Number of foraging honey bee workers / minute as affected by some weather factors during day-time period in autumn 2009 (mid October).

Hour of day	Temperature °C	Humidity RH%	Dew point °C	Light Intensity Lux	N°. foraging bee / minute		
					strong colony	medium colony	weak colony
05:00	18.3	75	16	28	0	0	0
05:10	17.8	74	16	117	4	2	0
05:20	19.4	73	16	376	7	4	1
05:30	20	74	17	640	8	2	1
05:40	21	74	17	1071	6	2	1
05:50	21	74	17	2790	11	5	3
06:00	21.5	72	17	4070	15	9	3
06:30	21.5	74	17	5430	24	11	5
07:00	22.5	74	17	7230	23	15	7
07:30	23	76	18	8830	45	20	16
08:00	23.5	76	18	10760	63	31	17
08:30	24	65	18	14570	60	34	18
09:00	27	68	18	16210	65	39	18
09:30	29	69	18	20220	62	40	19
10:00	31	67	18	25200	69	47	20
10:30	33	56	20	40200	68	45	22
11:00	34	55	20	54500	66	44	22
11:30	36	51	15	66540	64	43	21
12:00	34	53	12	73400	67	40	21
12:30	34	54	16	71400	64	36	20
13:00	32	50	16	70200	64	34	21
13:30	27.5	52	17	65500	56	32	19
14:00	27.5	57	18	61100	53	30	20
14:30	27.5	64	18	54420	54	31	18
15:00	26.5	67	19	28900	57	30	17
15:30	26	66	18	13290	51	25	15
16:00	26	69	18	5070	50	21	16
16:30	25.5	70	18	2264	52	23	15
17:00	24.3	71	18	836	49	20	12
17:10	23.5	68	18	325	38	11	9
17:20	24	66	17	179	23	9	4
17:30	22.5	66	16	111	12	4	2
17:40	22.5	59	15	76	9	3	1
17:50	22	55	13	48	6	1	0
18:00	22	50	11	24	5	0	0
F value	22.17						

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Electrophoretic patterns of malic dehydrogenase of seven different treatments by gamma radiation are shown and illustrated in Figure (1). The zymogram, reveals different isozyme bands which were detected in some bees of different doses in maximum of four bands with different intensities.

Malic dehydrogenase isozyme band no 1 is the major band which nearly has the same ee of intensity in all treatment by gamma radiation. Isozyme band no 2 is present in all treatment of bees with different intensities. For instance, band no 2 appears in low activity in the dose 50 rad compared with the control. Also the same band is observed to be in low activity in the dose 200 rad compared with the control (Table 6 & Illus. 1). Band no 3 is absent in the all treatment bees and control expect dose 20 rad. Band no 4 appears in low activity in the bees, then it is nearly has the same intensity in all treatments.

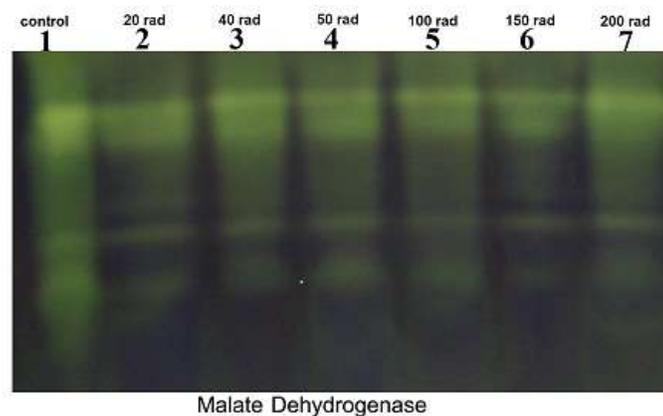
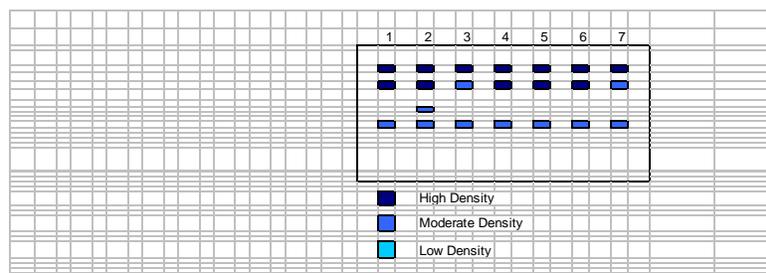


Fig. (1). Electrophoretic patterns of malic dehydrogenase of seven different treatments by gamma radiation



Illus. (1): Edeogram analysis of Malate dehydrogenase isozyme bands patter resulted from different treatments by gamma radiation compared with control (c)

Table (6): Densitometric analysis for Malate Dehydrogenase isozyme of the worker bee

Malate dehydrogenase Group								
Rf		1	2	3	4	5	6	7
Mdh1	0.2	++	++	++	++	++	++	++
Mdh2	0.3	++	++	+	++	++	++	+
Mdh3	0.5	0	+	0	0	0	0	0
Mdh4	0.6	+	+	+	+	+	+	+

DISCUSSION

Among the many biotic and environmental factors, has been mentioned as the most important factor that exerts an effect on honeybee activity^(2, 5,65). Experiments of the present work showed that that time of day together with temperature affected on honeybee activity. The activity of the honeybee workers to temperature was positive; increasing temperature resulted in an increase in flight departures and vice versa. Burrill and Dietz⁽¹⁾ reported that an increase in temperature led to an intensive foraging activity, while low temperatures decreased number of departing bees from their hives.

The effect of gamma irradiation was determined on the activity of isozyme malate dehydrogenase in honey bee workers following irradiation. The isozyme, malate dehydrogenase was slightly affected, as Mdh 2 (rh 0.3) was reduced in intensity. Also, exposure to the lowest dose tested i.e. 20 rad, led to the appearance of a 4th band of malate dehydrogenase enzyme (Mdh 3) which was not detected in untreated honey bee workers neither in those irradiated with the higher doses. It might be reasonable to assume that this enzyme was involved with an increased metabolic rate in the irradiated honey bee and was initiated by the low dose.

Relatively similar to the results of the present work, Tripathi and Dixon⁽⁷⁾ found two and three malate dehydrogenase (MDH) isoenzymes in the hemolymph of queen and worker honeybees (*Apis mellifera* L.), respectively. Also, the work of Sylvester⁽⁸⁾ showed that in honeybees, Mdh was controlled by three alleles, possessing three bands.

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تأثير المناخ والاشعاع علي سلوك شغالات نحل العسل

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1 - قسم وقاية النبات - كلية الزراعة - جامعة عين شمس - القاهرة - مصر

2- قسم المنتجات الطبيعیه المركز القومي لبحوث وتكنولوجيا الاشعاع - هيئة الطاقة الذرية - مدينة نصر - القاهرة - مصر

المستخلص

أجريت الدراسة علي شغالات نحل العسل من سلالة كرينولي وملكة كرينولي. تم دراسته نشاط شغالات نحل العسل من طائفه قوية، متوسطة وضعيفة في وقت الفجر وحتى غروب الشمس من فصول السنة الأربعة. كان أعلى ذروة لنشاط شغالات النحل بين 11، 00-11:30 ص، 8.30-09:00 ص، 8.00-08:30 ص و 10.00-10:30 ص في الشتاء والربيع، والصيف وموسم الخريف، على التوالي. ومع ذلك، كان هناك في موسم الربيع والصيف ذروة ثانية في نشاط شغالات نحل العسل، ولكن انخفاض في الحجم، بين 4.00 إلى 04:30 م. وفي جميع الحالات كان نشاط شغالات نحل العسل كما تتأثر بدرجة الحرارة إيجابية، أما بالنسبة لكثافة الضوء ولوحظ أن مستوى ضوء معين كان المطلوبة لبدء نشاط شغالات نحل العسل، ولكن ليس من الضروري عندما كان في IUX على أعلى.

استخدمت شغالات نحل العسل الناتجة من ملكات نحل كرينولي ملقحة طبيعية. تم تعريض الشغالات لاشعة جاما بجرعات 20 و40 و50 و100 و150 و200 راد لتقدير المشابهة الانزيمي مالميت ديهيدروجينيز لمعرفة تأثير اشعة جاما علي نحل العسل أظهرت النتائج الخاصة بالمشابهة الانزيمي Mdh المعاملات المختلفة بأشعة جاما وجود اربعة حزم بكثافات مختلفة حيث كانت الحزمة رقم 1 (Mdh1) هي الرئيسية في كل المعاملات والحزمة رقم 2 (Mdh2) وجدت بكثافة مختلفة في كل المعاملات والحزمة رقم 3 (Mdh3) غابت في كل المعاملات ما عدا الجرعة 20 راد وجدت الحزمة رقم 4 (Mdh4) بنشاط منخفض في كل المعاملات.