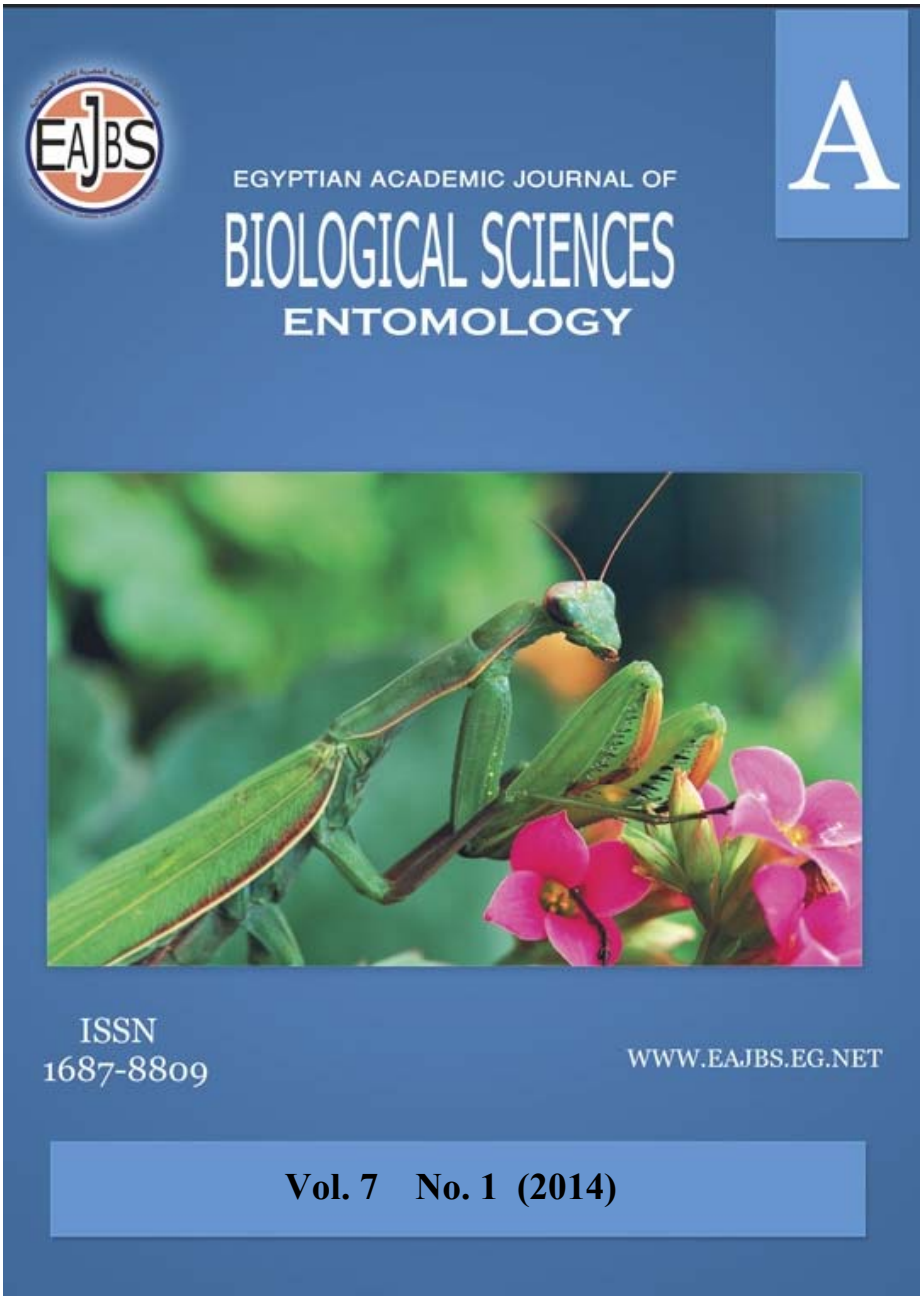

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New applications for protecting honeybee, *Apis mellifera* L., colonies from attacking the oriental hornet (*Vespa orientalis* Fab.)

Mohammad Abd Al-Wahab Abd Al-Fattah[1]; Mahmoud Elsayed Nour[1]; Dana, Aziz Ahmed[1] and Wael, Mahmoud Marzouk[2]

1- Dept. of Econ. Entmol. & Pesticides, Fac. Agric., Cairo Univ. Egypt.
2- Beekeeping Sect., Plant protection, Res. Inst., Agric. Res. Cent., Minist. Agric., Egypt.

ABSTRACT

The efficiency of three modifications on hive entrance to protect honeybee colonies from the serious damage occurred by the predatory hornet, *Vespa orientalis* Fab. Was investigated at apiary in Giza region during hornet active season, 2012. These modifications were large or small cuboid queen excluder (LCQE & SCQE, respectively) and a piece of queen excluder (QE) covered wintering entrance of the hive door, in comparison with unprotected colonies, (control). The numbers of predatory hornets attack SCQE and control colonies was significantly higher (6.8 & 6.7 hornets/col./3 min., respectively) than those attacking colonies supplied with LCQE and winter hole with QE, (6.0 & 6.3 hornets/col./3 min., respectively). The peak of hornet onslaught recorded during October and September, (9.6 & 8.8 hornets/col./3 min., respectively). Unprotected colonies were significantly lost the highest number of bees by predation, (2.39 bees/col./3 min.) in contrast with LCQE and SCQE (0.27 & 0.29 bees/col./3 min.) treatments. Sever attack resulted in extermination of control colonies within three weeks of September and colonies of QE through October. Good success was attained using LCQE and SCQE stabled over hive entrance which resulted in 100 % survival.

INTRODUCTION

It is known that honeybee play an important role in the pollination of various crops (Klien, *et al.* 2007). However, it attacks by many nature enemies which range from minute bacteria and fungi to large mammals like the bear, (Akre & Mayer, 1994). Among the large number of natural enemies in beekeeping, predatory wasp (named the yellow-banded brown wasp or oriental hornet, (*Vespa orientalis* L.) is important as a primary pest of honeybee in the Middle East (Mellor, 1928; Wafa, 1956). This hampered the health and normal working of bee colonies and ultimately influenced the productivity of bee yard (Matsuura, 1988; Matheson, *et al.*, 1989; Sihag, 1992; Khater *et al.*, 2001; Abd Al-Fattah and Ibrahim, 2009 and Abdel-Rahman & Moustafa, 2012).

The population of oriental hornet fluctuates according to prevailing weather conditions and between annual colonies, (Sharkawy, 1964 and Ibrahim & Mazeed, 1967). So, the queen hornet emerges from its winter period of dormancy in spring and visits apiaries in search of food for her and larvae after constructed its small cup-shaped nest. After the first generation of brood has been reared, the nest size and colony strength increases throughout the summer and reaching a peak in autumn. During the period from August to November the demand of

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hornet for food is greatest and bee colonies are greater risk, (Muzaffar & Ahmed, 1986; Ahmed, 1999; Yousief-Khalil *et al*., 2000; Gomaa & Abd El-Wahab, 2006; Abd Al-Fattah and Ibrahim, 2009 and Abd Al-Fattah, *et al*., 2013). Therefore, various procedures have been suggested to protect honeybee colonies from wasps in the world. These include the killing of individual hornet workers with a swatter, (Matsuura and Sakagami, 1973), destroying nests by burning, fumigation with calcium cyanide after plugging the entrance hole and using toxic baits have been advocated, (Sihag, 1992).

Killing the hornet queens during spring (Wafa, *et al.*, 1969 and Mishear, *et al.,* 1989) have also, been tried. Different types of traps have been devised and many kinds of materials have been evaluated as lures which attained attractiveness with varying degrees, (Wafa, *et al.,* 1968; Sharma, *et al.,* 1979; Ahmed, 1999; Yousief-Khalil *et al*., 2000; Bacandritsos, *et al*., 2006; Gomaa & Abd El-Wahab, 2006 and Hussain, *et al.,* 2009). Screens reducers for hive entrance, fixing a part of queen excluder at the hive entrance and elimination of the alighting board have been reported to be useful in reducing wasp attack, (Subbiah & Mahadevan, 1957; Rye, 1986; Mayer, *et al*., 1988; Akre & Mayer, 1994; Ibrahim, 2009). In conclusion of the above attempts for protecting or reducing the serious problems of honeybee colonies due to hornet attacks, the present work was undertaken to evaluate the efficiency of some hornet excluder devises in this continuation.

MATERIAL AND METHODS

The present experiment was undertaken in the apiary of the Agriculture Experimental Station, Faculty of Agriculture, Cairo University, during the active season of yellow-banded brown hornet, *Vespa orientalis* L., from September to November of year 2012.

Twelve honeybee healthy colonies each consisted of single storey, which approximately similar in their strength (number of brood combs, food stores, number of combs covered with bees and mated young queen aged 5-6 months old) were prepared during August for this work. These colonies were randomly divided into four equal groups. At the end of August, the hive entrances of the first group colonies were completely removed and replaced by a devise designed from plastic queen – excluder to take a shape of a cuboid. Each hive entrance of this group was fitted by large cubiod queen excluder diminished 40 x 5 x 5 cm, (Fig. 1). Three small cubiod queen – excluder with dimensions' of 15 x 5 x 5 cm over a hive entrance of the second group colonies, (Fig. 2). The residual part of each entrance was blocked with a piece of wood. For the third group colonies, each winter hole of the movable hive doors was fitted by a piece of plastic queen-excluder dimensioned 5 x 2 cm, (Fig. 2). The hive entrances of the fourth group colonies were left without any modifications as control treatment.

To follow the activity and attacking of hornet on the honeybee colonies and the reaction of bee workers against this attack, a visual record of hornets were daily made at three hour intervals from 0700 hr. to 1600 hr. during the period from September, 1 until the 2nd week of December, 2012. Each of the following parameters were recorded for 3 minutes/colony during each observation period mean numbers of attacking hornets and mean numbers of honeybee preyed, (Abd Al-Fattah, *et al*., 2013).

Statistical analysis:

Data of all treatments were analyzed in a randomized complete block design (ANOVA) by MSTAT-C version 1.41 (Sendecor and Cochran, 1980), and using graph pad prisma version 3.03 for windows, software. All means were compared by Duncan's multiple range test at level 0.05.

RESULTS AND DISCUSSION

Mean numbers of attacking hornets

Data recorded in Table (1) and illustrated in Fig. (1) appear the mean number of oriental hornets attack honeybee colonies for 3 minutes at 3 hour intervals during day – time throughout the period from the first of September to the second week of December, 2013. Colonies supported by small cuboid queen excluder and unprotected colonies (control colonies) received high numbers of attacking hornets which represented 6.8 and 6.7 hornets / colony, respectively. They were significantly higher than those registered for colonies supported by large cuboid queen excluder or a piece of queen excluder the wintering entrance, (6.0 hornets / colony and 6.3 hornets / colony, respectively).

Table 1: Mean no. of attacking hornet / 3 min. on honeybee colonies fitted with various entrance protectors during hornet active season from Sep.1 to Dec.,15,2012.

Month	Time	No. attacking hornet / 3 min.				
		Large cuboid QE	Small cuboid QE	Wintering entrance with QE	Control	Mean ± SE
September	0700 -0959	10	8.5	5.8	6.3	7.7 ±1.70
	1000 - 1259	11.6	9.7	6.3	7.8	8.9 ±2.00
	1300 - 1559	11.7	12.3	7	7.8	9.7 ±2.30
	16:00 - Sunset	8.4	13.3	9.8	4.9	9.1 ±3.01
	Mean ± SE	10.4±1.35A	10.95±1.93A	7.2±1.54B	6.7±1.21B	8.8 ± 0.73 A
October	0700 - 0959	8.6	12.7	4	wiped out	8.4 ±3.55
	1000 - 1259	10.1	11.6	6.5		9.4 ±2.14
	1300 - 1559	13.2	14.6	4.7		10.8 ±4.37
	1600 - Sunset	10	13.4	5.8		9.7 ±3.10
	Mean ± SE	10.5±1.68B	13.1±1.08A	5.3±0.97C		9.6 ± 0.86 A
November	0700 - 0959	2.2	1	wiped out		1.6 ±0.6
	1000 - 1259	3.5	3.4			3.5 ±0.05
	1300 - 1559	3	3.9			3.5 ±0.45
	1600 - Sunset	3.1	2.4			2.8 ±0.35
	Mean ± SE	3±0.47A	2.7±1.11A			2.9 ± 0.78 B
December	0700 - 0959	0.0	0.0			0±0
	1000 - 1259	0.6	0.4			0.5±0.1
	1300 - 1559	0.3	0.6			0.5±0.15
	1600 - Sunset	0.0	0.0			0±0
	Mean ± SE	0.2±0.25A	0.3±26A			0.25±0.25 C
Mean ± SE / Treatment		6.0±2.27 b	6.8 ±2.69 a	6.3 ±0.5 b	6.7 ±0.6 a	6.5 ±0.13

*QE: Queen Excluder

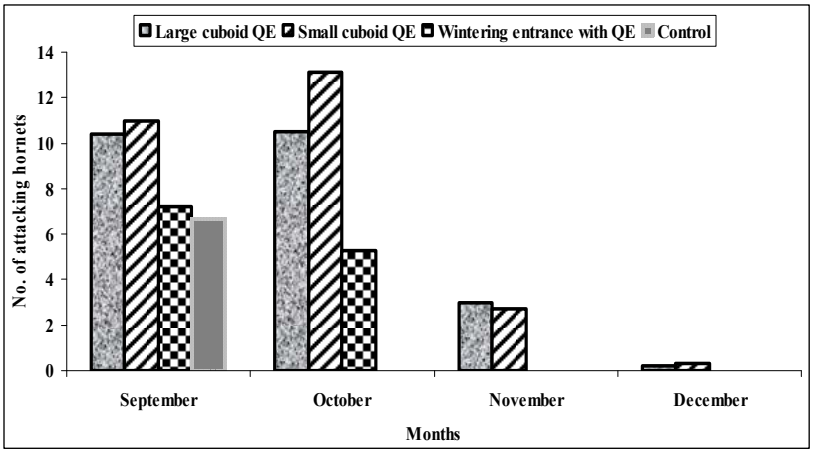

Fig. 1: Mean no. of attacking hornet / 3 min. on honeybee colonies fitted with various entrance protectors during hornet active season from Sep.1 to Dec.,15,2012

On the other hand, highly significant differences were found between the numbers of hornets attack bee colonies during different times of day, Table (2). The highest attacks (7.2 hornet/colony/3 min.) was occurred during the time between 1300 hr. to 1559 hr., followed by (6.8 hornet/colony/3 min.) during the period from 10:00 hr. to 1259 hr. The lowest attack was recorded in the morning period (5.5 hornet/colony/3 min.) during the period from 7:00 – 9:59 hr. Therefore, each colony daily exposed to a number of attacking hornets ranged from 1500 to 1626 with an average of 1546.5 hornet / day during its active season, Table (2) and Fig. (2). Hornet population reached its climax during October, (9.6 hornet/colony/3min.). Followed by September, (8.8 hornet/colony/3 min.). While this population was significantly decreased during November, (2.9 hornet/colony/3 min.) and nearly disappeared during December, (0.3 hornet/colony/3 min.).

Table 2: Mean no. of attacking hornet / 3 min. on honeybee colonies fitted with various entrance protectors during hornet active season from Sep.1 to Dec.,15,2012.

Time	No. of attacking hornet / colony / 3 min.								
	Large cuboid QE		Small cuboid QE		Winter entrance QE		Control		Mean / Time
	3 min.	3 hrs.	3 min.	3 hrs.	3 min.	3 hrs.	3 min.	3 hrs.	
0700 - 0959	5.2	312	5.6	336	4.9	294	6.3	378	5.5 c
1000 - 1259	6.5	390	6.3	378	6.4	384	7.8	468	6.8 a
1300 - 1559	7.1	426	7.9	474	5.9	354	7.8	468	7.2 a
1600 - Sunset	5.4	324	7.3	438	7.8	468	4.9	294	6.4 b
Mean / Treat.	6.0 B	363	6.8 A	406.5	6.3 B	375	6.7 A	402	6.4
Total /col./ day		1452		1626		1500		1608	

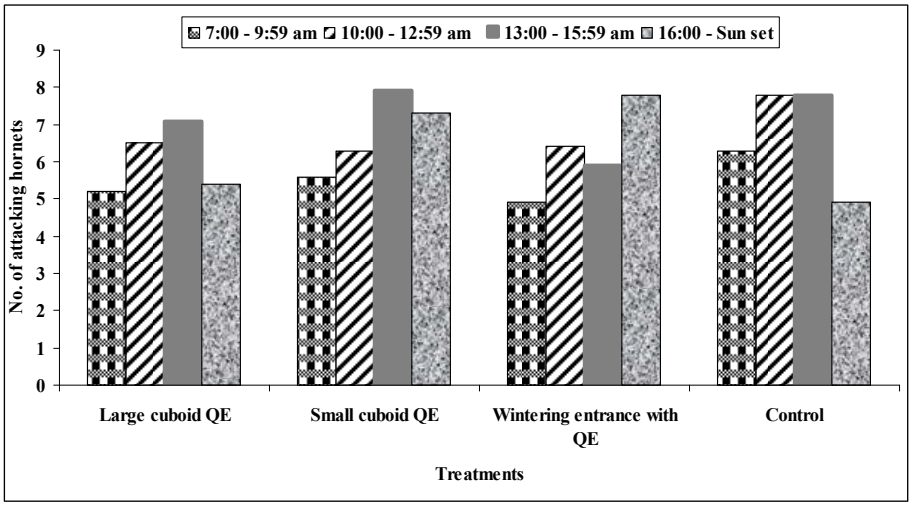

Fig. 2: Mean no. of attacking hornet / 3 min. on honeybee colonies fitted with various entrance protectors during hornet active season from Sep.1 to Dec.,15,2012.

The above results were agreed with the findings of many investigators in the same or similar circumstances such as (Ibrahim & Mazeed, 1967; Singh, 1972; Ahmed, 1999; Sihag, 1992; Khater *et al.*, 2001; Gomaa & Abd El-Wahab, 2006; Abd Al-Fattah and Ibrahim, 2009 and Marzouk, 2013). They agreed that Oriental hornet, *Vespa orientalis* L. started to visit in *Apis mellifera* L. apiaries from June or July and continued up to November. Increasing the population during autumn season might be due to emergence of over wintering graved female which started to increase the population. In the same time, the weakness of honeybee colonies due to dearth period in many regions, also, proved too helpful in multiplication.

Varshneya, *et al*., (2009), also, recorded the population of, *Vespa orientalis* L. in honeybee colonies having different number of frames during Autumn season for two successive years. They reported that maximum activity of predator wasp was recorded between last fortnight of September to first fortnight of October during both years of study and the highest population of wasp was recorded in October month, thereafter decreasing trend was up to end in the month of December. Increasing the attack of hornet after 1000 hr. and continue till the end of the day time is, also, coincided with the findings of Ibrahim, (2009) and Marzouk, (2013). This may be due to increase of sun shine and inconsequently the ray of ultra violet (UV), which used by hornet as source of energy, (Ishay, 2004).

Mean number of preyed bees

In regard to worker bees as prayers, data recorded in Table (3) show the mean number of bee workers that preyed within 3 minutes at 3 hour intervals during hornet active season from September, 1 to December, 15, 2012. Highly significant differences between the numbers of honeybee workers preyed due to hornet attack from control colonies, (2.39 workers / colony / 3 min.) and the other treatments. Colonies supported with large or small cuboid queen excluder lost the lowest number of bees, (0.27 and 0.29 bees / colony / 3 min. respectively)when compared with those lost from colonies supported with a piece of queen excluder on the wintering entrance, (0.51 bees / colony / 3 min.).

Table 3: Mean no. of preyed bees /3min from honeybee colonies fitted with various entrance protectors during hornet active season from Sep.1 to Dec.,15,2012.

Month	Time	No. of preyed bees / 3 min.				
		Large cuboid QE	Small cuboid QE	Wintering entrance with QE	Control	Mean ± SE
September	0700 - 0959	0.78	0.77	0.4	3.13	1.27±0.54
	1000 - 1259	0.7	0.75	0.42	3.03	1.23±0.52
	1300 - 1559	1.08	0.48	1.17	2	1.18±0.27
	1600 - Sunset	0.53	0.62	0.65	1.4	0.8±0.17
	Mean ± SE	0.77 ± 0.099 B	0.66 ±0.058 B	0.66 ± 0.155 B	2.39 ±0.361 A	1.12±0.35A
October	0700 - 0959	0.15	0.3	0.07	Wiped-out	0.17±0.05
	1000 - 1259	0.23	0	0.33		0.19±0.07
	1300 - 1559	0.2	0.35	0.67		0.41±0.10
	1600 - Sunset	0	1.13	0.33		0.49±0.24
	Mean ± SE	0.15 ±0.044	0.45 ±0.220A	0.35 ± 0.107 A		0.32±0.06B
November	0700 - 0959	0.55	0	Wiped-out		0.28±0.14
	1000 - 1259	0.15	0.05			0.1±0.03
	1300 - 1559	0.03	0.13			0.08±0.03
	1600 - Sunset	0	0			0±0
	Mean ± SE	0.18 ± 0.109	0.05±0.027			0.12±0.033C
December	0700 - 0959	0	0			0±0
	1000 - 1259	0	0.05			0.03±0.01
	1300 - 1559	0	0			0±0
	1600 - Sunset	0	0			0±0
	Mean ± SE	0 ± 0.00	0.01 ± 0.010			0.005±0.002D
Mean ± SE / Treatment		0.27± 0.15 C	0.29±0.14 BC	0.51±0.07 B	2.39±0.36A	

*QE: Queen Excluder

Concerning the preyed bees throughout different hours of the day-time, it appears from results in Table (4) that the predation was significantly high from the beginning of the

day until 15:59 hr. where it recorded (1.0, 0.97 and 0.87 bees / colony / 3 min. respectively). The mean number of preyed bees during the period from 16:00 hr. to sun set was 0.62 bees / colony / 3 min. as shown in Fig.(3).

It is noteworthy that the highest predation occurred during September (1.12 bees / colony / 3 min.), especially for unprotected colonies, (control). The predation during October, (0.32 bees / colony / 3 min.), November, (0.12 bees / colony / 3 min.) and December, (0.01 bees / colony / 3 min.) were significantly less than those reported for September, as shown in Fig. (4).

Table 4: Mean no. of preyed bees/ colony / 3 min. of honeybee colonies fitted with various entrance protectors during hornet active season from Sep.1 to Dec.,15,2012.

Time	No. of preyed bees / colony / 3 min.								
	Large cuboid QE		Small cuboid QE		Winter entrance QE		Control		Mean / Time
	3 min.	3 hrs.	3 min.	3 hrs.	3 min.	3 hrs.	3 min.	3 hrs.	
0700 - 0959	0.37	22.2	0.27	16.2	0.24	14.4	3.13	187.8	1.00 a
1000 - 1259	0.27	16.2	0.21	12.6	0.38	22.8	3.03	181.8	0.97 a
1300 - 1559	0.33	19.8	0.24	14.4	0.92	55.2	2.00	120	0.87 a
1600 - Sunset	0.13	7.8	0.44	26.4	0.49	29.4	1.40	84	0.62 c
Mean / Treatment	0.28	16.5	0.29	17.4	0.51	30.45	2.39	143.4	0.87
Total / col./day	66.0		69.6		121.8		573.6		

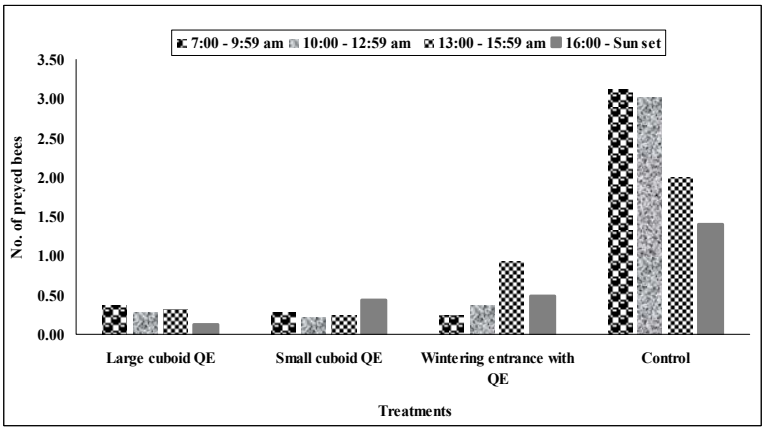

Fig. 3: Mean no. of preyed bees/ colony / 3 min. of honeybee colonies fitted with various entrance protectors during hornet active season from Sep.1 to Dec.,15,2012.

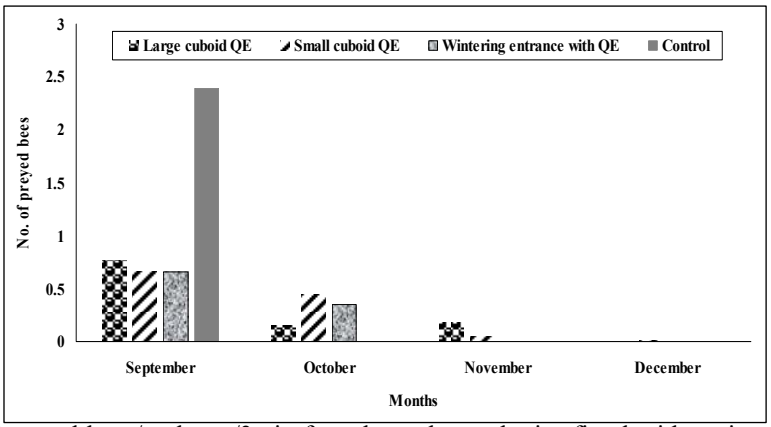

Fig. 4: Mean no. of preyed bees/ colony /3min from honeybee colonies fitted with various entrance protectors during hornet active season from Sep.1 to Dec.,15,2012.

It is, also, obvious from data in Tables (1&3) that the unprotected colonies were wiped out through the month of September, (mostly during the 3rd week of September). Similarly, colonies supported with hive door fitted by a piece of queen excluder on the wintering entrance were completely wiped out at the 3rd week of October .This may be due to the great numbers of the daily preyed bees, (an averages of 573.6 bees / colony / day). This means that honeybee colony lost about 12.1 thousand bees after 21 days, so, it wiped out. The mean number of preyed bees during September was 4752 bees, while those lost during October was 2604 bees. This means that colony which supported with this type of protection lost more than 7.36 thousand bees from their population during this dearth period. This great weakness may push colony to abscond its hive to avoid the destructive effects of hornet.

This conclusion may confirmed by the findings of many researchers. (Singh, 1972; Sharma & Ray, 1988 and Shah & Shah, 1991) who agreed that wasps are serious enemies of honeybee and cause considerable damage. They, also, reported that a persistent attack wasps weakness the colony and most often the colonies either perish or abscond. Besides, Marzouk, (2013) found that weak colonies that contained from 4 to 6 combs covered with bees, (about 8-12 thousand bees) lost a considerable number of bees during hornet attack, (1.9 & 0.9 bees /3 min. respectively), than strong ones that contained 8-10 combs covered with bees (about 0.8 and 0.7 bees / 3min. respectively). Colonies enhanced with large or small cuboid queen excluder on the hive entrance lost the lowest number of bee workers, (about 5.9 and 6.3 thousand bees, respectively), during the hornet active season, (4 month).

Therefore, these colonies still survivor after spent the hornet active season with enough population of bees which enabled them to pass from winter and start in developing through spring season. On the other hand, the cuboid queen excluder may be offers many benefits to honeybee colony, i.e. as protective area on the front of bee hive, which permit to collect numerous mass of bees in save position during hornet attack, prevent hornets from predominance on a limited portion of hive entrance which cause a great predation from bees by introducing a chance to bees to outgoing and returning through any part of the excluder holes, and finally this cuboid queen excluder makes as curtain enable the bees to retreat behind it avoiding hornet skirmish.

Abrol, (1994) recorded that diurnal activity of oriental wasp showed a peak between 0900 and 1300 hr. Similar results was, also, found under the circumstance of study by Ibrahim, (2009) and Marzouk, (2013).

Therefore, this simple device, (cuboid queen excluder) offers a great protection for honeybee colonies from predatory hornet by preventing them from entering the bee hives and avoiding the direct contact with bees during the onsloughting of hornet, in turn, decrease the number of preyed bees. Abd El-Wahab, (2010) in Assiut governorate, Upper Egypt, found that no mortalities in honeybee colonies as a result of *Vespa orientalis* attacks when the hives were supplied with modified and or queen excluder hive entrances. But, the mortality ranged from 25 % to 37.5 % for the unprotected colonies. However, he does not explain the rate of hornet onsloughting in honeybee colonies. The loss percentage of the present study record 100 % for control colonies and those supplied with hive entrance fitted by a piece of queen excluder.

The present technique may supported by (Rye, 1986) who reported that screens and reducers for hive entrances sometimes help to decrease predation by yellow jackets by reducing the area that must be defended by the bees. Also, good success was reported using a galvanized window screen stapled over the hive entrance with about a 5.0 cm opening in the centre, (Mayer, *et al.,* 1988). Another method suggested by Matsuura & Sakagami, (1973) in Japan for combating hornets by trapping it at the hive entrance by using a series of baffles that permit honeybee workers to pass but trap hornets.

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ARABIC SUMMARY

تطبيقات جديدة لحماية طوائف نحل العسل من مهاجمة الدبور الشرقي

محمد عبد الوهاب عبد الفتاح[1]، محمود السيد نور[1]، دانا عزيز أحمد[1]، وائل محمود مرزوق[2]
1- قسم الحشرات الاقتصادية والمبيدات – كلية الزراعة – جامعة القاهرة
2- قسم بحوث النحل – معهد بحوث وقاية النباتات – مركز البحوث الزراعية – وزارة الزراعة

أجريت هذه الدراسة في منحل محطة التجارب الزراعية - كلية الزراعة جامعة القاهرة خلال عام 2012م وذلك بهدف تقييم كفاءة ثلاثة تعديلات على مدخل خلية النحل لحماية الطوائف من الأضرار الخطيرة لهجوم دبور البلح خلال موسم نشاطه. وكانت هذه التعديلات وضع حاجز ملكات كبير الحجم علي شكل متوازي مستطيلات بأبعاد 40 x 5 x5 سم وحاجز ملكات صغير الحجم علي شكل متوازي المستطيلات بأبعاد 15 x 5 x5 سم وقطعة من حاجز ملكات صغيرة وضعت في فصل الشتاء علي مدخل باب الخلية وذلك بالمقارنة مع خلايا متروكة بدون حماية (الكنترول)، وأوضحت النتائج أن أعداد الدبابير المهاجمة علي الخلايا ذات حاجز الملكات المستطيل الصغير وخلايا الكنترول أعلى بكثير (6.8 و 6.7 دبور/الطائفة/3 دقائق على التوالي) عن تلك التي تهاجم الطوائف ذات حاجز الملكات الكبير (6.0 دبابير / الطائفة / 3 دقيقة) . ذروة الهجوم دبور البلح سجلت خلال شهري أكتوبر وسبتمبر (9.6 و 8.8 دبور / الطائفة / 3 دقيقة على التوالي). فقدت الطوائف المتروكة بدون حماية أكبر عدد من النحل المفترس، (2.39 نحلة مفترسة / الطائفة / 3 دقيقة) في حين كان متوسط عدد النحل المفترس من الخلايا ذات حاجز الملكات الكبير والصغير (0.27 و0.29 نحلة مفترسة / الطائفة / 3 دقيقة، علي التوالي). وأسفر هجوم دبور البلح عن إبادة الخلايا المتروكة بدون حماية (الكنترول) خلال ثلاثة أسابيع من شهر سبتمبر وإبادة الخلايا ذات القطعة الصغيرة من حاجز الملكات في حين حققت الخلايا ذات حاجز ملكات متوازي المستطيلات كبير وصغير الحجم نسبة بقاء 100%.