SUGAR FEEDING PATTERN AND AGE STRUCTURE OF MOSQUITO SPECIES IN TWO EGYPTIAN VILLAGES

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(Received 3-7-2004)

INTRODUCTION

Male and female mosquitoes obtain sugars in nature from nectar, extrafloral sugars (Mogi and Miyagi 1989, Jaenson and Ameneshewa 1991), fruits (Schaefer and Miura 1972) and plant exudates (Reisen *et al.* 1986). In addition, plant fluids may be an important water source in arid climates (Reisen *et al.* 1986) and are the only food ingested by males. Sugars provide energy for flight and in the female serve as precursors for the synthesis of lipids reserves that eventually surpass caloric levels of glycogen (Nayar 1982; Van Handel 1984). The apparent preference of potential vector mosquito species to feed on certain plants suggests that they may be of indirect role in the epidemiology of mosquito borne diseases. In spite of this few studies have been conducted on the pattern of sugar feeding and the main sugar sources of Egyptian mosquitoes.

In this study the main objective was to determine which plant species serve as sugar sources for mosquito species in two different localities, El-Mekhames village, (Qalubiya Governorate) which is known to have a history of being endemic for human filariasis and El-Takadom village, a new settlement in Ismailia Governorates, which has no history of indemicity to the disease.

MATERIAL AND METHODS

Studies were conducted in two villages, El-Mekhames village (Qalubiya Governorate) located north east of Cairo and El-Takadom village east of the lakes area in Ismailia Governorate. The two villages were environmentally and socioeconomically different. El-Mekhames is a typical rural village surrounded by

cultivated land and irrigation canals. El-Takadom village represents a new settlement surrounded by newly reclaimed lands and inhabited with immigrant mostly from the Nile valley.

Mosquitoes were collected at 15d intervals from April 1998 to April 1999 from different cultivated and wild plants. A battery-powered aspirator (D-vac) (Nasci, 1981) was used to collect mosquitoes, resting outdoors on short plants for one to two hours twice a day, at early morning immediately after sunrise and before sunset. A series of collection, 10 minutes each was made in the different sites within a radius of 250 m.

CDC light traps (Hausherr's Machine works, Toms, River, New Jersey 8753,USA), were used to collect mosquitoes from long plants and trees from dusk to down. Mosquitoes collected by both methods were anesthetized by a least amount of chloroform and identified according to Gad (1963) and Harbach (1985). Females were classified according to their abdominal stages and dissected to determine Christopher's ovarian stages. Parity was determined according to Detinova (1962). All the dissected mosquitoes were tested for assesment of sugar feeding using cold anthrone test according to Van Handle (1972). Data were statistically analyzed using statistical package (Microstate).

RESULTS AND DISCUSSION

EL-Mekhames village:

A total of 5856 female *Cx. pipiens* were collected from long plants and trees (Table 1). The percentages of females collected from each plant revealed that citrus (25.2%), banana (17.3%) and berry trees (13.3%) were significantly the preferable resting sites (X^2 = 2020.9& P = 0.00001). Over all, 34.02% were sugar fed at comparable ratios on the available long plants (X^2 = 7.189 &P = 0.5164) (Table 1).

The significantly higher ratio of sugar fed females (X^2 =6131.503 & P = 0.00001) were empty (99.75% n = 1987) (Table 5), and at the first (60.53% n = 854) and second (38.41% n = 542) ovarian developmental stages (X^2 = 2768.643 & P = 0.00001) (Table6). Regarding their age structures, sugar feeding was significantly higher among nulliparous females (95.46% n = 1408) (X^2 = 384.219 & P = 0.00001) (Table7).

A total of 314 female *Cx. pipiens* were collected from short plants. Out of them 53.5% were collected from maize, a ratio which was significantly higher (X^2= 91.85 & P = 0.00001) than those collected from other short plants. Over all the collected females (46.2% n = 145) were sugar fed (Table 2).

Sugar feeding was recorded at significantly higher ratio (X^2 = 32.69 & P < 0.00001) among females collected from clover (71.4% n = 50) (Table 2) indicating that clover was a preferable sugar source for female *Cx. pipiens*.

Significantly higher ratio of the sugar fed females (X^2 = 55.125 & P = 0.00001) were empty (72.22% n = 104) (Table 5) at the second ovarian developmental stage (41.99% n = 55) (X^2 = 60.248 & P = 0.00001) (Table 6). Sugar feeding was recorded at significantly higher ratio (X^2 = 154.188 & P= 0.00001) among nulliparous females (72.92% n = 105) (Table 7).

EL Takadom village:

A total of 1331 female *Cx. pipiens* was collected from long plants and trees. Over all, 12.6%, 11.8%, 11.1%, 10.8%, 9.5% were collected from nerium, wolf grapes, mango, berrey and acassia respectively, indicating that they represented significantly favorable resting sites (X^2 = 323.14 & P =0.00001) (Table 3). Sugar feeding was recorded in 19% of the total collected mosquitoes. The percentages of sugar feeding on the different plants revealed that banana (32.8% n= 21), guava (32.6% n=14) and berry (31.5% n= 45) were significantly (X^2=97.25% & P=0.00001) preferable sugar sources for *Cx. pipiens* (Table 3).

Sugar feeding appeared at significantly higher ratio (X^2=1001,375 & P= 0.00001) among empty females (99.60% n=252) (Table 5), at the second developmental stage (69.69% n= 177)(Table 6). Regarding the age structure, significantly higher ratio of sugar feeding (X^2=325.66 & P=0.00001) was recorded among nulliparous females (73.75% n= 191) (Table 7).

On the other hand, a total of 104 female *Cx. pipiens* were collected from short plants. Over all significantly higher ratios (X^2=33.87& P=0.00001) were collected from maize (34.6%) and wild vegetations (33.7%) (Table 4). Sugar feeding was recorded at comparable ratios (X^2= 10.75& P=0.096) on the available short plants (Table4).

Like those collected from long plants, significantly higher ratio of sugar feeding (X^2=17.47 & P=0.000157) was recorded among empty females (75.0% n=36) (Table 5) at the second ovarian developmental stage (39.59% n=19) (X^2= 22.292 & P= 0.0002) (Table6). Regarding their age structure, *Cx. pipiens* females were recorded to take their sugar meals at significantly higher ratio (X^2= 15.14 & P=0.0005) while they were nulliparous (55.81% n=24) (Table 7).

A total of 407 female *Ae. caspius* were collected from long plants and trees. Collections from mango (21.6%) guava (17.5%) and olive trees (17.0%) revealed

that they were significantly preferable resting sites (X^2=2.0 &P=0.00001) for *Ae. caspius* (Table3).

Sugar feeding was recorded at significantly higher ratios (X^2=62.52 & P<0.00001) among females collected from banana (91.5% n=54), mango (87.5% n=77) and guava (80.3% n=57) (Table 3).

Significantly higher ratio of sugar fed females (X^2=1238.577 &P=0.00001) were empty (97.87 n=321) (Table 5), at the second ovarian development stage (92.06% n=197)(X^2=871.92 P=0.00001)(Table6). Regarding their age structure a significant ratio of them (X^2=612.413 & P=0.00001) were nulliparous (85.32% n=279) (Table 7).

On the other hand a total of 92 female *Ae. caspius* were collected from short plants. Over all, significantly higher ratio (X^2=120.98 & P=0.00001) were collected from maize (72.8%)(Table4). However, sugar feeding was recorded at comparable ratios (X^2=1.23 &P=0.942) on the available short plants (Table4).

Significantly higher ratio of sugar feeding (X^2=48.3 &P=0.00001) was recorded among empty females (47.06% n=40)(Table5). However comparable sugar feeding ratios were recorded in females with ovaries at stage II (32.56% n=28), III (23.26% n=20) and IV and V (39.53% n=34). On the other hand significantly lower ratio of sugar feeding (X^2=39.302 & P=0.00001) was recorded in females with ovaries at stage I (4.65% n=4)(Table 6).

Accorded to their age structure, comparable ratios of sugar feeding was recorded in nulliparous (44.05% n=29) and gravid females (34.52% n=25). However significantly lower ratio of sugar feeding (X^2=10.882 & P=0.004) was recorded among parous females (21.4% n=18).

TABLE (I)

Percentage of resting and sugar feeding of *Cx. pipiens* females collected from long plants and trees in El-Mekhames village Qalyubiya Governorate (1998-1999).

Type of vegetation	No. ♀♀ Collected	Resting (%)	No. ♀♀ Sugar +ve	Sugar (%+ve)
Custer oil plant	364	(6.2)	106	(29.1)
Maize	420	(7.3)	137	(32.6)
Sasaban	690	(11.8)	199	(28.8)
Safsaf	479	(8.2)	145	(30.3)
Beech	284	(4.8)	93	(32.8)
Citrus	1473	(25.2)	536	(36.4)
Berry	778	(13.3)	337	(43.3)
Banana	1011	(17.3)	321	(31.8)
Apricot	357	(6.1)	118	(33.1)
Total	5856		1992	(34.02)

TABLE (II)

Percentage of resting and sugar feeding of *Cx. pipiens* Females collected from short plants in El-Mekhames village Qalyubiya Governorate (1998-1999).

Type of Vegetation	No. ♀♀ Collected-	Resting (%)	No. ♀♀ Sugar +ve	Sugar (%+ve)
Clover	70	(22.3)	50	(71.4)
Wild vegetation	76	(24.2)	32	(42.1)
Maize	168	(53.5)	63	(37.5)
Total	314		145	(46.4)

TABLE (III)

Percentage of resting and sugar feeding in mosquito species collected from long plants and trees in El-Takadom village Ismailia Governorate (1998-1999).

Type of Vegetation	*Cx. pipiens*				*Ae. Caspius*			
	No. ♀♀ Resting Collected	(%)	No. ♀♀ Sugar +ve	Sugar (%+ve)	No. ♀♀ Resting Collected	(%)	No. ♀♀ Sugar +ve	Sugar (%+ve)
Custer oil plant	78	(5.9)	12	(15.4)	22	(5.4)	15	(68.2)
Acassia	128	(9.5)	27	(21.0)	2	(0.5)	2	(100.0)
Beech	109	(8.2)	21	(19.3)	7	(1.7)	7	(100.0)
Nerium	168	(12.6)	15	(8.9)	19	(4.7)	19	(100.0)
Wolf Grapes	157	(11.8)	20	(12.7)	21	(5.2)	17	(81.0)
Cazwarina	15	(1.1)	3	(20.0)	3	(0.7)	2	(66.7)
Mango	148	(11.1)	45	(30.4)	87	(21.4)	76	(87.5)
Olive	84	(6.3)	24	(28.6)	69	(17.0)	37	(53.6)
Berry	143	(10.8)	45	(31.5)	20	(4.9)	20	(100.0)
Banana	64	(4.8)	21	(32.8)	59	(14.5)	54	(91.5)
Guava	43	(3.2)	14	(32.6)	71	(17.4)	57	(80.3)
Vitis	70	(5.3)	1	(1.4)	3	(0.7)	0	(0.0)
Apple	56	(4.2)	2	(3.6)	23	(5.7)	20	(87.0)
Peach	68	(5.1)	3	(4.4)	1	(0.3)	1	(100.0)
Total	1331		253	(19.0)	407		328	(80.6)

TABLE (IV)

Percentage of resting and sugar feeding in mosquito species collected from short plants in El-Takadom village Ismailia Governorate (1998-1999).

Type of vegetation	*Cx. pipiens*				*Ae. Caspius*			
	No.♀♀ Resting Collected	(%)	No. ♀♀ Sugar Collected	(%+ve)	No. ♀♀ esting Collected	(%)	No. ♀♀ Sugar +ve	(%+ve)
Clover	16	(15.4)	6	(37.5)	1	(1.1)	1	(100.0)
Wild vegetation	35	(33.7)	14	(40.0)	19	(20.7)	18	(94.7)
Maize	36	(34.6)	16	(44.4)	67	(72.8)	61	(91.1)
Tomato	17	(16.3)	11	(64.7)	5	(5.4)	5	(100.0)
Total	104		47	(45.2)	92		85	(92.4)

TABLE (V)

Sugar feeding in the different metabolic stages of mosquito species collected from long and short plants in the two villages during (1998-1999).

Village & Type of vegetation	Sugar feeding in the different metabolic stages								
	Total Sugar Fed mosquitoes	Empty		Blood fed		H. Gravid		Gravid	
		No.	Sugar (%+ve)	No.	Sugar (%+ve)	No.	Sugar (%+ve)	No.	Sugar (%+ve)
El-Mekhames	*Cx.pipiens*								
Long plants	1992	1987	(99.75)	2	(0.10)	0	(0.00)	3	(0.15)
Short plants	144	104	(72.22)	2	(1.39)	10	(6.95)	28	(19.44)
El-Takadom	*Cx .pipiens*								
Long plants	253	252	(99.60)	1	(0.40)	0	(0.00)	0	(0.00)
Short plants	48	36	(75.0)	0	(0.00)	1	(2.08)	11	(22.92)
El-Takadom	*Ae. caspius*								
Long plants	328	321	(97.87)	4	(1.22)	3	(0.91)	0	(0.00)
Short plants	85	40	(47.06)	10	(11.76)	6	(7.06)	29	(34.12)

TABLE (VI)

Sugar feeding in the different ovarian developmental stages of mosquito species collected from long and short plants in the two villages during (1998-1999).

Village & Type of vegetation	Sugar feeding in the different Christopher's stages								
	Total sugar fed mosquitoes	I		II		III		IV&V	
		No.	Sugar (%+ve)	No.	Sugar (%+ve)	No.	Sugar (%+ve)	No.	Sugar (%+ve)
El-Mekhames	*Cx. pipiens*								
Long plants	1411	854	(60.53)	542	(38.41)	12	(0.85)	3	(0.22)
Short plants	131	27	(20.61)	55	(41.99)	11	(8.40)	38	(29.00)
El-Takadom	*Cx. pipiens*								
Long plants	253	68	(27.16)	177	(69.69)	8	(3.15)	0	(0.00)
Short plants	48	10	(20.83)	19	(39.58)	7	(14.58)	12	(25.0)
El-Takadom	*Ae. caspius*								
Long plants	215	14	(6.54)	197	(92.06)	0	(0.00)	4	(1.40)
Short plants	86	4	(4.65)	28	(32.56)	20	(23.26)	34	(39.53)

TABLE (VII)

Sugar feeding in the different age structures of mosquito species collected from Long and short plants in the two village during (1998-1999).

Village & Type of vegetation	Sugar feeding in the different metabolic stages						
	Total Sugar fed mosquitoes	Nulliparous		Parous		Gravid	
		No.	Sugar (%+ve)	No.	Sugar (%+ve)	No.	Sugar (%+ve)
El-Mekhames	*Cx.pipiens*						
Long plants	1475	1408	(95.46)	64	(4.34)	3	(0.20)
Short plants	144	105	(72.92)	14	(9.72)	25	(17.36)
El-Takadom	*Cx. pipiens*						
Long plants	260	191	(73.75)	69	(26.25)	0	(0.00)
Short plants	43	24	(55.81)	8	(18.61)	11	(25.58)
El-Takadom	*Ae. caspius*						
Long plants	327	279	(85.32)	48	(14.68)	0	(0.00)
Short plants	84	37	(44.05)	18	(21.43)	29	(34.52)

Culex pipiens and *Ae. caspius* were the main mosquitoes collected in El-Takadom village. On the other hand, *Cx. pipens* was the only species collected in El-Makhames village. It has been noticed that mosquitoes of both species tend to rest on the most abundant plants. For instance, most of the outdoor resting *Cx pipiens* in El-Mekhames were collected from citrus and banana trees, which were widely distributed in the village. On the other hand, in El-Takadom, the same species was collected at high ratios from nerium and wolf grape plants, which were found covering wide areas in the village. Maize was the most preferable short resting plant for *Cx. pipiens* in both study areas especially at the season of its maturation when the leaves of the plant reached their maximum sizes providing the adult mosquitoes with suitable shaded resting sites.

For *Ae. caspius*, it was found resting mainly between, mango, and guava trees which were cultivated near its breeding sites in El-Takadom and their orchards occupied relatively wide areas.

In El-Mekhames *Cx. pipiens* collected from long plants and trees, showed an opportunistic feeding behavior as it fed at comparable ratios on the nine available plants (custer oil, maize, sasabania, safsaf, beech, citrus, berry, banana and apricot). However, among short plants, *Cx. pipens* showed a preference to take their sugar meals from clover that was rotated everywhere in the village and its sequence in time provided a continuous carbohydrate source for mosquitoes. Consequently, the number of mosquitoes feeding on a plant species could be affected by its abundance i.e. mosquitoes tend to use the most abundant plants as sugar sources demonstrating opportunism (Magnarelli,1979).

On the other hand, in El-Takadom, significantly high ratios of fructose feeding were recorded in *Cx. pipiens* collected from banana, guava, berry and mango, and *Ae. caspius* collected from mango and banana where the mosquitoes can obtain their sugar meals either from their fruits (Schaefer and Miura, 1972), or their flowers (Kevan and Baker, 1983). which were characterized by their light colors, shallow cups and short straight corollas that make it easy for the mosquito to obtain their sugar meals (Kevan and Baker, 1983 and Gadawski and Smith, 1992). Also the distinctive and dominant volatiles such as the terpenoids and aromatic of the flowers and fruits might also elicit both chemosensory and behavioral responses in mosquitoes.

The study showed also that the highest fructose-feeding acceptance was observed mainly in nulliparous empty *Cx. pipiens* and *Ae. caspius* females at early ovarian developmental stages(I and II) suggesting the need of newly emerged

females to sugar meals for early flight (Martinez-Ibarra et al., 1997) before directing to their hosts. It could be also probably due to the intensive need of female mosquitoes to deposit their nutritive reserves at the early stages of ovarian development to be used later in advanced stages (Detinova, 1962 and Magnarelli, 1978). However, the presence of few anthron positively reacted mosquitoes at the other metabolic stages may be due to the storage of nectar that was not consumed during the course of digestion and maturation in the mosquitoes diverticulae at the time of taking blood meals (Nasci and Edman, 1984).

In El-Takadom village, the presence of comparable ratios of sugar feeding in *Ae. caspius* females collected from short plants while their ovaries at stages II,III.IV and V revealed that *Ae. caspius* may also actively seek nectar during oogensis as previously recorded by Andersson, (1990) in *Ae. communits*.

Consequently, it could be deduced that mosquito's sugar feeding in nature is affected by several factors such as the abundance of the plant hosts, the color and shape of their flowers as well as the distinctive volatiles of their flowers and fruits. The study also revealed that both *Cx. pipiens* and *Ae. caspius* seek sugar mainly while empty, nulliparous and at early ovarian developmental stages. However, *Ae. caspuius* showed also a tendency to seek sugar during oogensis.

SUMMARY

The sugar feeding pattern in nature of *Culex pipiens* and *Aedes caspius* were studied in two villages, El Mekhames village (Qalubiya Governorate) and El-Takadom village (Ismailia Governorate) from April 1998 to April 1999. Mosquitoes were collected by D-Vac from short plants and CDC light traps from long plants and trees. The collected females were dissected for parity and Christopher's stages and tested for sugar feeding using cold anthron test for fructose. In El Mekhames, *Cx. pipiens* was the only species recorded mean while in El Takadom the main mosquito were *Cx. pipiens* in addition to *Ae. caspius*. Mosquitoes of both species tend to rest on the most abundant plants. In El Mekhames *Cx. pipiens* showed an opportunistic feeding behavior and tends to use the most abundant plants as sugar sources. In El Takadom, *Cx. pipiens* females prefer to obtain their sugar meals from banana (32.8% n=21), guava (32.6% n=14), and berry (31.5% n=45). In both study areas *Cx. pipiens* females tend to take their sugar meals at significantly high ratios (P=0.00001) while they were empty, nulliparaus and at early ovarian developmental stages. In El Takadom, *Ae. caspius* females prefer to obtain their sugar meals from banana (91.5% n=54), mango (87.5% n=77), and guava (80.3% n=57) while they were empty (92.87% n=321) at the second ovarian developmental stage (92.06%

n=197). On the other hand comparable ratios of sugar feeding were recorded among *Ae. caspius* females which were collected from short plants. Sometimes *Ae. caspius* actively seek sugar during oogensis. Mosquitoes of both species tend to obtain sugar meals from plants, which are characterized by flowers with light colors, shallow cups and short straight corollas which make it easy for the mosquito to obtain their sugar meals.

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