

A study of mosquito fauna (Diptera: Culicidae) and the phenology of the species recorded in Wilanów (Warsaw, Poland)

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Abstract

The occurrence of 33 species (26 species recorded as larvae and 30 species as adults) has been shown. Nine species (*Anopheles plumbeus*, *Aedes rossicus*, *Ochlerotatus caspius*, *Oc. cyprius*, *Oc. euedes*, *Oc. nigrinus*, *Oc. riparius*, *Culiseta alaskaensis* and *Coquillettidia richiardii*) were recorded in Warsaw for the first time. Only two species (*Cs. morsitans* and *Cs. subochrea*), previously reported from Warsaw, were not recorded. For most of the species both larvae and adults were found. Adult females of nine species occurred in the fields for several months - *An. maculipennis* for seven months, *An. claviger* and *Ae. cinereus* for six months and *Oc. cantans*, *Ae. vexans*, *Oc. sticticus*, *Cs. alaskaensis*, *Cs. Annulata* and *Cx. pipiens* for five months. Females of *Oc. caspius* and *Oc. euedes* were recorded for about four months, those of *Oc. annulipes*, *Oc. excrucians*, *Oc. flavescens* and *Cq. richiardii* for about three months. Adult snow-melt mosquitoes (*Oc. cataphylla*, *Oc. communis*, *Oc. leucomelas*, *Oc. intrudens* and *Oc. punctor*, as well as tree-hole species (*An. plumbeus* and *Da. geniculata*) were on the wing for about two months, while *Oc. rusticus* occurred for a month.

Larvae of thirteen species were observed in study ponds in April. By the first days of May six species had completed their larval development for the season (*Oc. cataphylla*, *Oc. communis*, *Oc. intrudens*, *Oc. leucomelas*, *Oc. punctor* and *Oc. rusticus*). The remaining species continued their development beyond this time. Larvae of *Culex* were recorded in Wilanów from June to October and those of *Cs. annulata* and *Cs. alaskaensis* from May to October. Several species: *An. claviger*, *An. maculipennis*, *Ae. cinereus*, *Ae. vexans*, *Oc. cantans*, *Oc. sticticus*, *Oc. caspius*, *Oc. euedes*, *Oc. excrucians*, *Oc. flavescens*, *Cs. alaskaensis*, *Cs. annulata*, *Cx. pipiens* and *Cx. modestus* developed at least two generations per year.

Introduction

There are 3490 mosquito species formally recognized worldwide (Harbach & Howard, 2007). 101 of them occur in Europe (Snow & Ramsdale, 2003) of which 49 occur in Poland (Wegner, 2007). The Mazovian Lowland and the Warsaw agglomeration are some of the best studied areas of Poland, but previous studies of the Lowland focused mainly on the Kampinos Forest National Park (about 30 km North of Warsaw). The Southern part of the region has not previously been studied so intensively. Only Łukasiak (1965) and Wegner (1982) published rather scarce data on this part of the region. Therefore the mosquito fauna of Southern Mazovia (and Wilanów) need elaboration, especially because of the numerous and rich mosquito fauna of the lowlands along the Vistula river. The present entomological study of this area was started in order to prepare a mosquito control programme using environmentally acceptable methods.

Wilanów is a special place for Poles and the historic royal residence is an attraction for both Polish and foreign tourists. The palace park and the surrounding green areas play an important recreational role. In summer, however, countless mosquitoes are a severe nuisance to all visitors.

Mosquitoes in Wilanów breed in ecologically sensitive areas typical of a lowland river valley.

Study Area, Material and Methods

Wilanów lies in the Southern part of Warsaw on the lower terrace of the River Vistula floodplain, which extends in a generally south to north direction through the district.

In the past, when there were no flood banks, the area flooded regularly, and it is still seasonally marshy in numerous places. There are traces of historical changes in the course of the Vistula. The most recent of the dead channels are now the sites of lakes and ponds, and the oldest beds have become more or less overgrown (Biernacki, 2000). These originally wet areas are intersected with channels draining excess water to the lakes and to the River Wilanówka.

The entire area is full of depressions easily flooded by rainfall, which is managed as meadows or lies fallow. The channels and the lakes form a system of interconnected streams collecting water from a considerable part of Warsaw. After heavy rainfall these channels overflow and inundate (flood) nearby meadows and fields, creating vast temporary pools of

stagnant water in which huge numbers of mosquito larvae develop. Heavy rainfall also causes water levels in the lakes to rise and inundate shoreline areas. Moreover, land bordering the Wilanówka, and the lakes and channels is intermittently swampy.

A considerable part of this terrain lies within the Warsaw Area of Protected Landscape, a conservation area allowed to evolve naturally or used as fields and meadows. Other parts are covered by small forests.

The material comprised more than 11 thousand individuals collected as larvae and adult mosquitoes during the growing seasons of 2001-2004 and some additional sampling during 2005-2009. Larvae were collected from different ponds, temporary, semi-permanent and permanent, both in forests and in the open area. Also adult mosquitoes were captured in two forest sites and in three sites in the open area, as well as occasionally collections from a shelter and cellars.

Results

In the present research at Wilanów the occurrence of 33 species (26 species recorded as larvae and 30 species as adults) has been shown (Table I). Nine

species (*Anopheles plumbeus*, *Aedes rossicus*, *Ochlerotatus caspius*, *Oc. cyprius*, *Oc. euedes*, *Oc. nigrinus*, *Oc. riparius*, *Culiseta alaskaensis*, *Coquillettidia richiardii*) were recorded in Warsaw for the first time. Two of them have not been registered before also in Mazovian Lowland (*An. plumbeus*, *Oc. caspius*). *Culiseta fumipennis* is the only species known to occur in Mazovia which has not been recorded in Warsaw. Only two species (*Cs. morsitans* and *Cs. subochrea*) which have previously been reported from Warsaw were not recorded in the present study.

For most of the species both larvae and adults have been registered. Only adults were recorded for the tree-hole mosquitoes (*Oc. geniculatus* and *An. plumbeus*), as well as *Cq. richiardii*, with a specific larval habitat, and two rather rare species (*Oc. riparius* and *Oc. nigrinus*). In *Culex torrentium*, *Cx. territans* and *Culiseta ochroptera* only larvae were found (adults were reared from larvae).

Adult females of nine species occurred in the study area for several months - *An. maculipennis* from April to October, *An. claviger* from April to September, *Ae. cinereus* from May to October, *Oc. cantans* from May to September *Ae. vexans*, *Oc. sticticus*, *Cs. alaskaensis*, *Cs.*

annulata, and *Cx. pipiens* from June to October (Table II). Adult females of *Oc. caspius* (June - October) and of *Oc. euedes* (May - September) occurred in the fields for about four months, those of *Oc. annulipes*, *Oc. excrucians* (May - August), *Oc. flavescens* (June - September) and *Cq. richiardii* (June - August) for about three months.

Females of snow-melt mosquitoes (*Oc. cataphylla*, *Oc. communis*, *Oc. leucomelas*, *Oc. intrudens* and *Oc. punctor*) as well as tree-hole species (*An. plumbeus* and *Oc. geniculatus*) occurred in the fields for about two months. Adults of *Oc. rusticus* were observed for one month.

Larvae of thirteen species were observed in study ponds in April. By the first days of May six species had completed their larval development for the season (*Oc. cataphylla*, *Oc. communis*, *Oc. intrudens*, *Oc. leucomelas*, *Oc. punctor* and *Oc. rusticus*). The remaining species continued their development beyond this time.

Larvae of the genus *Culex* were recorded in Wilanów from June to October and those of *Cs. annulata* and *Cs. alaskaensis* from May or June to October (Table II).

Several species: *An. claviger*, *An. maculipennis*, *Ae. cinereus*, *Ae. vexans*, *Oc. cantans*, *Oc. sticticus*, *Oc. caspius*, *Oc. euedes*, *Oc. excrucians*, *Oc. flavescens*, *Cs. alaskaensis*, *Cs. annulata*, *Cx. pipiens* and *Cx. modestus* developed at least two generations per year.

In the course of a season (from April to October), observations each two weeks showed that at least ten species occurred. The greatest number of species was recorded during May, June and the first half of July (16-19 species). The greatest number of species in the larval stage (10-13) was observed in April and May, in the second half of June and the first half of October (9 species), while those as adults were recorded from the second half of May to mid July (15-18) (Table II).

Table I. Check-list of Culicidae species recorded in Wilanów (Total column) as larvae (L) or adults (A) compared with previous data for Mazovia (Maz) and Warsaw (Wa) (according to Wegner, 1982).

No	Species	Previous data		Wilanów		
		Maz	Wa	Total	L	A
1	<i>Anopheles (Anopheles) claviger</i> (Meigen, 1804)	*	*	*	*	*
2	<i>An. (Ano.) maculipennis</i> s.l. Meigen, 1818	*	*	*	*	*
3	<i>An. (Ano.) plumbeus</i> Stephens, 1828			*		*
4	<i>Aedes (Aedes) cinereus</i> Meigen, 1818	*	*	*	*	*
5	<i>Aedes (Aed.) rossicus</i> Dolbeskin, Gorickaja & Mitrofanova, 1930	*		*	*	*
6	<i>Ae. (Aedimorphus) vexans</i> (Meigen, 1830)	*	*	*	*	*
7	<i>Dahlia geniculata</i> (Olivier, 1791)	*	*	*		*
8	<i>Oc. (Ochlerotatus) annulipes</i> (Meigen, 1830)	*	*	*	*	*
9	<i>Oc. (Och.) cantans</i> (Meigen, 1818)	*	*	*	*	*
10	<i>Oc. (Och.) caspius</i> (Pallas, 1771)			*	*	*
11	<i>Oc. (Och.) cataphylla</i> (Dyar, 1916)	*	*	*	*	*
12	<i>Oc. (Och.) communis</i> (De Geer, 1776)	*	*	*	*	*
13	<i>Oc. (Och.) cyprius</i> (Ludlow, 1920)	*		*	*	*
14	<i>Oc. (Och.) diantaeus</i> (Howard, Dyar & Knab, 1912)	*	*	*		*
15	<i>Oc. (Och.) dorsalis</i> (Meigen, 1830)	*	*	*		*
16	<i>Oc. (Och.) euedes</i> (Howard, Dyar & Knab, 1913)	*		*	*	*
17	<i>Oc. (Och.) excrucians</i> (Walker, 1856)	*	*	*	*	*
18	<i>Oc. (Och.) flavescens</i> (Müller, 1764)	*	*	*	*	*
19	<i>Oc. (Och.) intrudens</i> (Dyar, 1919)	*	*	*	*	*
20	<i>Oc. (Och.) leucomelas</i> (Meigen, 1804)	*	*	*	*	*
21	<i>Oc. (Och.) nigrinus</i> (Eckstein, 1918)	*		*		*
22	<i>Oc. (Och.) punctor</i> (Kirby, 1837)	*	*	*	*	*
23	<i>Oc. (Och.) riparius</i> (Dyar & Knab, 1907)	*		*		*
24	<i>Oc. (Och.) sticticus</i> (Meigen, 1838)	*	*	*	*	*
25	<i>Oc. (Rusticoidus) rusticus</i> (Rossi, 1790)	*	*	*	*	*

26	<i>Cx. (Barraudius) modestus</i> Ficalbi, 1890	*	*	*	*	*
27	<i>Cx. (Culex) pipiens pipiens</i> Linnaeus, 1758	*	*	*	*	*
28	<i>Cx. (Cux.) torrentium</i> Martini, 1925	*	*	*	*	
29	<i>Cx. (Neoculex) territans</i> Walker, 1856	*	*	*	*	
30	<i>Culiseta (Culiseta) alaskaensis</i> (Ludlow, 1906)	*		*	*	*
31	<i>Cs. (Cus.) annulata</i> (Schrank, 1776)	*	*	*	*	*
32	<i>Cs. (Cus.) subochrea</i> (Edwards, 1921)	*	*			
33	<i>Cs. (Culicella) fumipennis</i> (Stephens, 1825)	*				
34	<i>Cs. (Cuc.) morsitans</i> (Theobald 1901)	*	*			
35	<i>Cs. (Cuc.) ochroptera</i> (Peus, 1935)	*	*	*	*	
36	<i>Coquillettidia (Coq.) richiardii</i> (Ficalbi, 1889)	*		*		*
	Total	34	26	33	26	30

Table II. Phenology of mosquito fauna in Wilanów. L = recorded as larvae; A = recorded as adults.

Species	April		May		June		July		August		September		October	
<i>An. claviger</i>	L	LA	LA	LA	A	LA	A		L	A	A		LA	LA
<i>An. maculipennis</i>	LA	LA	LA	LA	A	LA	A				A		LA	A
<i>An. plumbeus</i>											A	A	A	A
<i>Da. geniculata</i>									A	A	A	A		
<i>Oc. cataphylla</i>	L	LA	LA	A	A	A								
<i>Oc. communis</i>	L	LA	LA	A	A									
<i>Oc. leucomelas</i>	L	L	LA	A	A									
<i>Oc. intrudens</i>	L	LA	LA	A	A	A								
<i>Oc. punctor</i>	L	L	A	A	A	A								
<i>Oc. rusticus</i>		L	A	A	A									
<i>Oc. annulipes</i>	L	L	L	A	A	A	A	A	A	A				
<i>Oc. cantans</i>	L	L	LA	LA	A	LA	A	A	A	A	A	LA	A	
<i>Oc. excrucians</i>	L	L	L	LA	A	LA	A	A	A	A				
<i>Oc. flavescens</i>			L	L	A	A	A		L	LA	A			
<i>Oc. cyprius</i>		L	A	A										
<i>Oc. caspius</i>			L	LA	A	A	A	A	LA	A	A	A	A	
<i>Oc. euedes</i>				A	A	A	A	A	A	A	A	A		
<i>Oc. sticticus</i>				L	A	A	A	A	LA	LA	A	A	L	LA
<i>Aedes vexans</i>			L	LA	A	LA	A	LA	LA	LA	A	A	LA	LA
<i>Ae. cinereus</i>		L	LA	LA	A	A	A	A	LA	A	A	A	LA	A
<i>Coquillettidia richiardii</i>						A	A	A	A	A				
<i>Cx. modestus</i>						L	A				A		LA	A
<i>Cx. pipiens</i>	A				LA	LA	LA	LA	LA	LA	LA		L	LA
<i>Cs. alaskaensis</i>				L	LA	LA	A	LA	A			L	LA	LA
<i>Cs. annulata</i>					L	LA	A	LA				L	LA	LA
<i>Number of species recorded as adults</i>	2	5	11	15	18	18	16	12	12	13	13	8	10	10
<i>Number of species recorded as larvae</i>	10	13	13	10	3	9	1	4	6	4	1	3	9	6
<i>Number of all species recorded</i>	11	13	16	18	19	19	16	12	14	13	13	10	12	10

Discussion

The last major study of Warsaw's mosquito fauna was completed in 1980, when evidence for 26 species was published (Wegner, 1982). The present research adds a further nine species to the faunal list, thus 35 mosquito species are now reported from Warsaw. This equates to 97.2% of the fauna of Mazovian Lowland and 71.4% of the mosquito species of Poland.

Two species (*Cs. morsitans* and *Cs. subochrea*) previously reported for Warsaw, were not recorded in the present study. The first is rather common in Poland and further search will presumably show its occurrence in Wilanów. *Culiseta subochrea* was rarely met in Poland and it may be extinct in Warsaw due to the habitat degradation under urban pressure. The occurrence of *Culiseta fumipennis*, the only species known to occur in Mazovia which has not been recorded in Warsaw, needs to be verified. Its larvae develop in grassy shores of ponds which in Wilanów are abundant. The larval habitat of the species is similar to that of *Cs. morsitans*, which has also not been recorded in the study. In any case further search for both species will continue and the larval habitats will gain more attention.

The occurrence in Wilanów of two species - *An. plumbeus* and *Oc. caspius* – needs commentary. They have not been recorded in Masovian Lowland before. The first one is a tree-hole species, adults of which have been recorded in Poland only a few times before, mainly in autumn. Łukasiak (1956) has found its larvae at the end of August in Kudowa (Lower Silesia) in a tree-hole in an alder tree (*Alnus* sp.) and Skierska (1960) in Białowieża observed imagines from the second half of July to the end of September. Last year it was found in Kampinos Forest in September and October (Wegner, unpublished). Although the species is dendrolimnic, it has been observed to develop in overshadowed artificial containers (i.e. tyres) (Schaffner *et al.*, 2004). The second species is often misidentified as *Oc. dorsalis*, which had been reported from Warsaw before. The reports must have referred to one of these species.

The phenology of mosquitoes of Wilanów is similar to that observed in the Morava River Flood Plain in Slovakia (Michalková & Halgoš, 2005). The flight period of most species is similar, only the occurrence of females of flood-water species: *Ae. vexans* and *Oc. sticticus* as well as *Oc. flavescens* and *Culex pipiens* differ, but their development varies for different years and

depends on precipitation. Also the phenology of mosquito larvae in Masurian Lakeland published by Wojnarowicz (1961) is similar to that observed in Wilanów – although the period of occurrence of most species is somewhat shorter in Masuria than in Wilanów and vernal species complete their development about two weeks later. This cannot apply to *Oc. cataphylla*, which has been observed to breed even three times during the season – its larvae were observed till the second half of October. The differences are probably caused by rather more severe climate of Masuria. Several differences can be observed by comparing the mosquito phenology in Białowieża Forest with that of Wilanów. In Białowieża Forest females of four vernal species: *Oc. communis*, *Oc. punctor*, *Oc. intrudens* and *Oc. cataphylla* occur in the fields for a long time – to October (Skierska, 1960). The phenology of other species is more or less similar, although the growing season starts in Białowieża about two weeks later than in Mazovia.

Other aspects of mosquito phenology have been observed by Lumiaho & Itämies (1981) in Central Finland. The dissimilar climate and different mosquito species make the Polish and Finish data poorly comparable. The Finish study shows the second emergence of snow-melt species

(*Oc. communis* and *Oc. punctor*). The phenomenon has not been observed in Wilanów in these years, but in colder regions of Poland it is observed more often. Nevertheless, also in Mazovia the autumnal development of larvae has been observed in 1995 after an extremely dry summer followed by heavy rainfalls at the end of August (Wegner, 1999).

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