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Original Article

Species composition and monthly distribution of mosquito (culicidae) larvae in the Istanbul metropolitan area, Turkey

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ABSTRACT

There is no data available about the mosquito fauna of Istanbul. In 2003, a project to improve mosquito control and to reduce mosquito densities to an acceptable level began in the Istanbul metropolitan area. The present study gives an overview of data on the species composition, abundance and distribution of mosquito larvae in the Istanbul metropolitan area. Larval samples were collected between May and October, 2003-2007. A total of 293655 larvae were examined from 1701 different samples taken in 15 different potential larval habitats. 45.05% (n=132307) of mosquito larvae were from permanent and 54.95% (n=161348) were from temporary breeding sites. This study showed that Istanbul harbors 21 larval species from the genera *Culex, Anopheles, Aedes, Ochlerotatus and Culiseta.* When the density of each species was examined, it was found that *Cx. pipiens* was dominant (91%) and frequent (100%). The highest intensity was in July (134972 larvae) while the lowest was in October (2035 larvae). The larvae intensity and species diversity decreased from 2003 (223079 larvae/15 species) to 2007 (12700/9 species). The present work demonstrates that *Cx. pipiens* was dominant in Istanbul and larvae intensity and species diversity decreased during this study period. It is likely that this reduction was due to the mosquito control strategy used in the Istanbul metropolitan area.

1. Introduction

Mosquitoes are vectors of numerous viruses and other parasitic disease pathogens affecting human and animal health. Despite the improved treatment and prevention of malaria, mosquitoes still constitute a severe nuisance for humans and domestic animals in many rural, suburban, and urban areas around the world [1,2]. There are 50 currently recognized endemic species of mosquito in Turkey [3]. In southern Turkey, where most malaria cases occur, An. saccharovi, An. superpictus and An. maculipennis are the most important malarial vectors [4,5]. The *Cx. pipiens* species complex is an important potential vector of the West Nile Virus (WNV) and lymphatic filariasis [6-9]. No cases of WNV have been reported in Turkey; however some cases of bancroftian flariasis have been seen [10,11].

Field research on mosquito biology and ecology has been aimed toward a better understanding of mosquito reproductive biology. Favorable larval habitats can be found mainly on the coast and in the lowlands. Mosquitoes appear in large numbers after flooding and the resulting tributaries cause considerable extension of mosquito breeding habitats [1, 2].

Istanbul is the most populated city in Turkey and has nearly 13 million inhabitants. It is an important socio-economic bridge between Asia and Europe. There are many canals, municipal

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moats, clay pits, pot holes, pools, wells and lakes and ponds in parks and gardens providing suitable breeding sites for mosquitoes in the Istanbul metropolitan area. Additionally, floods during the rainy spells result in numerous temporary water bodies in suburban areas. The climate is very favorable for mosquito growth, winters are mild and short and summers are long and warm [12].

In 2003, a project to improve mosquito control and to reduce mosquito densities to an acceptable level began in the Istanbul metropolitan area and is still in operation today. The field research results of this project have been used to construct a model of integrated mosquito control that includes planning, organization, administration and realization of a control project with special emphasis on microbial elimination of mosquito larvae.

2. Material and Methods

2.1. Study area

Istanbul is located between the coordinates 28º 01' and 29º 55' East longitudes and 41º 33' and 40º 28' North latitudes. The total area is nearly 5400 km2 and there are 32 counties. Istanbul is located on two peninsular area divided by the Bosporus. As a result of geological movements, Istanbul resembles a worn-out plateau. The geomorphological units in Istanbul such as valleys, plains, light wave heights and higher grounds have no distinct shapes. Higher grounds with continuous rises (+350 m) are found in the eastern peninsula. The western side contains a plateau with wide based river valleys. In this peninsula, there are hills and ridges ranging between 200-350 m and the maximum elevation above sea level are 540 m.

The natural flora of the Istanbul Metropolitan area is composed of forest, maquis, pseudo-maquis and seaside plants. The plant groups have adapted to varying environments, with "humid" species in the north and "dry" species in the south.

Istanbul is on the border of a subtropical high pressure zone and the cold-warm part of a low-pressure zone. It has terrestrial, dry, alize winds and west winds coming from the sea that are humid and rainy. The annual temperature ranges from 3-5ºC degrees in January-February to 23-28ºC degrees in July-August. The average temperature between May-October is 20.1ºC while annual average is 14.3ºC. The average annual relative humidity and rainfall ranges between 55-75% and 500-700 mm [12,13].

There are diverse macro-ecosystems such as forests, streams, lakes, marshlands, canals, residential areas as well as hundreds of micro-ecosystems. Therefore, a great variety of larval habitats are found in Istanbul.

2.2.Sampling

Mosquito larvae were gathered from May to October 2003-2007. At 1701 sampling sites, larvae from 15 different habitats were collected. Sampling sites included various water bodies, for example flooded cellars, wells, pools, potholes, marshes, ponds in parks and gardens and irrigation canals. Mosquitoes were collected for at least 10 consecutive days. Ten dips were taken from each habitat with a standard mosquito dipper to collect larvae [14]. The samples were transported to the laboratory and some larvae (approximately 10%) were grown to adulthood in order to confirm species identification, while others were preserved in 70-80% alcohol and were classified according scheme developed by Harbach [15].

2.3. Data analysis

All data were tested for significance using Kolmogroff-Smirnoff (1999, Version 3.0). The seasonal dynamics of mosquito larvae populations in sampling sites were analyzed using the following factors [2]:

2.3.1. Distribution was determined as the percentage of sampling sites in which a species was found according to the formula:

C = (n/N) x 100% (where: C = distribution, n= number of sites of the species, N= number of all sites). The following distribution classes were adopted:

C1 = sporadic appearance (constancy 0 – 20 %)
C2 = infrequent (20.1 – 40 %)
C3 = moderate (40.1 – 60 %)
C4 = frequent (60.1 – 80 %)
C5 = constant (80.1 -100 %)

2.3.2.Density was expressed as the percentage of specimens of a given species in the whole sample according to the formula:

D = l/Lx100% (where: D = density, l = number of specimens of each of mosquito species, L = total number of specimens). The following density classes were used:

Satellite species (D<1%)
Subdominant species (1<D<5%)
Dominant species (D>5%)

3. Results

3.1.Mosquito species

Twenty one mosquito species were identified from the 5 genera *Culex, Anopheles, Aedes, Ochlerotatus* and *Culiseta*. There were 9 Culex: *Cx. pipiens Linnaeus, Cx. theileri Theobald, Cx. torrentium Martini, Cx. laticinctus Edwards, Cx. perexiguus Theobald, Cx. territans Walker, Cx. tritaeniorhynchus Giles, Cx. mimeticus Noé and Cx. hortensis Ficalbi.* There were 4 Anopheles species: *An. maculipennis Meigen, An. sacharovi Favre, An. superpictus Grassi, An. claviger Meigen* There were 2Aedes species: Ae. cinereus Meigen, *Ae. vexans Meigen*; Four Ochlerotatus species were found: *Oc. echinus Edwards, Oc. dorsalis Meigen, Oc. caspius Pallas, Oc. rusticus Rossi.* Finally 2 Culiseta species were found: *Cs. langiareolata Macquart and Cs. annulata Schrank* (Table 1)

Table 1: Identified mosquito genera and species from Istanbul Metropolitan area

GENERA	*Culex*	*Anopheles*	*Aedes*	*Ochlerotatus*	*Culiseta*
SPECIES	*Cx. pipiens*	*An. maculipennis*	*Ae. cinereus*	*Oc. echinus*	*Cs. langiareolata*
	Cx. theileri	*An. sacharovi*	*Ae. vexans*	*Oc. dorsalis*	*Cs. annulata*
	Cx. torrentium	*An. superpictus*		*Oc. caspius*	
	Cx. laticinctus	*An. claviger*		*Oc. rusticus*	
	Cx. perexiguus				
	Cx. territans				
	Cx. tritaeniorhynchus				
	Cx. mimeticus				
	Cx. hortensis				

3.2.Abundance of mosquito species

In term of density, *Cx pipiens* was dominant (91%); *Cx. torrentium* (3%), *Cx. tritaeniorhynchus* (2%) and *Cx. laticinctus* (1.1%) were subdominant and *Cx. theileri*, *Cx. perexiguus,* Cx. *territans, Cx. mimeticus, Cx. hortensis, An. maculipennis., An. sacharovi, An. superpictus, An. claviger, Ae. cinereus, Ae. vexans, Oc. echinus, Oc. dorsalis, Oc. caspius, Oc. rusticus, Cs. langiareolata* and *Cs. annulata* species were satellite (<1%).

The distribution was as follows: *Cx pipiens* (100%) and *Cx.torrentium* (86.6%) were constant (constancy = 80.1-100%), *Cs. langiareolata* (66.6%) was frequent (60.1-80%), *An. maculipennis* (60%), *Cx. theileri* (53.3%), *An. sacharovi* (40%), *Cx.laticinctus* (40%) were moderate (40.1-60%), other species *Cx. territans* (33%), *Cx. tritaeniorhynchus* (33%), *Cx. perexiguus* (27%) and *Cs. annulata* (27%) were infrequent (20.1-40%) and *Cx. mimeticus* (6.6%), *Cx. hortensis* (13.3%), *An. superpictus* (13.3%), *An. claviger* (33.3%), *Ae. cinereus* (6.6%), *Ae. vexans* (6.6%), *Oc. echinus* (13.3%), *Oc. dorsalis* (13.3%), *Oc. caspius* (13.3%), *Oc. rusticus* (6.6%) appeared sporadically (0-20%) (Table 2).

3.3.Habitat preferences of mosquito species

In Table 3 and 4, the occurrence of the mosquito larvae in the breeding sites is documented. A total of 293655 larvae were collected from 1701 samples of 15 different potential larval habitats. The larvae were taken from 45.05% (n=132307) permanent and 54.95% (n=161348) temporary breeding sites. It was determined that the contribution of permanent and temporary sites to the species population density was roughly equal. *Cx. pipiens* was the domiant species in both types of breeding sites, with an abundance of 41.17% in the permanent and 49.93% in the temporary sites. The second most abundant species was *Cx. torrentium* in the permanent sites and *Cx. tritaeniorhynchus* and *Cx. laticinctus* in the temporary sites. All species were found in the permanent breeding sites except for *Cx. mimeticus* and in temporary breeding sites except for Ae. cinereus, *Ae. vexans, O. dorsalis* and *O. rusticus.* Only *Cx. pipiens* was found during all sampling periods at all of the breeding sites. The highest intensity of mosquito larvae was in cellar (n=51096), watercourse (n=50550) and stagnant water (n=46490) while the lowest was in wheel (n=172) and fountain (n=558). There was no breeding site that contained all species. Ponds had the most species variety and contained 15/21 of the species (71%) while wheel contained the least variety with 1/21 (4.7%) of the species. There was a significant distribution of larvae in ponds ($p<0.002$), pools ($p<0.021$), marshes ($p<0.047$), cellars ($p<0.055$), shafts ($p<0.017$), stagnant water ($p<0.003$) and watercourses ($p<0.007$). Some species were found only in one breeding site: *Cx. mimeticus* was only seen in shafts, Ae. cinereus only in watercourses and Ae. vexans and *O. rusticus* only in ponds.

3.4. Monthly changes in larval abundance

The seasonal changes in abundance of different species of mosquito larvae that occurred during the study period of May to October are shown in Table 5. The highest intensity of larvae was in July (n=134972) while the lowest was in October (n=2035). The differences of in larval abundance were significant ($p<0.05$) from May to September. *Cx. pipiens, Cx. torrentium, Cx theileri, An. maculipennis* and *O. rusticus* were found from May to October, whereas *Cx. mimeticus* was found only in June, *Ae. cinereus* in July, *Ae. vexans* in May and *O. rusticus* in September.

The larvae intensity and species diversity decreased from 2003 (n=223079, 15 species) to 2007 (n=12700, 9 species) but there was no significant difference in the distribution of the larvae over the study period ($p>0.05$). Cx. tritaeniorhynchus, Cx. laticinctus, Cx. mimeticus, An. superpictus and Ae. cinereus were found only in 2003, Ae. vexans and O. rusticus in 2004 and O. dorsalis in 2005 (Table 6).

Table 2: Occurrence of characteristic mosquito species in the sampling sites in Istanbul region

SPECIES	Total (2003-007)	Distribution (2003-2007)	Density (2003-2007)	Density, Distribution status [a]
Cx. pipiens	267559	100,00	91,11	Dominant, Constant
Cx. torrentium	8883	86,6	3,02	Subdominant, Constant
Cx. territans	1128	33,3	0,38	Satellite, Infrequent
Cx. theileri	1414	53,3	0,48	Satellite, Moderate
Cx. perexiguus	466	26,6	0,16	Satellite, Infrequent
Cx. tritaeniorhynchus	6082	33,3	2,07	Subdominant, Infrequent
Cx. hortensis	35	13,3	0,01	Satellite, Sporadic
Cx. laticinctus	3280	40,0	1,12	Subdominant, Moderate
Cx. mimeticus	22	6,6	<0,01	Satellite, Sporadic
An. maculipennis	1706	60,0	0,58	Satellite, Moderate
An. claviger	86	33,3	0,02	Satellite, Infrequent
An. sacharovi	270	40,0	0,09	Satellite Moderate
An. superpictus	415	13,3	0,14	Satellite, Sporadic
Ae. cinereus	100	6,6	0,03	Satellite, Sporadic
Ae. vexans	400	6,6	0,14	Satellite, Sporadic
Oc. echinus	715	13,3	0,24	Satellite, Sporadic
Oc. dorsalis	23	13,3	<0,01	Satellite, Sporadic
Oc. caspius	24	13,3	<0,01	Satellite, Sporadic
Oc. rusticus	15	6,6	<0,01	Satellite, Sporadic
Cs. langiareolata	872	66,6	0,30	Satellite, Frequent
Cs. annulata	160	26,6	0,05	Satellite, Infrequent

a) Dominant (D>5%), Subdominant (1<D<5%), Satellite (D<1%), Constant (80.1 -100 %), Frequent (60.1 – 80 %), Moderate (40.1 – 60 %), Infrequent (20.1 – 40 %), Sporadic (0-20%)

Table 3: The distribution of mosquito larvae in permanent and temporary breeding sites

SPECIES	PERMANENT BREEDING AREAS[a]		TEMPORARY BREEDING AREAS[b]		TOTAL
Cx. pipiens	120909 [c]	(45.19) (41.17)[d]	146650[c]	(54.81) (49.93) [d]	**267559**
Cx. torrentium	7255	(81.67) (2.47)	1628	(18.33) (0.55)	**8883**
Cx. territans	1113	(98.67) (0.38)	15	(1.33) (0.00)	**1128**
Cx. theileri	266	(18.81) (0.09)	1148	(81.19) (0.39)	**1414**
Cx. perexiguus	452	(96.99) (0.15)	14	(3.01) (0.00)	**466**
Cx. tritaeniorhynchus	33	(0.54) (0.01)	6049	(99.46) (2.06)	**6082**
Cx. hortensis	5	(14.28) (0.00)	30	(85.72) (0.01)	**35**
Cx. laticinctus	562	(17.13) (0.19)	2718	(82.87) (0.93)	**3280**
Cx. mimeticus			22	(100.00) (0.00)	**22**
An. maculipennis	198	(11.60) (0.06)	1508	(88.40) (0.51)	**1706**
An. claviger	66	(76.74) (0.02)	20	(23.26) (0.00)	**86**
An. sacharovi	113	(41.85) (0.04)	157	(58.15) (0.05)	**270**
An. superpictus	315	(75.90) (0.10)	100	(24.10) (0.03)	**415**
Ae. cinereus	100	(100.00) (0.03)			**100**
Ae. vexans	400	(100.00) (0.14)			**400**
O. echinus	15	(2.10) (0.00)	700	(97.90) (0.24)	**715**
O. dorsalis	23	(100.00) (0.00)			**23**
O. caspius	9	(37.50) (0.00)	15	(62.50) (0.00)	**24**
O. rusticus	15	(100.00) (0.00)			**15**
Cu. langiareolata	310	(35.55) (0.10)	562	(64.45) (0.19)	**872**
Cu. annulata	148	(92.50) (0.05)	12	(7.50) (0.00)	**160**
TOTAL	**132307**	**(45.05)**	**161348**	**(54.95)**	**293655**

a : Ponds, pools, marshes, watercourse, irrigation canals.

b : Cellar, dung pits, fountain, cistern, tires, shaft, stagnant water, wastewater grid, reedy etc.

c : Number of species

d : Percentage and relative abundance of the species

Table 4: The mosquito larvae in different breeding sites

SPECIES	POND	POOL	MARSHES	CELLAR	DUNG PITS	FOUNTAIN	WHEEL	CISTERN	SHAFT	PURIFICATION		WASTEWATER GRİD	WATERCOURSE	IRRIGATION CANALS	REEDY	TOTAL
Cx. Torrentium	6025	565	54	741	115	25		131	123	36	277		467	144	180	**8883**
Cx. Theileri	73	13	180	205	17				30	80	816					**1414**
Cx. Tritaeniorhynchus		6		5522					2		525			27		**6082**
Cx. Laticinctus	33			33				2500	152		33			529		**3280**
An. Maculipennis	130	8	22		5			2	19		1482		34	4		**1706**
An. Sacharovi	84		8	25					24		108		21			**270**
Ae. cinereus													100			**100**
O. echinus											700			15		**715**
O. caspius											15		9			**24**
Cs. langiareolata	20	148		141				78	139	0	167	36	140	2	1	**872**
TOTAL	**36269**	**31154**	**5350**	**51096**	**16546**	**558**	**172**	**10037**	**28323**	**1515**	**46490**	**5352**	**50550**	**8984**	**1259**	**293655**

Table 5: The seasonality of larval abundance of mosquito larvae species

SPECIES	MONTHS OF 2003-2007						TOTAL
	May	June	July	August	September	October	
Cx.torrentium	366	1315	5620	829	504	249	**8883**
Cx. theileri	48	362	502	316	158	28	**1414**
Cx.tritaeniorhynchus		49	5506		2	525	**6082**
Cx.laticinctus	152	3128					**3280**
An. maculipennis	5	126	40	66	1463	6	**1706**
An.sacharovi	23	18	138	69	22		**270**
Ae. cinereus			100				**100**
O. echinus				15	700		**715**
O. caspius			15	9			**24**
Cs. langiareolata	88	20	193	368	113	90	**872**
TOTAL	**10644**	**78801**	**134972**	**48907**	**18296**	**2035**	**293655**

Table 6: The larval abundance of mosquito larvae species from 2003 to 2007

SPECIES	YEARS					TOTAL
	2003	2004	2005	2006	2007	
Cx. pipiens	201556	25830	22313	6360	11500	**267559**
Cx.torrentium	7295	908	321	180	179	**8883**
Cx. territans	1097	22	8		1	**1128**
Cx. theileri	1105	308			1	**1414**
Cx. perexiguus	216			250		**466**
Cx. tritaeniorhynchus	6082					**6082**
Cx. hortensis		30	5			**35**
Cx.laticinctus	3280					**3280**
Cx. mimeticus	22					**22**
An. maculipennis	1593	4	20	13	76	**1706**
An. claviger	48	28	9		1	**86**
An. sacharovi	224	43	3			**270**
An. superpictus	415					**415**
Ae. cinereus	100					**100**
Ae. vexans			400			**400**
O. echinus			15		700	**715**
O. dorsalis				23		**23**
O. caspius			15	9		**24**
O. rusticus			15			**15**
Cs. langiareolata	33	297	268	44	230	**872**
Cs. annulata	13	116	9	10	12	**160**
TOTAL	**223079**	**27586**	**23401**	**6889**	**12700**	**293655**

4. Discussion

Ramsdale et al [3]. recently published a revised list of the mosquitoes of Turkey. They recognized 50 endemic species of mosquitoes from 8 genera. Other studies have identified different numbers of species of mosquitoes [16, 17]. There are a lot of studies on the mosquito species of Turkey, especially in the Central and South-Eastern Anatolian and Mediterranean areas. We found that there is no data available about the mosquito fauna of Istanbul since 1960. This study contains novel findings showing that there are 21 mosquito species from 5 genera present in the Istanbul metropolitan area (Table 1).

The results of some studies show that Cx. pipiens is the most abundant species in several different areas [18-21] and is the primary cause of mosquito bites in urban areas [9]. Mostafa et al [22] and El-Bashier et al [23], reported that, in fourteen Egyptian Governorates, the Culex genus were the most common and that in that genus, C. pipiens was the most frequently found species. Geery and Holub [24] reported that only larvae from Cx. pipiens (63% of total) and Cx. restuans (37% of total) were found in catch basins in Illinois. Knio et al [25], found that Cx. pipiens was the most dominant species in Lebanon. Rydzanicz and Lonc [2] also reported that the most abundant and constant species in Wroclaw, Poland was Cx. pipiens. The results from studies in Turkey have been similar. The majority of the mosquitoes in the Cukurova region are Cx. Pipiens [26, 27]. Simsek [28] found that the Cx. pipiens, Cx. theileri and Oc. caspius were the most frequently found species in the Sanliurfa province where there are substantial numbers of irrigated fields due to the Southeastern Anatolia Project. Aldemir [29] took a sample of mosquitoes in immature stages in the Ankara region and found that Cx. pipiens was most common. Alten [30] showed that Cx. pipiens and Cx. tritaeniorhynchus are the most abundant species in the Belek region. Cetin and Yanikoglu [31] determined that Cx. pipiens was the dominant species in different habitats found in the Antalya city center. However, different dominant mosquito species were identified in some areas. Doran and Lewis [32] showed that Oc. stimulans is the most abundant species in suburban Montreal, Quebec. Aldemir et al [33] revealed that the most dominant species in the Igdir Plain of Turkey was Oc. dorsalis. El Shazly et al [34] reported that the most common larvae in Egypt are Cx. univittatus, Cx. antennatus and Ae. caspius. Our data showed that Cx. pipiens was dominant (91%), Cx. torrentium (3%), Cx. tritaeniorhynchus (2%) and Cx. laticinctus (1.1%) were subdominant and other species were satellite (<1%).

In the last decade, many studies have published findings about the species composition and abundance of mosquitoes in different places. Diversity and intensity have been found to depend on differences in geographical location, ecological patterns, habitat specificity, and population size and/or research methods. Devi and Jauhari [35] reported that in India, the existence of sites with high and low species diversity is closely related to disturbance and fragmentation of habitats, such as emerging new habituation, deforestation, development of urban areas, etc. In addition, mosquitoes control activities should be targeted to sites that generate the most adult vectors, thereby reducing operational costs. Larval source management, a strategy for mosquito larval control which includes source reduction through environmental manipulation, modification and elimination of aquatic habitats, has long been used to reduce the incidence of malaria in many parts of the tropics [36]. In this study, we found that temporary breeding sites are abundant (54.95% of total) and important larval habitats. As a result of mosquito control activities and larval source management, the larvae intensity and species diversity decreased from 2003 (n= 223079, 15 species) to 2007 (n= 12700, 9 species).

In this study we discovered that the Culex complex (98.35% of total), especially Cx. pipiens, is the dominant (91.1 % of total) species in the Istanbul metropolitan area. In addition, it was found that Cx. pipiens does not have a specific habitat preference, was collected during all of the study periods and could breed in all of the aquatic habitats. The greatest intensity of Cx. pipiens larvae was in June, July and August. Cx. hortensis, Cx laticinctus, Cx. mimeticus, An.superpictus, Ae. vexans and Cs. annulata were found before June. This is an important finding for mosquito control inspectors. Cx. torrentium was identified as the subdominant species (3% of total) in this investigation and it shares similar ecological requirements and morphology with Cx. Pipiens [37] Harbach [38] reported that the Culex species had high population densities generally in urban areas rather than in rural regions. Cx. pipiens is a well-recognized vector of diseases throughout the world. It is a domesticated species that has developed in close association with man and is considered to be of high importance because of its disease transmission potential. This species is one of the most important vectors of West Nile Virus (WNV). Urban Cx. pipiens is a ubiquitous Turkish urban pest mosquito and is the most plausible vector for Bancroftian filariasis transmission in various parts of the country [3] Although WNV could not be detected in any mosquito species, the antibodies against virus were found positive in human serum samples in Turkey [39].

Monitoring and identifying mosquito species is an important component of the Public Heath Service's commitment to protecting the health of residents and preventing the spread of vector-borne diseases. Until now, only chemical insecticides have been used for mosquito control in the Istanbul metropolitan region. This is the first study, which provides data for the design of an integrated mosquito control strategy for the Istanbul area with environmentally friendly larvicidal biopreparations.

5. Conclusion

This investigation reveals certain aspects of the species composition and seasonal abundance of mosquitoes in the Istanbul metropolitan region. Cx. pipiens is most abundant and constant species. Additionally, it was found that both permanent and temporary sites contributed about equally to species population density. The highest intensity of larvae was in July. The larvae intensity and species diversity decreased from 2003 to 2007. These results strongly suggest that the mosquito control program in the Istanbul region is going to continue successfully.

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