



Determined and estimated mosquito (Diptera, Culicidae) fauna in the city of Osijek, Croatia, using dry-ice baited CDC traps

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Abstract

Background and Purpose: The city of Osijek is well known as city of molesting mosquitoes. The investigation was done with the purpose of establishing a scientific basis for modern mosquito control. In this paper the results of a 10 year investigation of mosquitoes in Osijek (Croatia, south Panonian Plain) are presented.

Materials and Methods: Dry-ice baited CDC traps were used for sampling. The traps were placed on 9 localities in the city of Osijek and were active 22–24 hours a day. The traps were active twice a month (May–Sep) during ten years (1995–2004) and sampled 207.136 specimens of mosquitoes.

Results and Conclusions: In the sampled material 20 species of mosquitoes were determined. The most numerous species was *Aedes vexans* which represented 75.59% of the fauna in the area. Most of the species (11) were present throughout the whole, and only 2 species appeared at the beginning of season. The mosquito fauna is very rich with domination of one species.

INTRODUCTION

Mosquitoes and Osijek seem to be two complementary terms. Geomorphologic characteristics of the Osijek area indicate the existence of a large number of potential large breeding sites. It is estimated that about 10,000 ha of floodplains near the city are the potential breeding sites for mosquitoes that are present in Osijek. The first research article on mosquitoes in Osijek was published during World War II (1). Even though there were many problems with mosquitoes, it took almost 50 years before they were investigated in the Osijek area. There had been several attempts by the city government to organize a more expert and scientific approach to this problem, and they finally succeeded in the mid 1990s. They established continuous monitoring of mosquitoes, creating a database on the breeding sites, species and the number of mosquitoes. This paper presents qualitative and quantitative composition of mosquito fauna from 1995 to 2004.

Baranov registered 8 mosquito species in 1943 and described breeding sites in the city and the surrounding area. In two other papers the focus was on the mosquitoes that hibernate in Osijek basements (2, 3). The paper identified three hibernating species, categorized the basements, and the abundance of mosquitoes during hibernation. Special attention has always been paid to mosquitoes that are potential malaria

vectors. In Osijek, there have been investigations of the Anophelinae fauna represented by two species: *Anopheles messeae* and *An. maculipennis*, the former of which is predominant in the sites closer to flooded areas, and the latter in sites more remote from them (4). In a 1996 paper (5), there is an overview of earlier research based on recorded 21 mosquito species, four of which had not been recorded in the city. During 2001 some authors (6) investigated the population dynamics of two of the most abundant species in Osijek: *Aedes vexans* and *Ochlerotatus sticticus*. Both species breed in flooded area around the city, and the paper determined the ecological factors that directly influence their population abundance. An investigation on seasonal dynamics of *Anopheles maculipennis* complex in Osijek showed that localities closer to Kopački rit area had more mosquitoes of this complex, and bimodal peak of abundance was noted (7).

All published papers and the established monitoring system are a sound foundation for a well-organized mosquito control. The main principle in this approach is to use the least invasive and harmful method that will not damage the environment and endanger other organisms. A biological, highly selective method was selected, based on the toxic activity of the bacteria *Bacillus thuringiensis israelensis*, that affects only mosquitoes (Culicidae) and black flies (Simuliidae) that also belong to the hematophagous insects (8).

MATERIAL AND METHODS

The sampling was done from 1995 to 2004 using dry ice-baited CDC traps. The traps consist of a plastic tube 10 cm in diameter, in which there is a fan for taking in mosquitoes. The tube has a lid that increases the sucking area and protects it from rainfall. Mosquitoes are trapped in a net attached to the plastic tube. The fan is powered by DC 6V battery. The attractant, 9 kg of dry ice, was placed in 9 traps in the city. The traps were turned on twice a month from May to September, and worked between 22 and 24 hours on a given day. The total of 207.136 mosquitoes were trapped, 206.904 were determined. The determination was conducted using the keys by (9, 10).

Three specimens of the same species trapped at each of the sites were mounted. The mounting was carried out using the dry method of sticking individual mosquitoes on entomological needles no. 2 or 3, using organic insect glue. The collection was stored in the entomological collection of the Department of Biology, Josip Juraj Strossmayer University in Osijek.

RESULTS

During ten years of investigation of mosquitoes in the city of Osijek, we have the total of 20 mosquito species. Of the recorded species, seven are from the genus *Ochlerotatus*, four from the genus *Anopheles*, three from the genera *Aedes* and *Culex* each, and there was one species belonging to each of the genera *Culiseta*, *Coquillettidia* and *Uranotaenia*, as follows:

Family CULICIDAE

Subfamily ANOPHELINAE

Genus *Anopheles* Meigen, 1818

Subgenus *Anopheles* Meigen, 1818

1. *claviger* Meigen, 1804
2. *hyrcanus* Pallas, 1771
3. *maculipennis* Meigen, 1818
4. *plumbeus* Stephens, 1828

Subfamily CULICINAE

Genus *Aedes* Meigen, 1818

Subgenus *Aedes* Meigen, 1818

5. *cinereus* Meigen, 1818
6. *rossicus* Dolbeshkin, Gorickaja and Mitrofanova, 1930

Subgenus *Aedimorphus* Theobald, 1903

7. *vexans* Meigen, 1830

Genus *Ochlerotatus* Lynch – Arribáizaga, 1891

Subgenus *Ochlerotatus* Lynch – Arribáizaga, 1891

8. *cantans* Meigen, 1818
9. *caspicus* Pallas, 1771
10. *cataphylla* Dyar, 1916
11. *excrucians* Walker, 1856
12. *leucomelas* Meigen, 1804
13. *sticticus* Meigen, 1838

Subgenus *Rusticoides* Shevchenko & Prudkina 1973

14. *rusticus* Rossi, 1790

Genus *Coquillettidia* Dyar, 1905

Subgenus *Coquillettidia* Dyar, 1905

15. *richiardii* Ficalbi, 1889

Genus *Culex* Linnaeus, 1758

Subgenus *Barraudius* Edwards, 1921

16. *modestus* Ficalbi 1890

Subgenus *Culex* Linnaeus, 1758

17. *pipiens* Linnaeus, 1758

Subgenus *Neoculex* Dyar, 1905

18. *territans* Walker, 1856

Genus *Culiseta* Felt, 1904

Subgenus *Culiseta* Felt, 1904

19. *annulata* Schrank, 1776

Genus *Uranotaenia* Lynch – Arribáizaga, 1891

Subgenus *Pseudoficalbia* Theobald, 1912

20. *unguiculata* Edwards, 1913

The species composition varied from year to year. First, there were differences in the number of recorded species, it varied from 11 to 16. In the first year of investi-

TABLE 1

Quantitative and qualitative composition of mosquito species in Osijek during 1995–2004.

Species / Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total
<i>Aedes vexans</i>	31475	12581	22787	4870	5564	4437	12925	35069	68	26762	156538
<i>Ochlerotatus sticticus</i>	3724	1949	592	210	1126	1748	638	2043		15563	27593
<i>Culex pipiens c.</i>	1457	333	1631	513	2894	216	871	894	307	3024	12140
<i>Anopheles maculipennis c.</i>	213	538	478	99	574	1376	149	81	31	492	4031
<i>Ochlerotatus cantans</i>	220	34	186	187	1052	60	7	12	50	31	1839
<i>Ochlerotatus caspius gr.</i>	156	19		7	143	24	442	150	12	244	1197
<i>Ochlerotatus excrucians</i>	895	8	15	154	3	9	30	9	27	18	1168
<i>Culex modestus</i>	1	385	113	85	31	1	4	9	53	28	710
<i>Coquillettidia richiardii</i>	14	156	181	151	64	53	26	16	13	1	675
<i>Aedes rossicus</i>	168	6			2	1	150	11			338
<i>Aedes cinereus</i>	157	8	1		1	3		23	2		195
<i>Culex sp.</i>				5	2	115	55	16			193
<i>Ochlerotatus rusticus gr.</i>		67	37	30	22	5		2			163
<i>Culiseta annulata</i>	18	9	8	23	5	7	3	25	2	1	101
<i>Anopheles hyrcanus</i>	5	28			14	12	19	2	2		82
<i>Anopheles claviger</i>	4	2		57	4	2					69
<i>Ochlerotatus cataphylla</i>	12										12
<i>Aedes sp.</i>					2		2				4
<i>Anopheles plumbeus</i>									1		1
<i>Culex territans</i>				1							1
<i>Ochlerotatus leucomelas</i>								1			1
<i>Uranotenia unguiculata</i>	1										1
Indeterminate			24	3				8			35
Total	38520	16123	26053	6395	11503	8069	15322	38370	568	46213	207136

gation, 16 species were recorded. In 1996, 1999 and 2000 there were 15 species, in 2002 there were 14, in 1998 and 2001 there were 13, in 2003 there were 12, and in 1996 there were 11 species. The fauna composition also varied every year. Table 1 shows the composition of species that were recorded during the years of investigation.

The highest share of 75.59% belongs to the species *Ae. vexans*. It is the dominant species in the Osijek area. *Oc. sticticus* also has a big share of 13.32%. *Cx. pipiens* had a share of 5.86%. These three species make 94.77% of the mosquito fauna in Osijek. The remaining 17 species have the share of 5.33%. It is worth noting that only one specimen of each of the four species: *Ur. unguiculata*, *Oc. leucomelas*, *Cx. territans* and *An. plumbeus*, was trapped during nine years of investigation. The share of each species in the analyzed material is presented in Figure 1.

The abundance also varied considerably. 1995 and 2002 were good years for mosquitoes, when over 38,000 specimens were trapped. In contrast, in 2003 only 565 specimens were trapped during the entire season (Figure 2).

Seasonal appearance. Mosquitoes can be subcategorized in two ecological groups. The first group consists of mosquitoes that appear throughout the season, from the beginning of May to the end of September. This group is the largest and includes *Ae. vexans*, *Oc. sticticus*, *Cx. pipiens c.*, *An. maculipennis c.*, *Oc. caspius*, *Cx. modestus*, *An. hyrcanus*, as well as *Cq. richiardii*, *Cs. annulata*, *Ae. cinereus* and *Ae. rossicus*. Mosquitoes from the second group

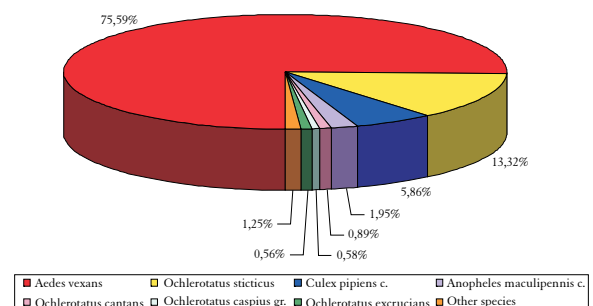


Figure 1. Species composition of mosquitoes during Osijek during 1995–2004.

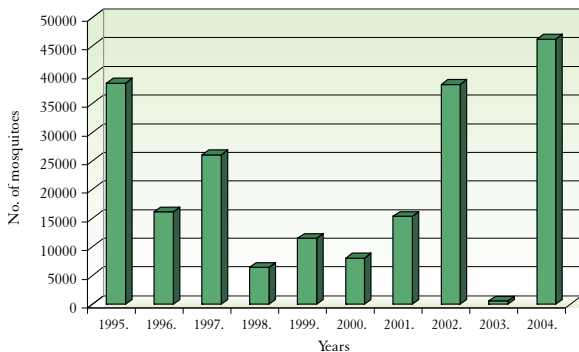


Figure 2. Changes in number of mosquitoes in Osijek in investigated years.

appear only at the beginning of the season and mostly have only one generation. The second group includes *Oc. excrucians* and *Oc. cantans* (Table 2). The species *An. claviger* and *Oc. rusticus* were recorded only sporadically and there is not enough data to classify them in one of the groups. For the species recorded only once (*Cx. territans*, *Ur. unguiculata*, *Oc. cataphylla*, *An. plumbeus* *Oc. leucomelas*), we also do not have sufficient data.

DISCUSSION

In ten years of investigating mosquitoes in Osijek we recorded 20 species, which means that the fauna is very

rich. If we take into account that the sampling was conducted in a city extending on about 6,000 ha, the figure of 20 species becomes even more significant. Since more species have been recorded so far in the neighboring areas: 43 in Hungary (11) and 33 in Vojvodina (12), we may expect to find more species in Osijek.

Ae. vexans has the most prominent position among the recorded species. Its share in the fauna is 75.59% (ten-year average). It is a typical flood species that occurs in generations parallel to floods (6). The generations are large because they appear in the entire flooded area. The situation is similar in Vojvodina (13), where this species makes 55% of the total share (from 5 to 95, depending on the sampling place and time).

Other species of flood mosquitoes are also very abundant and, because of the dominance of *Ae. vexans*, we can call them followers. They include *Oc. sticticus*, *Ae. cinereus* and *Ae. rossicus*.

The species *Culex pipiens*, although its systematic status is erratic (14), is continuously present in the city. Since it uses small water bodies (canals, barrels) that are difficult to control as breeding sites, it is present throughout the season. In the years when there were no flood mosquitoes (like 2003), this species became the main molestant. In 2003, the specimens of this species made 54% of the mosquito fauna in the city.

TABLE 2

Average appearance of mosquito species throughout the season.

Species / Date	11. 5.	25. 5.	11. 6.	25. 6.	11. 7.	25. 7.	11. 8.	25. 8.	11. 9.	25. 9.
<i>Aedes vexans</i>	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
<i>Ochlerotatus sticticus</i>	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
<i>Culex pipiens c.</i>	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
<i>Anopheles maculipennis c.</i>	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
<i>Ochlerotatus caspius gr.</i>	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
<i>Culex modestus</i>	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
<i>Anopheles hyrcanus</i>	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
<i>Coquillettidia richiardii</i>		XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
<i>Aedes cinereus</i>	XXX	XXX	XXX	XXX	XXX	XXX		XXX	XXX	XXX
<i>Culiseta annulata</i>	XXX	XXX	XXX	XXX	XXX	XXX	XXX		XXX	XXX
<i>Aedes rossicus</i>	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX		XXX
<i>Ochlerotatus excrucians</i>	XXX	XXX	XXX	XXX	XXX	XXX				
<i>Ochlerotatus cantans</i>	XXX	XXX	XXX	XXX	XXX					
<i>Ochlerotatus rusticus gr.</i>	XXX	XXX					XXX	XXX		
<i>Anopheles claviger</i>		XXX	XXX	XXX	XXX			XXX		XXX
<i>Ochlerotatus cataphylla</i>	XXX									
<i>Ochlerotatus leucomelas</i>				XXX						
<i>Anopheles plumbeus</i>				XXX						
<i>Culex territans</i>								XXX		
<i>Uranotenia unguiculata</i>									XXX	

This investigation included only adult species, which means that some groups of mosquitoes could not be determined to the level of species as they could not be determined based on imago. It is the case with the sibling species of the *Anopheles maculipennis* complex that is represented in the area by two species (4, 7, 15, 16). Taking into consideration the data from the quoted papers, we can safely assume that the sampled material included both species. The presence of the species that breed mostly in the woods are very interesting. There are three species that are good flyers, since the nearest woods is about 10 km north of the city. All three species appear in one generation and are present only at the beginning of the season.

Rare species have a large share in the mosquito fauna. For as many as four species, only one specimen was found. There are two basic reasons for that. The first is that those species normally do not occur in large populations, and the second that there are not many suitable breeding sites in the city and the surrounding area. An example is *An. plumbeus* that breeds in tree holes.

The data on the number of species is actually fascinating: the total of 20 species were recorded in such a small area (the total area of the city of Osijek is about 6,000 ha). It should be stressed that in the entire Croatia the total number of species recorded so far is 50 (17, 18, 19), which means that in Osijek we recorded 40% of the Croatian fauna. In the entire Europe, 100 species were recorded (10). We can establish that a large number of species is characteristic of the Osijek area because we recorded in only three years as many as 16 species. Furthermore, the composition changes from year to year, but most species (11) appear every year. Certain rare species are representative of the specific fauna for a given year; four such species were recorded so far. When we discuss the possibility of recording new species, it refers only to rare species. Based on previous research and statistical data, there is a possibility of recording more species in the area.

The number of mosquitoes actually directly depends on the number of *Ae. vexans* specimens, and it in turn depends on the number and extent of flooding for a given year. In 1995 and 1997 there were three floodings, and in 2002 there were two extensive ones. They resulted in a large number of mosquitoes in the city.

The results for 2003 are considerably different, as the sampling was conducted at entirely different sites. The results show a significantly different quantitative and qualitative fauna composition. The reasons are considerably different climatic conditions. The year was very dry, the water level of plain rivers (Danube and Drava) did not increase at least once in the year (which had not been recorded in the past fifty years), and there was little rainfall. Such conditions reflected on the changes in the mosquito fauna composition in Osijek.

It is evident that 7 species were present during the entire season. This is the average value for all nine years of

investigation. Furthermore, 4 more species were recorded 9 times. For all those species we can safely say that they are present throughout the season. However, there were 2 more species recorded only sporadically at the beginning and at the end of the season, so we could include them in the above group. Only three species occurred only at the beginning of the season, and two at the end. Generally speaking, most species could appear during the entire season.

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