495
Arab Univ.
J. Agric. Sci.,
Ain Shams Univ.,
Cairo, 15(2), 495-511, 2007

MONITORING THE REPRODUCTIVE INDIVIDUALS IN THE ORIENTAL HORNET *Vespa orientalis*

[43]

Elbassiouny[1], A.M.
1- Plant Protec. Dep., Fac. of Agric., Ain Shams Univ., Shoubra El-Kheima, Cairo, Egypt

Keywords: Oriental hornet, *Vespa orientalis*, Male, Female, Reproductive system, Spermatozoa

ABSTRACT

Individuals of the oriental hornet, *Vespa orientalis* Fab. were monitored at the apiary of Faculty of Agriculture .Ain Shams University throughout the year of 2006. The individual which was first detected in early spring at the first week of February was the mated queens, later during the last week of April workers were appeared. At the first week of September individuals large in size appeared which were workers with developed ovary and not a new queen as believed previously. New queens started to appear at the second week of November after about three weeks from appearance the drones which appear at the last week of October. The numbers of ovarioles varied from 7 to 8 for each ovary in queens either in spring or in autumn. On the other hand the numbers of ovarioles were only 7 for each ovary in workers either normal or with developed ovary. The measurements of the spermatheca showed no significant differences between all female individuals. The average numbers of spermatozoa in the queen's spermatheca of spring queen hornet were 1.486± 0.370 million spermatozoa and in the new queens who appear in the end of the year, the numbers of spermatozoa recorded 1.343±0.332 million. The counts of spermatozoa in the seminal vesicles of drone hornet recorded 2.336 ± 0.408 million sperms per drone.

INTRODUCTION

The world of the oriental hornet, *Vespa orientalis* Fab. (Hymenoptera: Vespidae) is full of secrets and a most attractive subject. The hornet is the most serious hymenopterous predator for honey bee colonies. It causes great damage to apiculture and beekeepers by invading bee colonies and destroy them by feeding on either bees or stored honey. Moreover, the hornet indirectly disrupts pollination of fruit and vegetable crops **(El-Sherif, 2003).**

The subject most cited for the oriental hornets were mainly concerned with their cell construction **(Ishay *et al* 1983 and Stokroos *et al* 2001)**; daily activity **(Ishay *et al* 1991)**; their control by using different types of traps **(Hussein, 1989; Yousif Khalil *et al* 2000 and El-Sherief, 2003);** physical and biological condition for their immature stages **(Shabtai and Ishay, 1998);** seasonal activity **(Shoreit, 1998; Abouel-Enain,1999 and Khater *et al* 2001**); and adult parasitoids **(Heidari *et al* 2004).**

Information about the reproduction of hornet's is relatively scarce in the available literature, which mainly concentrates on queen andry (**Foster *et al* 1999; Ratnieks *et al* 2001; Goodisman, *et al* 2002 and Takahashi *et al* 2002)** kin selection predictions (male production) **(Foster and Ratnieks, 2001**, **Foster *et al* 2000 and Takahashi *et al* 2004a & 2004b);** taxonomy and distribution (**Archer, 1998)** and worker policing behavior (**Makino and Yamane, 1997 and Foster *et al* 2002**).

As far as I know and in the available literature. The reproductive system either in male or female was not fully covered. For this reason the present work was undertaken to establish some information on the morphology and structure of the reproductive system of male and female oriental hornet, *Vespa orientalis* (Hymenoptera: Vespidae) and kin structure of such hornet.

(Received May 9, 2007)
(Accepted May 19, 2007)

MATERIALS AND METHODS

The present work were conducted at the apiary of Faculty of Agriculture, Ain Shams University during, 2006

Monitoring individuals of the oriental hornet

The occurrence of the oriental hornet *Vespa orientalis* individuals were monitored on a weekly bases throughout the year 2006 by their catching with a sweep net, starting from 1st week of February until the last week of December (end of the year) where no hornet were founded.

Body size

Biometrical investigations were carried out for body size measurements for different individuals. The longitudinal diameter of tergite 3 and 4 were measured under stereo-microscope by micrometric lines (magnification 8x, 16x, 32x).

Dissecting live hornets

Collected live hornets were sexed and preserved in a refrigerator for at least 2 hours, then prepared for dissection under a stereo-microscope. Hay's saline solution was added to cover the dissected hornet so as to separate the reproductive organs from the fat body (irregular masses field the abdominal body cavity) and the ramify trachea.

Preparing Reproductive organs for examination

The delicate reproductive system of female and male hornets were carefully separated from both the adhesive fat body and the fine terminal branches of the tracheae and carefully transferred to a glass slide with a central concave hollow. Droplets of a solution containing 40 % glycerin, 40% alcohol and 20% water were added to the specimen to facilitate their separation and to prevent dryness.

Ovariole numbers

The numbers of ovarioles were counted in each ovary of every investigated female.

Spermatheca

The spermathecal length and width were measured to obtain the outer spermatheca area. Longitudinal and transverse sections were made using a surgical scalpel blade to obtain the inner area measurement which was considered the spermathecal sac. The difference between outer and inner area were considered as the tracheal net area.

Spermathecal gland

The lengths of the both branches of the spermathecal gland were measured.

Spermatozoa count

(i) Spermatozoa counts in the queen's spermatheca

After dissecting the queen hornet, the spermatheca was transferred into a small vile and immersed in 1 ml of Hay's saline solution, it was then punctured and the spermatozoa were then well dispersed. Distilled water was added to make 10 ml, and spermatozoa were counted using a counting slide as described by **Elbassiouny (1992).**

(ii) Spermatozoa counts in drone's seminal vesicles

After dissecting the drone hornet, the seminal vesicles and vasa differentia were removed and separated from the abdomen. They were then placed in 1ml Hay's solution and spermatozoa were then counted as described in the previous step.

RESULTS AND DISCUSSION

Monitoring of hornet's individuals

The weekly hornet catch by the sweep net were identified into five different individuals, which were: mated queens, new queens, normal workers, workers with developed ovary and drones. Their numbers was counted and presented in **Table (1) and Fig. (1)**.

Hornets were not detected before the first week of February (early spring), and the first evident individual was the queens and were still detected until the second week of May. Upon investigations, these queens were all mated as detected by the presence of spermatozoa in their spermatheca. After this time the queens was not collected in the weekly sweeps as they remained in their nest until the end of the year where they died with all other individual in the nest.

Table 1. Individuals percentages of the oriental hornet *Vespa orientalis* throughout the year 2006

Inspection Week	Total catch	Queen				Worker (Type of Ovary)				Drone	
		Spring		New		not Develop		Develop			
		No.	%	No.	%	No.	%	No.	%	No.	%
Feb., 1st	1	2	100	0	0	0	0	0	0	0	0
2nd	2	2	100	0	0	0	0	0	0	0	0
3rd	2	3	100	0	0	0	0	0	0	0	0
4th	4	4	100	0	0	0	0	0	0	0	0
Mar., 1st	6	6	100	0	0	0	0	0	0	0	0
2nd	11	11	100	0	0	0	0	0	0	0	0
3rd	10	10	100	0	0	0	0	0	0	0	0
4th	14	14	100	0	0	0	0	0	0	0	0
Apr., 1st	12	12	100	0	0	0	0	0	0	0	0
2nd	9	9	100	0	0	0	0	0	0	0	0
3rd	11	11	100	0	0	0	0	0	0	0	0
4th	14	10	71.4	0	0	4	28.6	0	0	0	0
May 1st	13	5	38.5	0	0	8	61.5	0	0	0	0
2nd	10	1	10.0	0	0	9	90.0	0	0	0	0
3rd	12	0	0	0	0	12	100	0	0	0	0
4th	11	0	0	0	0	11	100	0	0	0	0
Jun 1st	14	0	0	0	0	14	100	0	0	0	0
2nd	15	0	0	0	0	15	100	0	0	0	0
3rd	19	0	0	0	0	19	100	0	0	0	0
4th	17	0	0	0	0	17	100	0	0	0	0
Jul., 1st	24	0	0	0	0	24	100	0	0	0	0
2nd	29	0	0	0	0	29	100	0	0	0	0
3rd	33	0	0	0	0	33	100	0	0	0	0
4th	46	0	0	0	0	46	100	0	0	0	0
Aug., 1st	32	0	0	0	0	32	100	0	0	0	0
2nd	38	0	0	0	0	38	100	0	0	0	0
3rd	33	0	0	0	0	33	100	0	0	0	0
4th	30	0	0	0	0	30	100	0	0	0	0
Sep., 1st	35	0	0	0	0	32	91.4	3	8.6	0	0
2nd	42	0	0	0	0	36	85.7	6	14.3	0	0
3rd	57	0	0	0	0	45	78.9	12	21.1	0	0
4th	61	0	0	0	0	44	72.1	17	27.9	0	0
Oct., 1st	77	0	0	0	0	49	63.6	28	36.4	0	0
2nd	71	0	0	0	0	39	54.9	32	45.1	0	0
3rd	84	0	0	0	0	44	52.4	40	47.6	0	0
4th	78	0	0	0	0	38	48.7	36	46.2	4	5.1
Nov., 1st	65	0	0	0	0	30	46.2	29	44.6	6	9.2
2nd	72	0	0	0	0	36	50.0	25	34.7	11	15.3
3rd	61	0	0	5	8.2	25	41.0	14	22.9	17	27.9
4th	58	0	0	11	18.9	19	32.8	8	13.8	20	34.5
Dec., 1st	47	0	0	15	31.9	8	17.0	6	12.8	18	38.3
2nd	33	0	0	10	30.3	6	18.2	5	15.1	12	36.4
3rd	19	0	0	6	31.6	3	15.8	3	15.8	7	36.8
4th	8	1	12.5	3	37.5	2	25.0	0	0	2	25.0

Fig. 1. Occurrence of different hornet individuals throughout 2006 year

The first generation of workers started to become apparent during the last week of April making a 28.6% of the catch. Their number increased to represent 100% of the weekly catch in the period extending from 3rd week of May until the last week of August. These workers will be named "normal workers" as upon dissection, they appeared as female castes with ovaries void of any oocytes.

During the first week of September, beside the normal worker caste previously observed other workers caste become apparent making 8.6% of the catch. These workers appeared larger in body size with ovaries bearing oocytes in different stages of development, these will be named "workers with developed ovaries". The percentage of these workers gradually increased to reach its maximum 47.6% during the 3rd week of October, after which time their presence gradually decreased.

Male hornets started to appear during the last week of October making a 5.1% of the net sweep, their numbers reached a maximum of 38.3% during the 1st week of December.

After 3 weeks from appearance of drones i.e. 3rd week of November, new queen appeared (detected by the presence of spermatozoa in their spermatheca) making an average of 8.2 % of total catch. The percentage of new queen increased gradually till the end of the year where they completely disappeared for hibernation at the end of December.

Body size

The different individuals of the hornet's caste were identified according to their body size which was measured by the longitudinal diameter of tergite 3 and 4 **(Table 2)**.

The measurement of the total longitudinal diameter (mm) of the Tergite 3 and 4 showed that, there were three types of females:

1- Queen hornets appearing in spring (first week of April), their 3 and 4 tergite measured 10.46 ± 0.38 mm. Meanwhile, other queen hornets (new queen) appeared at the end of the season, i.e. third week of November exhibited slightly shorter 3 and 4 tergite which measured 9.92 ± 0.38 mm
2- Workers with developed ovaries, their 3 and 4 tergite measured 9.07 ± 0.26 mm.
3- Normal workers (undeveloped ovaries) exhibited shorter tergites as the 3 and 4 tergite measured 7.72 ± 0.34 mm.

Moreover, the 3 and 4 tergite of the male (drone) measured 8.52 ± 0.34 mm.

The analysis of variance between individuals ($F = 2.92$ & $LSD = 1.24$) showed that there was no significant variance in regard body size between the queens either found in the spring or at the end of the year (new). On the other hand, significant differences were detected between the normal workers and the workers with developed ovaries. It is noteworthy that, there were no significant differences between the new queen found at the end of the year and with workers with developed ovaries.

Although the results of the present work agree with those of **Shoreit (1998), Abouel-Enain (1999), Khater *et al* (2001) and El-Sherif (2003)** in regard the time which the spring queens still forages up to May. On the other hand the present results disagree with these reports for the timing of

Table 2. Longitudinal diameter (mm) of tergite 3 and 4 for different hornet individual's ±SD (n=20)

Character	Hornet individuals				
	Queen (spring)	Queen (new)	Worker (d.ov)	Worker (n)	Drone
Tergite 3	5.47 ± 0.23 (5.05 – 5.90)	5.13 ± 0.25 (4.90– 5.50)	4.73 ± 0.16 (4.50 – 4.90)	4.21 ± 0.21 (3.80 – 4.45)	4.55 ± 0.15 (4.35 – 4.75)
Tergite 4	4.99 ± 0.22 (4.75 – 5.35)	4.79 ± 0.18 (4.55– 5.05)	4.34 ± 0.23 (4.20 – 4.50)	3.51 ± 0.19 (3.25 – 3.70)	3.97 ± 0.23 (3.65 – 4.30)
Total (T3&4)	10.46 ± 0.38^{a} (10.95 – 9.90)	9.92 ± 0.38$^{a b}$ (10.55– 9.35)	9.07 ± 0.26$^{b c}$ (9.40 – 8.70)	7.72 ± 0.34^{d} (8.15 – 7.05)	8.52 ± 0.34$^{c d}$ (9.05 – 8.00)
F value	2.92*				
L.S.D.	1.24				

d.ov = developed ovary n = normal

which new queens appear, where their observations depending on the body size only. Also, observation of the present work emphasized that individuals who become evident in September up to October were not queens but workers with developed ovaries. This finding was supported by the degree of ovary maturation and the presence of spermatozoa within the Spermatheca, where the spermatheca of these workers did not contain at any time spermatozoa as will be explained in the following text.

Female Reproductive Organs

The Ovary

The ovary in the mated queen hornet collected in early spring, appeared with huge masses of closely packed ovarioles, their number varied between 7-8 ovarioles per ovary **(Table 3)**. It was noticeable that each ovarioles comprised a large number of mature eggs **(Figs. 2&3)**.

Table 3. Number of ovarioles in hornet female individuals ±SD (n=20)

Ovariole	Number of ovarioles / ovary			
	Queen		Worker	
	Spring	Autumn (new)	Developed ovary	Normal
Right	7.2 ± 0.3	7.3 ± 0.5	7	7
Left	7.1 ± 0.2	7.1 ± 0.3	7	7

Fig. 2. Queen reproductive system
Odc:Oviduct common; Odl:Oviduct lateral; Ov:Ovary; Spt: Spermatheca; Spt Dct:Spermathecal Duct; Spt Gld:Spermathecal Gland

Fig. 3. Queen reproductive system

At the base of each ovary, the ovarioles come together in a lateral oviduct which unit with the other one in common duct (common oviduct) which open to the outside by genital opening that lie between the basal part of the two lancet at the end of the sting shaft, **Figs. (11 &12)**.

In the normal workers **(Fig. 4&5)**, their ovaries appeared small in size, each comprised 7 ovarioles / ovary **(Table 3)** which were devoid of any oocytes, therefore it was easy to measure the whole reproductive system (from terminal filament until the genital opening) which measured an average of 9.3± 0.96 mm **(Table 4)**.

Table 4. Measurements the length of the female reproductive system (mm) ±SD

n	reproductive system	
	length	Range
20	9.3 ± 0.96	8.7 – 10.2

Meanwhile in workers which appear during the first week of September (workers with developed ovaries) exhibited well developed ovaries comprising 7 ovarioles per ovary. Their ovaries alternated in their function as developing oocytes were first observed in ovarioles of one ovary and not the other and this function was then switched to the other ovary, **(Figs. 6&7)**.

The new queens, which appeared during the third week of November (autumn) similar to spring queens exhibited 7 to 8 ovarioles per ovary **(Table 3)**, however, their ovaries were relatively empty of any developing oocytes, **Figs. (8, 9&10)**, presumably as they will hibernate for the winter. This observation for the shape of the ovary plus the spermathecal content of the spermatozoa (which found only in the queens) was taken to identify the new queen from the workers with developed ovaries.

The body size in the new queens and the workers with developed ovaries appear no significant differences between each other, which encourage the authors (**Shoreit, 1998; Abouel-Enain, 1999; Yousif khalil *et al* 2000; Khater *et al* 2001 and El-Sherif, 2003)** to believe that the individuals who appear in September are new queens. The emphasized that these individuals are not a new queens depending on the shape and the number of ovarioles moreover the presence of spermatozoa within the spermatheca.

At the base of each ovary, the ovarioles come together in a lateral oviduct which unit with the other one in common duct (common oviduct) which open to the outside by genital opening (Gonopore) that lie between the basal part of the two lancet at the end of the sting shaft, **Figs. (11 &12)**.

No significant differences (t = 0.875) were found between the area size of mature eggs present at the base of the ovarioles either in the queen [the egg area measured 1.452 ± 0.083 mm (2.052 ± 0.143 mm and 0.901 ± 0.80 mm for the length and the width, respectively)] or those detected in workers with developed ovaries [the egg area measured 1.363 ± 0.091mm (2.026 ± 0.118 mm and 0.842 ± 0.74 mm for the length and the width, respectively)], **Table (5) and Figs. (13)**.

Spermatheca

The spermatheca which lies on the dorsal wall of the common oviduct appeared as a semi-oval body, spindle in shape connecting to the spermathecal duct with the common oviduct just before the genital opening, **Fig. (14)**.

The total measurements of the spermatheca **(Table, 6)** was 3.185 ± 0.27, 3.102 ± 0.20, 3.060 ± 0.18 and 3.028 ± 0.27 mm in spring queen, new queen, workers with developed ovaries and normal worker, respectively. Dissecting the spermatheca by either longitudinal **(Figs. 15, 16 & 17)**

Fig. 4. Worker reproductive system
Odc:Oviduct common; Odl:Oviduct lateral; Ov:Ovary; PsnSc: Poison Sac;
Spt: Spermatheca; Spt Dct:Spermathecal Duct; Spt Gld:Spermathecal Gland; Stn: Sting

Fig. 5. Worker reproductive system

Fig. 6. Worker with developed ovaries
Odc:Oviduct common; Odl:Oviduct lateral; Ov:Ovary; PsnSc: Poison Sac;
Spt: Spermatheca; Spt Dct:Spermathecal Duct; Spt Gld:Spermathecal Gland; Stn: Sting

Fig. 7. Worker with developed ovaries

Fig. 8. New queen reproductive system (7+8 ovarioles)

Fig. 9. New queen reproductive system (7+8 ovarioles)

Fig. 10. New queen reproductive system (7+7ovarioles)
GoP: Gono Pore; Odc:Oviduct common; Odl:Oviduct lateral; Ov:Ovary; PsnSc: Poison Sac;
Spt: Spermatheca; Spt Dct:Spermathecal Duct; Spt Gld:Spermathecal Gland; Stn: Sting

Fig. 11. Genital opening lie between the basal part of the lancets
GoP: Gono Pore; Odc:Oviduct common; Odl:Oviduct lateral; Ov:Ovary; PsnSc: Poison Sac;
Spt: Spermatheca; Spt Dct:Spermathecal Duct; Spt Gld:Spermathecal Gland; Stn: Sting

Fig. 12. Genital opening close up

Table 5. Measurements the eggs (mm) ±SD (n=20)

Individuals	The egg		
	length	width	Area
Queen (spring)	2.052 ± 0.143	0.901 ± 0.80	1.452 ± 0.083
	(1.80 – 2.20)	(0.76 – 1.01)	(1.273 – 1.510)
Worker (d.ov)	2.026 ± 0.118	0.842 ± 0.74	1.363 ± 0.091
	(1.91- 2.11)	(0.70 – 0.95)	(1.216 – 1.498)
t			0.875

d.ov = developed ovary

Fig. 13. The egg

Fig. 14. The spermatheca
Spt Dct:Spermathecal Duct; Spt Gld:Spermathecal Gland

Table 6. Measurements the spermatheca (mm) in hornet female individuals ±SD (n=20)

Female individuals	Spermatheca						
	Outer (Total)			Inner (Spermathecal Sac)			Tracheal Area
	length	width	Area	length	width	Area	
Queen (spring)	2.60± 0.20	1.56± 0.21	3.185±0.27 (100%)	1.72±0.30	0.88± 0.18	1.189± 0.26 (37.3%)	1.996±0.23 (62.7%)
Queen (new)	2.50± 0.29	1.58± 0.18	3.102±0.20 (100%)	1.63± 0.37	0.92± 0.22	1.178± 0.31 (37.9%)	1.924± 0.29 (62.1%)
Worker (d.ov)	2.58± 0.20	1.51± 0.19	3.060±0.18 (100%)	1.79±0.30	0.80±0.15	1.125±0.29 (36.8%)	1.935±0.22 (63.2%)
Worker (n)	2.52±0.24	1.53±0.23	3.028±0.27 (100%)	1.64±0.32	0.86±0.12	1.108±0.29 (36.6%)	1.920±0.24 (63.4%)
F value (Area)	1.178			0.432			0.924

d.ov = developed ovary n = normal

Fig. 15. longitudinal section of the spermatheca
SptSc: Spermathecal Sac; TrNet:Tracheal Net

Fig. 16. longitudinal section of the spermatheca (showing inner surface)
SptSc: Spermathecal Sac; Spt Dct:Spermathecal Duct; Spt Gld:Spermathecal Gland; TrNet:Tracheal Net

Fig. 17. longitudinal section of the spermatheca (showing outer surface)

or transverse sections **(Fig. 18)** show that its inner area measurements (spermathecal sac) were 1.189 ± 0.26, 1.178 ± 0.31, 1.125 ± 0.29 and 1.108 ± 0.29 mm for the respective mentioned female individuals. The difference between the size of the spermatheca as a whole and its inner size represent the area of the tracheal net which was calculated to be 1.996 ± 0.23, 1.924 ± 0.29, 1.935 ± 0.22 and 1.920 ± 0.24 mm for spring queen, new queen, workers with developed ovaries and normal worker, respectively. This finding indicates that the tracheal net area occupies about two thirds of the total area of the spermatheca. Presumable the function of the tracheal net was not only to supplying oxygen to the spermatozoa but may also protect the spermatozoa within the spermathecal sac from the violent motion according to the hornet feeding habit.

Spermathecal gland

In the distal part of the spermatheca, a pair of very long tubular spermathecal gland were detected **(Figs. 19 & 20)** each measured 23.01 ± 2.55, 22.93 ± 2.91, 21.91 ± 2.73 and 22.42 ± 3.16 mm in spring queen, new queen, workers with developed ovaries and normal worker, respectively, **Table (7)**.

Table 7. Measurement the spermathecal gland (mm) ±SD (n=20)

Individuals	Spermathecal gland length (mm)	
	mean ± S.D.	Range
Queen (spring)	23.01± 2.55	19.7- 26.6
Queen (new)	22.93± 2.91	18.9 - 27.6
Worker (d.ov)	21.91±2.73	18.8 - 26.2
Worker (n)	22.42±3.16	18.3 - 27.2
F value	0.174	

Spermatozoa counts in queen's spermatheca

The spermatozoa count in the spermatheca of spring queens was 1.486 ± 0.370 million spermatozoa and ranged from 0.980 to 1.880 million spermatozoa. In the new queen that appeared in autumn, the numbers of spermatozoa recorded were 1.343 ± 0.332 million (1.040 – 1.920). Statistical analysis showed no significant differences (t = 0.915) between counts of spermatozoa in the spring queens or the new queens, **Table (8)**. No sperms were found in the spermatheca of the workers with developed ovary.

Table 8. Spermatozoa count within Queen's Spermatheca ± SD (n=20)

Individuals	No. of Spermatozoa (million)	
	mean ± S.D.	Range
Queen (spring)	1.486±0.370	0.980–1.880
Queen (new)	1.343±0.332	1.040–1.920
t value	0.915	

Male Reproductive Organs

In the drone hornet the testes appeared as a pair of small bodies set close together held by both tracheoles and fat body, in the center of the abdomen **(Figs. 21, 23 & 25)**.

The testis consisted of testicular follicle in which the primary reproductive cells developed into spermatozoa **(Figs. 22, 24 & 26)**. From each follicle there proceeds posteriorly a duct, the vas efferens, which connects to the vas deferens that soon enlarges into a long slender vesicula seminalis. The posterior ends of the two vesicles enter the lower ends of a pair of mucous glands lying side by side **(Figs. 28 & 29)**. The two glands open together into the ejaculatory duct which open into the distal part of the male genetalia **(Figs. 27, 30, 31, 32 & 33)**.

Fig. 18. Transverse section of the spermatheca

Fig. 19. Spermathecal gland
GoP: Gono Pore; Odc:Oviduct common; Odl:Oviduct lateral; Ov:Ovary; PsnSc: Poison Sac; Spt: Spermatheca; Spt Dct:Spermathecal Duct; Spt Gld:Spermathecal Gland; Stn: Sting

Fig. 20. Spermathecal gland

Fig. 21. Male Reproductive system
EjD:EjaculatoryDuct; MuGld:MucousGlands; SV:SeminalisVesicula; Tes:Testis; Vd:Vas deferens

Fig. 22. The testis (close up)
TesFol:Testicular Follicle; Vd:Vas deferens; Ve:Vas efferens

Fig. 23. Male Reproductive system

Fig. 24. The testes (close up)

Fig. 25. Male Reproductive system

Fig.26. The testes (close up)

Fig. 27. Male Reproductive system

Fig. 28. Seminal vesicle enter the lower end of a mucous gland lying side by side

Fig. 29. Male genetalia (ventral view)

Fig. 30. Male genetalia (dorsal view)

Fig. 31. Male genetalia (dorsal and ventral view)

Fig. 32. The ejaculatory duct open in the genital pore

Spermatozoa counts in drone's seminal vesicles

The counts of spermatozoa in the seminal vesicles of drone hornet were 2.336 ± 0.408 million sperms per drone and ranged from 1.840 to 3.040 million sperms per drone **(Table 9)**.

Table 9. Spermatozoa count within drone's seminal vesicles ±SD

No. of Spermatozoa (million)		
n	mean ± S.D.	Range
20	2.336 ± 0.408	1.840 – 3.040

According to **Elbassiouny (1992)**, the numbers of spermatozoa in the seminal vesicles were considered as the initial number produced by a drone. Therefore, the drone ejaculates spermatozoa less than their initial number found in the seminal vesicles. According to the biological route of sperm from testes until their storage in the female spermatheca shows that the queen hornet was mated from more than one drone. This finding agree with those of (**Foster *et al* 1999; Ratnieks *et al* 2001; Goodisman *et al* 2002 and Takahashi *et al* 2002)** who stated that the queen hornet was polyandry.

In conclusion, the monitoring of different hornet individuals may clarify their mating behaviour and therefore may aid in their control by preventing or reducing mating process in the new queen and before it enters the hibernation.

REFERANCES

Abouel-Enain, H. (1999). Studies on *Vespa orientalis* Fab. attacking honey bee colonies and its control by modified traps. **Egypt J. Appl. Sci., 14(2): 685-696.**

Archer, M.E. (1998). Taxonomy, distribution and nesting biology of *Vespa orientalis* L. (Hym.,Vespidae). **Entomologist's Monthly Magazine. 133(4): 45-51.** (c.f. **CAB Abst. AN: 19990503650**).

Elbassiouny, A.M. (1992). Comparative Studies on the Carniolan Honey Bee Race and Its Crosses. pp. 39-40. Ph.D. Thesis, Ain Shams University, Cairo.

El-Sherif, M.E. (2003). Seasonal fluctuation of oriental hornet, *Vespa orientalis* Fab., its trapping efficiency and honey bee activities. **J. Agric. Sci. Mansoura Univ., 28(4): 3133-3147.**

Foster, K.R. and F.L.W. Ratnieks (2001). Paternity, reproduction and conflict in vespine wasps: a model system for testing kin selection predictions. **Behav. Ecol. and Sociobiol.. 50(1): 1-8.**

Foster, R.K.; E.P. Seppa; F.L.W. Ratnieks and P.A. Thorean (1999). Low paternity in the hornet *Vespa crabro* indicates that multiple mating by queens is derived in vespine wasps. **Behav. Ecol. and Sociobiol. 46: 252 - 257.**

Foster, K.R.; F.L.W. Ratnieks and A.F. Raybould (2000). Do hornets have zombie workers? **Molecular Ecology. 9(6): 735-742.**

Foster,. K.R.; J. Gulliver and F.L.W. Ratnieks (2002). Worker policing in the European hornet *Vespa crabro*. **Insectes-Sociaux. 49(1): 41-44.**

Goodisman, M.A.D.; R.W. Matthews and R.H. Crozier (2002). Mating and reproduction in the wasp *Vespula germanica*. **Behav. Ecol. and Sociobiol. 51: 497–502.**

Heidari, S.; Y. Fathipour; S.E. Sadeghi and H. Baur (2004). Report of parasitoid wasp, *Pteromalus bifoveolatus* (Hym.: Pteromalidae) from Iran. **J. Entomol. Soc. of Iran. 24(1): 133-134**. **(CAB Abst. AN: 20053049449).**

Hussein, M.H. (1989). Studies on some pests of honey bee colonies in Dhofar, Oman. Proc. **4th Int. Conf. Apic. Tropic. Climates, Cairo. 370 – 376.**

Ishay, J.S.; D. Levanon; N. Avidor and O.S. Shechter (1983). Photoperiodicity stimulates cell size and caste determination in the oriental hornet **Vespa orientalis. Insectes-Sociaux. 30(3): 332-346.**

Ishay, J.S.; A.H. Abes; H.L. Chernobrov; I. Ishay and A. Ben Shalom (1991). Electrical properties of the Oriental hornet *Vespa orientalis* cuticle. **Comparative Biochemistry and Physiology. 100(2): 233-271. (CAB Abst. AN: 19920508668).**

Khater, A.M.; I.M.A. Ebadah and S.I. Youssif-Khalil (2001). The seasonal activity of oriental wasp, *Vespa orientalis* Fab. populations attacking honey bee colonies. **Arab Univ. J. Agric. Sci. 9(1): 447-454.**

Makino, S. and S. Yamane (1997). Nest contents and colonial adult productivity in a common hornet, *Vespa simillima simillima* Smith, in northern Japan (Hymenoptera, Vespidae). **Japanese J. of Entomol. 65(1): 47-54.**

Ratnieks, F.L.W.; T. Monnin and K.R. Foster (2001). Inclusive fitness theory: novel predictions and tests in eusocial Hymenoptera. **Annal. Zool. Fennici.; 38(3): 201-214. (c.f. CAB Abst. AN: 20033019767).**

Shabtai, Y. and J.S. Ishay (1998). Hornet silk caps maintain a clean room environment: a device for filtering out bacteria and dust particles. **Israel. Comparative Biochemistry and Physiology. 120(3): 565-570.**

Shoreit, M.N. (1998). Field observations on the seasonal abundance and control of *Vespa orientalis* Fab. attacking honey bee colonies in Egypt. **Assiut J. Agric. Sci., 29(1): 15-21.**

Stokroos, I.; L. Litinetsky; J.L. Want and J.S. Ishay (2001). Keystone like crystals in cells of hornet combs. Nature **London. 411(6838): 654. (CAB. Abst. AN: 20013082268).**

Takahashi, J.; S. Akimoto; E. Hasegawa and J. Nakamura (2002). Queen mating frequencies and genetic relatedness between workers in the hornet *Vespa ducalis* (Hymenoptera: Vespidae). **App. Entomol. Zool. 37(3): 481-486.**

Takahashi, J.; S. Akimoto; S.J. Martin; M. Tamukae and E. Hasegawa (2004 a). Mating structure and male production in the giant hornet *Vespa mandarinia* (Hymenoptera: Vespidae). **App. Entomol. Zool. 39(2): 343-349.**

Takahashi,J.; J. Nakamura; S. Akimoto and E. Hasegawa (2004 b). Kin structure and colony male reproduction in the hornet *Vespa crabro* (Hymenoptera: Vespidae). **J. Ethology. 22(1): 43-47. (CAB. Abst. AN: 20053049664).**

Youssif-Khalil S.I.; I.M.A. Ebadah and A.M. Khater (2000). Preliminary investigation on the efficiency of developed sticky trap in controlling *Vespa orientalis* Fab. attacking honey bee colonies. **Egypt J. Appl. Sci., 15(3): 282-294.**