Article available at http://www.parasite-journal.org or http://dx.doi.org/10.1051/parasite/2005123229

A TWO-YEAR SURVEY ON MOSQUITOES OF LEBANON

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Summary:

A total of 6,500 mosquitoes were identified during a two-year survey (1999-2001) in Lebanon, and these belonged to twelve species: *Culex pipiens*, *Cx. laticinctus*, *Cx. mimeticus*, *Cx. hortensis*, *Cx. judaicus*, *Aedes aegypti*, *Ae. cretinus*, *Ochlerotatus caspius*, *Oc. geniculatus*, *Oc. pulchritarsis*, *Culiseta longiareolata* and *Anopheles claviger*. *Culex pipiens* was the most predominant species in Lebanon, collected indoors and outdoors. It was continuously abundant and active throughout the year. *Culex judaicus* was a small and rare mosquito and it is reported to occur for the first time in Lebanon. On the coastal areas, *Ochlerotatus caspius* was very common, and proved to be a complex of species as two forms were detected. One of the vectors of malaria, *Anopheles claviger*, was collected from May to September, from eight sites in Lebanon. Its breeding sites were restricted to fresh, cool, and clean water in pools and wells. Most of these breeding sites were in the populated Metn County where a few indigenous cases of malaria were reported from 1997-2000. This shows that the reported malaria cases were not imported, but caused by the bites of locally infected *Anopheles* females.

KEY WORDS : mosquito, *Culex*, *Anopheles*, malaria, Lebanon.

Résumé : LES MOUSTIQUES DU LIBAN : RÉSULTATS DE DEUX ANS DE RÉCOLTES

Au cours d'une période d'observation de deux ans (1999-2001), 6 500 moustiques ont été identifiés au Liban et répartis en 12 espèces : Culex pipiens, Cx. laticinctus, Cx. mimeticus, Cx. hortensis, Cx. judaicus, Aedes aegypti, Ae. cretinus, Ochlerotatus caspius, Oc. geniculatus, Oc. pulchritarsis, Culiseta longiareolata *and* Anopheles claviger. Culex pipiens, *l'espèce prédominante, a été collectée à l'extérieur et à l'intérieur. Elle a été trouvée abondante et active tout au long de l'année.* Culex judaicus, *espèce petite et rare, a été observée et identifiée pour la première fois au Liban. Dans les zones côtières, il s'est avéré que l'espèce* Ochlerotatus caspius, *très communément observée, était en fait un complexe car deux formes ont été identifiées.* Anopheles claviger, *porteur de malaria, a été collecté de mai à septembre sur huit sites libanais. Leur habitat de prédilection était l'eau claire et froide des puits et bassins. La plupart des sites concernés se trouvent dans le comté du Metn où quelque cas de malaria autochtones ont été rapportés entre 1997 et 2000, ceci prouvant bien l'implication des anophèles femelles localement infectées.*

MOTS CLÉS : *moustique,* Culex, Anopheles, *paludisme, Liban.*

Mosquitoes are of great economic importance because many act as vectors for a number of human diseases, such as malaria, dengue, filariasis, and several types of encephalitis including West Nile fever (Service, 1993). With the constantly changing environment, the epidemiology of mosquito-borne diseases is also modified. Global warming, periodic flooding and deforestation have opened new habitats to mosquitoes which show high plasticity in their breeding behavior and readily spread their distribution. In fact, sporadic malaria outbreaks have been reported in non-endemic countries and transmission of the disease was caused by the bite of a locally infected *Anopheles* species (Zucker, 1996).

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In Lebanon, several mosquito-borne diseases mainly malaria and dengue were endemic until the 1950's when the government launched a mosquito eradication program (Matossian & Ibrahim, 1974). No cases of dengue and malaria were reported afterward; however, since 1997, several incidences of local malaria have occurred in some populated areas of Lebanon (Hamadeh, 1997). It seems that malaria still poses a threat to the country especially that the disease was never eradicated from the neighboring countries. To examine the transmission of diseases by mosquitoes in Lebanon, it is critical to start by studying the taxonomy, distribution and abundance of these vectors, especially that knowledge of the mosquito species in Lebanon is very patchy and dates from the 1940's and 70's (Parr, 1943; Matossian & Ibrahim, 1974).

The aims of this study are to update and evaluate the current status of mosquito species in Lebanon, and to determine the breeding sites, abundance and distribution of the Lebanese mosquitoes, with special emphasis on the malaria vectors.

MATERIALS AND METHODS

Starting 1999, a two-year survey on mosquito species was initiated in Lebanon. Mosquitoes were collected from all provinces and sectors of the country, with the exception of some inaccessible areas in the South (Fig. 1). The aquatic larvae and pupae were collected using dippers (Bioquip), from different breeding sites, such as rocky pools, ponds, swamps, irrigation ditches, streams... They were brought to the laboratory and reared into adults using mosquito breeders (Bioquip).

Adult mosquitoes were collected from outdoors and indoors using various methods, such as vials, aspirators, human bait technique, and mosquito traps (Standard New Jersey Light Trap, and Heavy Duty EVS CO_2 Mosquito Trap by Bioquip).

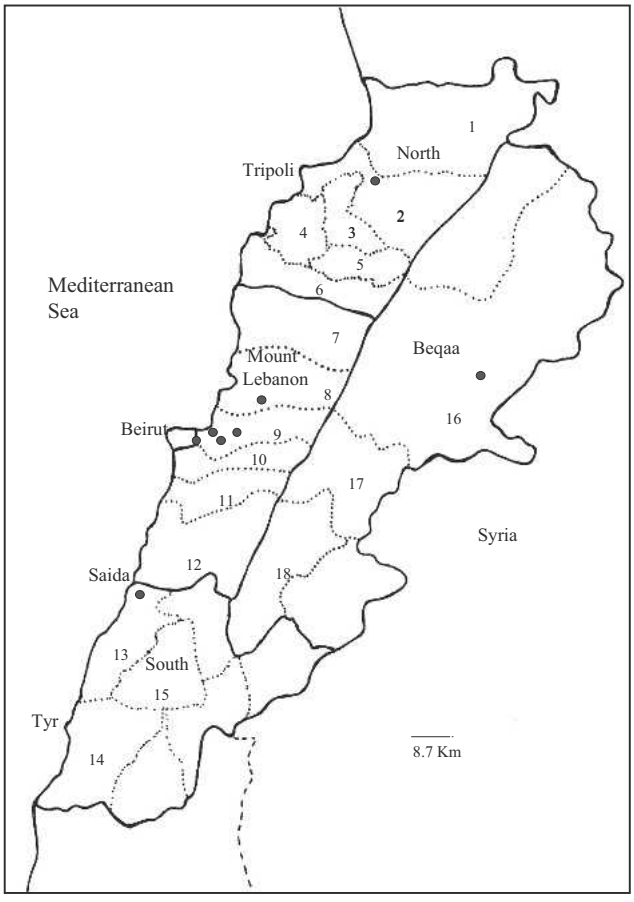

Fig. 1. – Map of Lebanon showing the different counties where mosquitoes were collected for this survey, and showing the sites of collection of *Anopheles* claviger.
(1) Akkar Co.; (2) Tripoli Co.; (3) Zgharta Co.; (4) Koura Co.; (5) Bcharre Co.; (6) Batroun Co.; (7) Jbeil Co.; (8) Kesrouan Co.; (9) Metn Co.; (10) Baabdah Co.; (11) Aaley Co.; (12) Chouf Co.; (13) Saida Co.; (14) Tyr Co.; (15) Nabatiyeh Co.; (16) Baalback Co.; (17) Zahleh Co.; (18) West Beqaa Co.
(• denotes sites of collection of *An. claviger*).

In order to estimate changes in mosquito density throughout the year, periodic indoor house collections from July 1999 to July 2000 were made weekly in five selected houses situated in Beirut and its suburbs: Ain El Roumaheh (Greater Beirut), Sabtieh (Greater Beirut), Zalka (Metn Co., Mount Lebanon), Nabay (Metn Co., Mount Lebanon), and Rabwe (Metn Co., Mount Lebanon). The weekly indoor collections involved the same catch efforts per unit time in each house: number of actively biting and resting mosquitoes caught during five hours after sunset.

The taxonomy of the collected mosquitoes were determined using keys by Dubose & Cutin (1965), Harbach (1985, 1988), Jayson (1992), Glick (1992), and Samanidou-Voyadjoglou & Harbach (2001) after an initial consultation and species confirmation by Dr Harbach (NHM, London). Voucher specimens were preserved in the NHM, American University of Beirut.

RESULTS

A total of 6,500 mosquitoes were collected from various sites in Lebanon. The mosquitoes belonged to two subfamilies, Culicinae and Anophelinae, and twelve species: a - *Culex (Culex) pipiens*; b - *Cx. (Culex) laticinctus*; c - *Cx. (Culex) mimeticus*; d - *Cx. (Maillotia) hortensis*; e - *Cx. (Neoculex) judaicus*; f - *Ochlerotatus (Ochlerotatus) caspius*; g - *Oc. (Finlaya) geniculatus*; h - *Oc. (Ochlerotatus) pulchritarsis*; i - *Aedes (stegomyia) cretinus*; j - *Ae. (Stegomyia) aegypti*; k - *Culiseta (Allotheobaldia) longiareolata*; and l - *Anopheles (Anopheles) claviger*.

The regions with GPS readings where different mosquito species were collected are indicated in the text below with the exception of *Cx. pipiens* which was extremely widespread in the country. For this reason, the counties and number of sites per county are indicated for the latter species.

a - *Culex (Culex) pipiens* Linnaeus, 1758
Greater Beirut: 442F:15M Beirut (20 sites). Mount Lebanon: 597F:36M (Aaley Co.) (14 sites); 514F:12M (Baabdah Co.) (4 sites); 292F:18M (Chouf Co.) (12 sites); 385F:40M (Kesrouan Co.) (14 sites); 588F:31M (Metn Co.) (22 sites); 205F:2M (Jbeil Co.) (5 sites). North Lebanon: 78F (Batroun Co.) (2 sites); 274F:5M Koura (Co.) (6 sites); 112F:5M (Tripoli Co.) (4 sites); 10F:4M (Akkar Co.) (2 sites); 10F (Zgharta Co.) (2 sites). South Lebanon: 156F:10M (Saida Co.) (6 sites); 94F:2M (Nabatiyeh Co.) (2 sites); 96F:4M (Tyr Co.) (4 sites). Beqaa Valley: 172F:13M (Zahle Co.) (5 sites); 507F:12M (Baalback Co.) (6); 329F:12M (West Beqaa Co.) (4 sites).
Culex pipiens was the most predominant and widespread species in Lebanon, collected indoors and outdoors, and comprising ca. 78 % of the total collected

Species	Total number	Females	Males	Percentage
Culex pipiens	5,082	4,861	221	78.2
Cx. laticinctus	142	77	65	2.18
Cx. mimeticus	99	51	48	1.52
Cx. hortensis	39	22	17	0.60
Cx. judaicus	33	22	11	0.51
Ochlerotatus caspius	769	526	243	11.83
Oc. geniculatus	20	20	–	0.31
Oc. pulchritarsis	2	2	–	0.03
Ae. cretinus	34	32	2	0.52
Ae. aegypti	1	–	1	0.01
Culiseta longiareolata	185	133	52	2.85
Anopheles claviger	94	66	28	1.45

Table I. – Total number and percentages of the 12 mosquito species collected in Lebanon during 1999-2001.

Species	Number	Percentage
Culex pipiens	1,466	97.93
Cx. laticinctus	8	0.53
Cs. longiareolata	10	1.34
Aedes cretinus	1	0.07
Anopheles claviger	2	0.13

Table II. – Number and percentage of mosquito species collected indoors in the five monitored houses, during 1999-2000.

mosquitoes (Table I). It was distributed throughout the country and found at all altitudes. Its breeding sites were diverse, ranging from artificial containers such as cans filled with rain water, water reservoirs, garden pools, to rivers, ponds, and irrigation ditches.

This species was continuously abundant and active throughout the year. Monitoring mosquitoes in five selected houses throughout the year demonstrated that *Cx. pipiens* was the most abundant mosquito indoors, accounting for 97.9 % of the catches (Table II). Its behavior was anthropophilic, endophagic, and endophilic. In 1999-2000, the changes in population density of *Cx. pipiens* indoors, as observed in the monitored houses, showed that the female mosquitoes were active throughout the year as long as the temperature was favourable (Fig. 2). An increase in the population of *Cx. pipiens* females was detected in November when the temperature started to drop. This could be explained by the fact that the females appeared to be the overwintering stage, and remained active and did not hibernate when the winter was wild.

b - *Culex (Culex) laticinctus* Edwards, 1913

Mount Lebanon: 4F Ainab (Aaley Co.) (33 45 963'N; 35 32 636'E); 1F Bolonia (Metn Co.) (33 54 656'N; 35 44 066'E); 2F:1M Chehim (Chouf Co.) (33 37 086'N; 35 29 160'E); 6F Deir El Kamar (Chouf Co.) (33 41 802'N; 35 33 928'E); 6F Doha (Chouf Co.) (33 45 461'N; 35 28 716'E); 2F Kornet El Hamra (Kesrouan Co.) (33 56 203'N; 35 39 065'E); 33F:21M Yahchouch (Kesrouan Co.) (34 03 998'N; 35 43 897'E); 5F:6M Nahr El Kalb (Metn Co.) (33 56 779'N; 35 38 008'E); 4F Rabwe (Metn Co.) (33 53 048'N; 35 34 320'E); 2F:2M Ghazir (Kesrouan Co.) (34 01 159'N; 35 39 324'E); 1M Jiye (Chouf Co.) (33 39 796'N; 35 25 563'E). South Lebanon: 3F Kasmieh (Tyr Co.) (33 19 314'N; 35 17 194'E); 5F:2M Saida (Saida Co.) (33 34 702'N; 35 25 030'E); 3F:1M Ras El Ain (Tyr Co.) (33 13 688'N; 35 13 061'E). North Lebanon: 1F:1M Enfe (Koura Co.) (34 21 534'N; 35 43 818'E); 3F Kousba (Koura Co.) (34 18 035'N; 35 51 017'E). Greater Beirut: 3F:2M Sabtieh (33 51 721'N; 35 34 826'E). Beqaa Valley: 8F:4M Btedaai (Baalback Co.) (34 06 623'N; 36 06 116'E); 3F:7M Chlifa (Baalback Co.) (34 05 037'N; 36 06 027'E).

This species was collected from April to November, as adults from indoors and as larvae from outdoor water sources. The larvae were found to breed in rivers, such

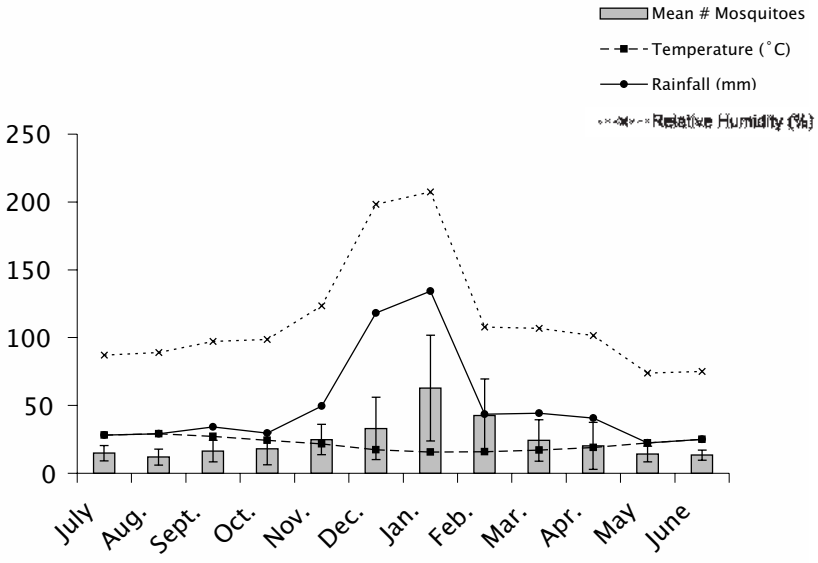

Fig. 2. – Changes in the population density of *Culex pipiens* females as observed in the monitored houses during 1999-2000.

as Nahr El Kalb, in garden pools, in artificial containers, such as water filled barrels, in water reservoirs, and in irrigation ditches. The adults were collected indoors, and were found to rest on indoor walls. In fact, *Cx. laticintus* was found to be the third most abundant mosquito species indoors, but it was found at a low density and accounted for only 0.53 % of the catches in the monitored houses (Table II). Therefore, this species also exhibits anthropophagic, endophagic, and endophilic behaviours, but with a much lesser degree than *Cx. pipiens*.

c - *Culex (Culex) mimeticus* Noè, 1899
North Lebanon: 43F:46M Oyoun El Samak (Akkar Co.) (34 26 630'N; 36 02 253'E). Mount Lebanon: 8F:2M Yahchouch (Kesrouan Co.) (34 03 998'N; 35 43 897'E).
This species was only collected outdoors in the summer, in natural and large fresh water sources, namely, river banks.

d - *Culex (Maillotia) hortensis* Ficalbi, 1899
Greater Beirut: 2M Achrafieh (33 53 467'N; 35 31 015'E). Beqaa Valley: 3F:3M Ras El Ain (Baalback Co.) (34 00 334'N; 36 13 269'E); 5F:3M Chlifa (Baalback Co.) (34 05 037'N; 36 06 027'E); 4F:2M Btedaai (Baalback Co.) (34 06 623'N; 36 06 116'E); 2F:4M Ammiq (West Beqaa Co.) (33 43 265'N; 35 46 667'E). North Lebanon: 4F:1M Bebnine (Akkar Co.) (34 29 901'N; 35 59 724'E). South Lebanon: 1F:1M Kasmieh (Tyr Co.) (33 19 314;N; 35 17 194'E). Mount Lebanon: 3F:1M Yahchouch (Kesrouan Co.) (34 03 998'N; 35 43 897'E).
This species preferred mainly natural fresh water sites for breeding purposes and was found from May to September. Larvae were collected from the Ammiq swamp, irrigation ditches, and large water reservoirs next to river banks. Only a few (5) adults were colleted from indoor houses although this species was not reported in the monitored houses. *Culex hortensis* comprised 0.60 % of the total collected mosquitoes, and was most prominent in the field (Table I).

e - *Culex (Neoculex) judaicus* Edwards 1926
Mount Lebanon: 20F:9M Nahr Ibrahim (Kesrouan Co.) (34 04 648'N; 35 44 135'E); 3M Yahchouch (Kesrouan Co.) (34 03 998'N; 35 43 897'E). South Lebanon: 2F Qâsmiyé (Tyr Co.) (33 19 314'N; 35 17 194'E).
This is a very small mosquito that was collected in the North and South of Lebanon, from April to September, and only in the field, in river banks or in water reservoirs next to rivers.

f - *Ochlerotatus (Ochlerotatus) caspius* (Pallas, 1771)
North Lebanon: 7F Batroun (Batroun Co.) (34 15 109'N; 35 39 251'E); 25F:4M Chekka (Batroun Co.) (34 19 525'N; 35 43 261'E); 90F:78M Enfe (Koura Co.) (34 21 714'N; 35 43 638'E); 3F Saidat El Nourieh (Koura Co.) (34 18 630'N; 35 40 592'E); 106F:35M Qalamoun (Tripoli Co.) 934 23 922'N; 35 47 826'E); 2F:2M El Mina (Tripoli Co.) (34 26 976'N; 35 48 579'E); 3F:2M Sanani Island (Tripoli Co.) (34 29 257'N; 35 46 696'E); 12F:11M Rabbit Island (Tripoli Co.) (34 29 808'N; 35 46 364'E). Mount Lebanon: 27F Berbâra (Jbeil Co.) (34 12 722'N; 35 38 397'E); 46F:41M Hâlât (Jbeil Co.) (34 05 539'N; 35 38 807'E); 4F Jbeil (Jbeil Co.) (34 07 859'N; 35 38 375'E); 8F:3M Nahr Ibrahim (Jbeil Co.) (34 03 943'N; 35 39 130'E); 1F:1M Nahr El Kalb (Metn Co.) (33 57 150'N; 35 36 089'E); 74F:2M Maameltein (Kesrouan Co.) (34 00 713'N; 35 38 375'E); 16F Aakaibe (Kesrouan Co.) (34 03 404'N; 35 37 987'E); 3M Kartaba (Jbeil Co.) (34 05 873'N; 35 50 520'E); 11F:9M Jiyé (Chouf Co.) (33 40 037'N; 35 24 884'E); 25F:18M Ouâdi ez Zeini (Chouf Co.) (33 37 563'N; 35 24 204'E); 38F:30M Saadiyât (Chouf Co.) (33 41 635'N; 35 25 366'E). South Lebanon: 12F:4M Nahr El Kasmieh (Tyr Co.) (33 19 314'N; 35 17 194'E); 12F Rachidiyeh (Tyr Co.) (33 14 172'N; 35 12 619'E). Greater Beirut: 4F Manara (33 53 542'N; 35 28 147'E).
Ochlerotatus caspius was mainly captured from the sea shore, from mid April to October. The larvae were found to breed in salty rocky pools and adult females became very active around sunset at high densities, and were capable of inflicting painful bites. This species was also found in natural fresh water river banks, mainly in the rivers close to the coast. It was not captured indoors, and appeared to have a strong anthropophilic, exophagic, and exophilic behaviors. With respect to its density, it was found to be the second most abundant mosquito, accounting for about 12 % of the total catches (Table I).
Ochlerotatus caspius appeared to be a complex of species. Morphological differences were detected between the population in the South of Lebanon from the Kasmieh River and the rest of the populations. The specimens collected at Kasmieh River matched the typical description of *Oc. caspius* (Dubose & Curtin, 1965; Lambert *et al.*, 1990) in having on the mesonotum all fawn-colored scales and two submedial lines of whitish scales running along the length of the scutum. Also, the abdominal terga showed transverse basal bands of pale scales, in addition to a pale, median, dorsal stripe. The rest of the specimens differed in having a scutum covered with scales golden-brown in color, which was similar to the description of *Ochlerotatus (Ochlerotatus) mariae* (Sergent & Sergent, 1903) (Dubose & Curtin, 1965; Samanidou-Voyadjoglou & Harbach, 2001), but they differed from the description of *Oc. mariae* because of the absence of scales on the metameron. Therefore, they seem to be a species near *caspius* and thus remain to be classified under *Oc. caspius*, which seems to be a species complex.

g - *Ochlerotatus (Finlaya) geniculatus* (Olivier, 1791)
North Lebanon: 12F Ehden (Zghorta Co.)(34 17 887'N; 35 58 838'E). Mount Lebanon: 8F Souq El Gharb (Aaley Co.) (33 47 393'N; 35 33 731'E).

This species was only caught during the month of June both in the field and indoors, at high elevations in Mount Lebanon.

h - *Ochlerotatus (Ochlerotatus) pulchritarsis* (Rondani, 1872)
Mount Lebanon: 2F Qlaiaât (Kesrouan Co.) (33 58 375'N; 34 42 409'E)
This is a rare mosquito that was captured during the month of June.

i - *Aedes (Stegomyia) cretinus* (Edwards, 1921)
Mount Lebanon: 3F Broummana (Metn Co.) (33 52 807'N; 35 38 267'E); 3F Douar (Metn Co.) (33 54 496'N; 35 41 546'E); 2F Baabda (Baabda Co.) (33 49 901'N; 35 32 702'E); 2F:1M Kafarchima (Baabda Co.) (33 48 600'N; 35 32 745'E); 4F Naqqach (Metn Co.) (33 55 566'N; 35 35 373'E); 1F Râbié (Metn Co.) (33 55 257'N; 35 35 312'E); 10F:2M Souq El Gharb (Aaley Co.) (33 48 393'N; 35 33 731'E); 4F Sahel Alma (Kesrouan Co.) (33 59 971'N; 35 39 281'E). Greater Beirut: 2F Achrafieh (33 53 467'N; 35 31 015'E).
This species was found at low density and was caught outdoors and indoors, from May to October. It accounted for 0.07 % of the catches made in the monitored houses. It appeared to have anthropophilic and endophagic behaviours, and seemed to be distributed from sea level to medium altitude mountains in Mount Lebanon.

j - *Aedes (Stegomyia) aegypti* (Linnaeus, 1762)
Mount Lebanon: 1M Kartaba (Jbeil Co.) (34 05 873'N; 35 50 520'E).
Only one male was collected outdoors next to a river bank.

k - *Culiseta (Allotheobaldia) longiareolata* (Macquart, 1838)
Mount Lebanon: 2F Hadath (Baabda Co.) (33 50 607'N; 35 31 979'E); 1F Hâzmiyé (Baabda Co.) (33 51 517'N; 35 32 329'E); 1F:2M Ain Saâdé (Metn Co.) (33 52 037'N; 35 35 088'E); 1M Bayyada (Metn Co.) (33 55 325'N; 35 38 679'E); 9F:12M Nahr El Kalb (Metn Co.) (33 56 779'N; 35 38 008'E); 2F Zouk (Metn Co.) (33 56 205'N; 35 36 024'E); 8F:1M Zalqa (Metn Co.) (33 54 117'N; 35 34 344'E); 1F Hammana (Aaley Co.) (33 49 474'N; 35 43 847'E); 20F:5M Nahr Ibrahim (Kesrouan Co.) (34 04 648'N; 35 44 135'E); 3F Yahchouch (Kesrouan Co.) (34 03 998'N; 35 43 897'E); 4F Tabarja (Kesrouan Co.) (34 01 994'N; 34 37 469'E); 6F:2M Okaiba (Jbeil Co.) (34 03 609'N; 35 38 418'E). Greater Beirut: 16F:5M Beirut (33 53 504'N; 35 29 855'E); 3F Ain El Roumaheh (33 51 108'N; 35 32 001'E); 7F:3M Sabtieh (33 51 721'N; 35 34 826'E) . Beqaa Valley: 18F:10M Labweh (Baalback Co.) (34 12 463'N; 36 22 589'E); 3F Btedaai (Baalback Co.) (34 06 623'N; 36 06 116'E); 4F:4M Chlifa (Baalback Co.) (34 05 037'N; 36 06 027'E); 1M Nahle (Baalback Co.) (34 01 240'N; 36 15 627'E); 6F:4M Ras El Ain (Baalback Co.) (34 00 334'N; 36 13 269'E). South Lebanon: 4F Saida (Saida Co.) (33 34 702'N; 35 25 030'E); 12F:2M Qâsmiyé (Tyr Co.) (33 19 314'N; 35 17 194'E); 3F Maaraké (Tyr Co.) (33 16 295'N; 35 18 550'E).
This large mosquito was caught from March to September, both indoors and as larvae in the field. The larvae bred in fresh, clean water sources such as irrigation ditches, water reservoirs, garden pools, water cans near Nahr Ibrahim, and water filled barrels.
Culiseta longiareolata accounted for 2.85 % of the collection (Table I). Although it represented only 1.34 % of the mosquitoes collected in the monitored houses (Table II), it was found to be the second most abundant mosquitoes indoors. Its behaviour appeared to be anthropophilic, endophagic, and endophilic.

l - *Anopheles (Anopheles) claviger* (Meigen, 1804)
Mount Lebanon: 1F Ain El Saadeh (Metn Co.) (33 52 037'N; 35 35 088'E); 1F Besalim (Metn Co.) (33 53 820'N; 35 34 475'E); 3F:2M Yahchouch (Kesrouan Co.) (34 03 998'N; 35 43 897'E); 6F Broummana (Metn Co.) (33 52 807'N; 35 38 267'E). Greater Beirut: 2F Sabtieh (33 51 721'N; 35 34 826'E). Beqaa Valley: 3F Nahle (Baalback Co.) (34 01 240'N; 36 15 627'E). South Lebanon: 2M Nahr El Awally (Saida Co.) (33 34 702'N; 35 25 030'E). North Lebanon: 50F:24M Oyoun El Samak (Akkar Co.) (34 26 630'N; 36 02 253'E).
This species was caught from late April to November both indoors as adults and as larvae in the field. The larvae were found only to breed in cold, fresh and clean water sources, such as wells, natural pools and clean puddles next to river banks.
Anopheles claviger accounted for 1.45 % of the total collection (Table I) and 0.13 % of the catches in the monitored houses (Table II). Gravid females were collected from houses in highly populated areas, in all of the three sites in the Metn Co. of Mount Lebanon, and in one of the monitored houses (Sabtieh) in Greater Beirut (Fig. 1).

DISCUSSION

The results of the survey demonstrated that *Cx. pipiens* was the most common and abundant mosquito species in Lebanon, both indoors and outdoors. Similarly, Parr (1943) previously reported that *Culex pipiens molestus* (Forskal 1775) was "*a domestic species whose distribution probably extends to every town and village in Syria and Lebanon*". In fact, *Culex pipiens* was reported to be very widely distributed in the whole Paleartic and eastern areas of the Afrotropical Region such as Yemen and the southwestern part of the Saudi Arabia (Harbach, 1988). Moreover, *Cx. pipiens molestus* has been identified in Lebanon by

Matossian & Ibrahim (1974) who reported that it was responsible for the transmission of the West Nile Virus infection in Egypt, and other countries in the Eastern Mediterranean.

Culex laticinctus was the second most abundant *Culex* species collected indoors and outdoors, yet with a much lower density. In accordance with our results, this species was reported to be mainly paleartic (Harbach, 1988), and was previously reported in Lebanon by Parr (1943) and Harbach (1985). In 1943, Parr noted that *Cx. laticinctus* started to breed in late spring and became abundant in coastal areas during the summer. This species is not known to be involved in the transmission of diseases.

Culex mimeticus was also reported by Parr (1943) who found it common in the summer months in coastal and inland areas of Lebanon. On the other hand, in 1974, Matossian & Ibrahim did not observe its presence. Our results indicate the current rarity of this mosquito and its association with wild habitats.

Regarding the rest of the *Culex* species, they were found at low densities in Lebanon. *Culex hortensis* was also reported by Parr (1943) who found it abundant in the spring. Our results showed its occurrence from April to September, in natural aquatic habitats. As for *Cx. judaicus*, it was found to be a rare species in Lebanon. This species was not previously reported to occur in Lebanon, and thus we report it as a new record. It was noted as a new record in Jordan by Amr *et al.* (1997). As for other *Culex* species, Parr (1943) reported the occurrence of *Culex (Culex) univittatus* Theobalt 1901 in different areas of the country during the summer and fall. This species might have become rare as it was not encountered in our survey and during the work of Matossian and Ibrahim in 1974. Moreover, Harbach (1985, 1988) reported the occurrence of three *Culex* species that we did not encounter in our survey. These species are: *Culex (Culex) perexiguus* Theobald 1903, *Culex (Culex) theileri* Theobald 1903, and *Culex (Culex) tritaeniorhynchus* Giles, 1901. Parr (1943) did not report the presence of *Cx. perexiguus*, but mentioned that he collected larvae of *Cx. tritaeniorhynchus* but no adults from a rain water cistern in one site of Lebanon and reported that *Cx. theileri* is not common at all in Lebanon. He found a few adults of this later species in the Ammiq swamp, which is today quite altered as the water level has tremendously decreased. It could be that these species became rare due to habitat modification.

Several *Ochlerotatus* species were collected in this survey. *Ochlerotatus caspius* was found to be very common and abundant in the coastal areas. Two forms were detected; thus, this species seems to form a complex and needs further investigation. *Ochlerotatus caspius* has not been previously reported in Lebanon. Parr (1943) found the presence of one female *Oc. mariae*, and Matossian & Ibrahim (1974) confirmed its presence. However, this could have been a misidentified *Oc. caspius*. *Ochlerotatus caspius* was reported in other Middle Eastern countries, such as Egypt (El Shazly *et al.*, 1998) and Israel (Braverman *et al.*, 1991).

The rest of the *Ochlerotatus* species, *Oc. geniculatus*, and *Oc. pulchritarsis* were less abundant. None were reported previously to occur in Lebanon. Parr (1943) mentioned the possibility of the presence of *Oc. geniculatus* in Lebanon, but he could not make an accurate identification as his specimen was in poor condition.

Two *Aedes* species were encountered in this survey. *Aedes cretinus* was found at low densities in both outdoors and indoors. This mosquito species was not reported previously to occur in Lebanon. On the other hand, Parr (1943) reported the presence of *Ae. aegypti*, which we encountered only one specimen in our survey, most probably as it occurs now at a very low density and perhaps because it was the target of eradication programs by the government. In fact, Matossian & Ibrahim (1974) noted that several epidemics of dengue took place in Lebanon from 1861 to 1946, but none for the 25 years after, and the reasons for the disease disappearance were not fully understood. They also postulated that the eradication of *Ae. aegypti* vector could be the main reason.

Culiseta longiareolata was quite common in Lebanon. Parr (1943) reported the presence of *Theobaldia longiareolata* (Macquart), but Matossian & Ibrahim (1974) did not report its existence in Lebanon. This species was also reported from other Middle Eastern countries such as Jordan (Khyami-Horani *et al.*, 1999), Egypt (El Shazly *et al.*, 1998) and Israel (Braverman *et al.*, 1991).

One of the vectors of malaria, *Anopheles claviger*, was collected from May to September, from eight sites in Lebanon. The breeding sites for this species were restricted to fresh, cool, and clean water habitats. Three of these breeding sites were in Ain Saade and its surrounding areas (Metn Co.), where a few indigenous cases of malaria were reported in 1997, 1999, and 2000 (Hamadeh, 1997; El Awar, personal communication). In all these cases, the patients did not leave the country and did not have any blood transfusion. These observations clearly show that the reported malaria cases were not imported, but autochthonous and caused by the bites of locally infected *Anopheles* females.

Previous studies reported other *Anopheles* species in Lebanon, such *An. (Anopheles) algeriensis* Theobald 1903, *An. (Anopheles) hyrcanus* (Pallas 1772), *An. (Cellia) dthali* Patton 1905, *An. (Cellia) multicolor* Cambouliu 1902, *An. (Cellia) pulcherrimus* Theobald 1902, *An. (Cellia) rhodesiensis rupicola* Lewis 1937, and *An. (Cellia) sergentii* (Theobald 1907) (Glick 1992), *An. (Anopheles) marteri* Senevet and Prunelle 1927, *An.*

(Anopheles) sacharovi Favre 1903, and *An. (Cellia) superpictus* Grassi 1899 (Glick, 1992; Parr, 1943). However, these species were not collected in our survey. It could be that either they became very rare after the Mosquito Eradication Campaign in the 1960's or their breeding sites were altered.

In the 1940's, malaria vectored by several *Anopheles* species was hyperendemic in Lebanon, especially in the coastal regions. After the initiation of the Malaria Eradication Program, eradication was achieved in Lebanon as no indigenous cases of malaria were observed after 1963 (Matossian & Ibrahim, 1974). However, because of the resurgence of malaria in many parts of the world, and because the disease was never completely eradicated from neighbouring countries, such as Syria and Israel (Schwartz, 1994), malaria still poses a threat to Lebanon, especially that the returning tourism and post-civil war influx from different countries, such as Africa, have made the protozoan reservoir available. Our findings demonstrate the occurrence of the malaria vector at low densities in a few populated regions of Mount Lebanon where tourism is common. This indicates that malaria surveillance should be strengthened and the vector breeding sites should be closely monitored.

ACKNOWLEDGEMENTS

The authors would like to thank Dr R. Harbach (NHM, London) who helped in the initial identification of the mosquitoes, and Miss H. Zournajian who helped in processing the collected specimens. This research was made possible because of a 'URB' research grant from the American University of Beirut.

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Reçu le 10 janvier 2005
Accepté le 3 mai 2005