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SEASONAL CHANGES IN THE MOSQUITO FAUNA (DIPTERA, CULICIDAE) IN THE CITY OF SZEGED IN 1999

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Abstract. Authors systematically investigated the Culicidae fauna in Szeged in 1999, with regard to quantitative and qualitative aspects of the mosquito species living in the city following disturbance of their natural habitat by insecticidal treatment. The main species observed in Szeged were *Culex pipiens* (46.9%), *Culex modestus* (10.1%) and *Aëdes vexans* (10.1%). In the course of the mosquito season, the species composition changed at the different sampling sites. Different mosquito assemblages were observed in Szeged than those along the flood area of the River Tisza. After insecticidal treatment, *Aëdes* species may immigrate from other habitats. The investigation revealed a species not reported previously in Szeged: *Anopheles hyrcanus* Pallas, 1771.

Keywords: mosquito assemblages, disturbed habitat, density, multivoltine

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Introduction

Mosquitoes have probably always disturbed humans. People began to think about protection against mosquitoes only last century. For this purpose, floral poisons were utilized. These were effective, but expensive. Pesticides with neurotoxic effects (e.g. DDT) and later phosphoric-acid-esters (e.g. Diazinon and Gesarol M) were used more recently. Anti-mosquito treatment must be applied prudently because these chemicals are not only dangerous for aquatic and land animals (Mihályi 1963).

The Culicidae-fauna of Hungary was investigated over a long period by Mihályi and co-workers. The mosquito assemblages in the Tisza basin have been monitored by others, but no study has been reported on urban mosquitoes living in a disturbed habitat. Three main species were revealed in the Tisza basin by the previous measurements: *Aëdes vexans* (41.17%), *Culex modestus* (26.68%) and *Aëdes rossicus* (19.06%) (Branka 1984, Tóth 1977). One of the most important tasks in combating the problem caused by mosquitoes has always been to identify the entomological situation. Weekly chemical anti-mosquito treatment can lead to changes in the composition of the mosquito assemblages. *Aëdes* genus appears after a wet period (Mihályi 1963). The density of natural mosquito assemblages is influenced by the flood of the River Tisza and by the current rainfall. The mosquito assemblages in the Tisza basin are similar to those of the urban mosquitoes in the early and wet springtime. The several-generation mosquitoes remain dominant in the flood area of the Tisza basin. In the course of an arid season, the multivoltine species accompany the several-generation mosquitoes. The individual numbers of the *Culex* genus can be markedly high in a precipitation-poor season. These species easily find the water necessary for their development in the environs of houses and rubbish dumps. The species of the *Culex* genus lay their eggs on the surface of water in the form of rafts (Mihályi 1963).

A detailed investigation of the Culicidae fauna in the Tisza basin is important both inside and outside the built-up areas.

Materials and Methods

Collecting method

Mosquitoes were collected at 11 sampling points in Szeged, selected with regard to the diverse habitats of mosquitoes (Fig. 1). The collection at the

different sampling points was performed at the same time. The ”hand sucking” procedure was applied in the capturing of the individuals. Settled blood-sucking mosquitoes were covered up with the funnel-shaped end of the ”hand sucking” device and were sucked up inside the tube. Collection was performed between 19:30 and 21:30, the time depending on the time of sunset. At the time of collection, no other person was present within 20 m. The collected individuals were provided with a slip of paper indicating the date and site of sampling (Erdős 2001). After the mosquito season, the caught mosquitoes were identified via the characteristic features of the species. The main features for the imagos were the colour, size and shape (Mihályi 1963).

Certain phrases were applied in relation to the dominance:

dominant species: the most frequent species or species accounting for >25% of the total number of caught mosquitoes

subdominant species: species accounting for 10-25% of the total number of caught mosquitoes

rare species: species accounting for <10% of the total number of caught mosquitoes

The weekly mosquito control

Chemical anti-mosquito treatment was performed weekly from May until the end of September. This was done by plane with UNITOX 14 ULV at a dose of 0.6 litre/ha (14% dichlorphos) or with K-OTHRIN 1 ULV 0.6 litre/h (0.12% deltametrin) and with the use of a thermal-fog making machine on the ground with UNITOX 100 SC (1000 g dichlorphos/litre) in a concentration of 0.02 litre/ha. The fog-maker was made by the addition of 2 litres of material to 98 litres of diesel oil. The insecticide was sprayed on the vegetation at a dosage of 10-15 litre/ha. The chemical anti-mosquito was applied at dawn or at nightfall in order to protect useful insects (Erdős 2001). The efficacy of this anti-mosquito treatment was 92-100% (Szító 1999, personal communication).

The sampling sites

Szeged is a typical lowland city. The wet areas suitable for the breeding of mosquitoes involve both alkaline waters and non-alkaline waters. The character of these areas depends on the geological factors and on environmental pollution. The data on the composition of the various water samples were kindly provided by L. Zs. Nagy (AtiKöFe) (personal communication).

Alkaline waters: These waters are characterized by a high salt concentration, a high conductance (2000-4000 μS/cm) and a high pH (8.5-9.5). The dominant cations are Na^+ (800-1200 mg/l) and Mg^{2+} (200-400 mg/l). The dominant anions are SO_4^{2-} (300-600 mg/l), Cl^- (400-700 mg/l) and HCO_3^- (500-1000 mg/l).

Non-alkaline waters: These are lakes, back-waters and channels, in general with a layer of silt covering their bed. A moderate conductance (700-1300 μS/cm) and weakly basic pH (8.5-9.5) are characteristic. The dominant cations are Na^+ (30-80 mg/l) and Mg^{2+} (10-30 mg/l). The dominant anions are SO_4^{2-} (20-60 mg/l), Cl^- (20-40 mg/l) and HCO_3^- (100-300 mg/l).

Transitionally alkaline waters: Originally these were not alkaline waters, but by reason of the harmful effects of the local agricultural, communal and industrial pollution (e.g. chemical fertilizer systems, pollution of hot springs, etc.) a considerable quantity of pollution material passed into the water and it began to become alkaline. The waters around Szeged are usually polluted or moderately polluted (Felföldy 1987).

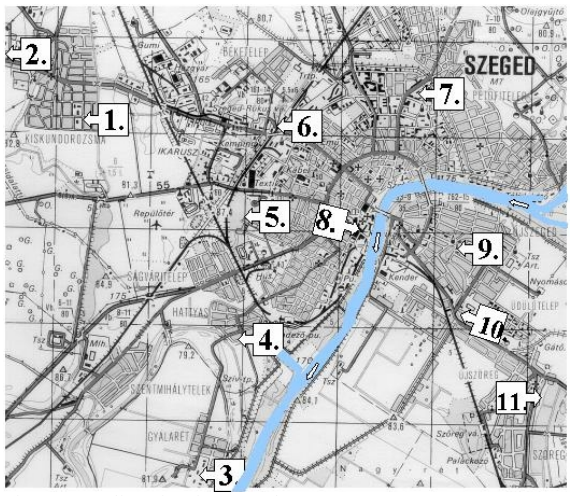

Fig. 1. Sampling sites in Szeged

1. Dorozsma sampling site: This area is situated in a garden suburb with detached houses. The Domaszéki Channel is situated near by. Its surface is 1 ha; average depth is 1-1.5 m. It is not alkaline water. Agricultural pollutants affect this area, as do chemical fertilizers and communal pollution.

2. Dorozsma Sziksós Lake sampling site: This is situated in a holiday home area with detached houses. There is a local clayey-alkaline lake where mosquitoes breed among the reeds along the shore. Its surface is 21 ha, with an average depth of 1.1 m.

3. Gyálarét sampling site: This is situated in a holiday home area with detached houses. The natural waters comprise several channels of the transitionally alkaline Gyálai Holt-Tisza backwater. Total surface of the channels is 1 ha, with an average depth of 1 m and an average width of 4 m. The inshore parts are often reedy.

4. Hattyas sampling site: This area is situated in a garden suburb with detached houses. The Feketepart section of the Gyálai Holt-Tisza backwater is situated nearby. It is tending to become alkaline water because of the inflow of hot water. It is at an advanced stage of silting. Length of the Feketepart section is 1.3 km, with an average width of 20 m, an average depth of 1.6 m and a total surface of 2.6 ha. The inshore parts are often reedy.

5. Móraváros sampling site: This area is situated in a housing estate with blocks of flats. The Sancer Lakes are transitionally alkaline. Average depth of the lakes is 2-4 m and their total surface is 11 ha.

6. Kossuth L. Avenue sampling site: This area is situated among housing estates. There are several lakes: the non-alkaline, highly silted Búvár Lake (3 ha), the alkaline Csemegi Lake (2 ha) and the transitionally alkaline Lencsés Lake (7-8 ha).

7. Olajbányász Square sampling site: This area is situated in a housing estate. There is no natural water.

8. Dom Square sampling site: This is the city centre of Szeged, an area characterized by blocks of flats. There is no natural water.

9. Újszegedi Víztorony Square sampling site: This area is situated in a housing estate and a garden suburb with detached houses. Its natural water is the silted Holt-Maros backwater, which has a length of 4 km, an average width of 25 m, an average depth of 1.5 m and a total surface of 10 ha. It is undergoing rapid silting and is becoming overgrown with vegetation.

10. Kállay Park sampling site: This greenwood area is situated in a garden suburb with detached houses. Its natural water is the silted Holt-Maros backwater (see point 9).

11. Szőreg sampling site: This area is situated in a garden suburb with detached houses. Its natural water is the non-alkaline, silted Szőreg-Deszk main canal. The inshore parts are often reedy.

Characteristics of collected biting mosquito genera

Aëdes genus: In autumn, the females lay their eggs one by one on the ground or on blades of grass. In spring, the eggs develop into larvae in pools which remain on the flood area after flooding. The imagos fly even 18 km per day. The adults are active at daybreak and at nightfall (Mihályi 1963).

Culex genus: This is the most frequent mosquito genus in the studied area. These mosquitoes are active also at night time and enter buildings. The fertilized female mosquitoes live here during the winter and in summer they lay their eggs on the surface of water in the form of a raft. Each raft of eggs contains approximately 300 eggs (5 × 2-3 mm). The imagos move up to 500 m from their breeding water. During summer 6-7 generations develop (Mihályi 1963). This genus has a high species richness, but not a varied species composition. In Szeged, the species *Culex pipiens molestus* is more frequent than *Culex modestus*, which is dominant alongside the River Tisza.

Theobaldia genus: The large body is a characteristic feature. The fertilized female mosquitoes spend the winter here and in summer they lay their eggs on the surface of water in the form of a raft. The imagos do not enter houses. They are active in biting during winter too (Mihályi 1963). These mosquitoes are relatively rare in their disturbed habitat in Szeged.

Anopheles genus: The fertilized female mosquitoes spend the winter here and in summer they lay their eggs on the surface of water in the form of a net. The female imagos in general suck blood at night. These mosquitoes prefer warm-blooded animals (e.g. cows, horses, pigs, etc.) to humans for their blood. The female imagos display a predilection for dwelling on the walls of stables. Larvae are not found in highly polluted water. Imagos fly 1-4 km per day (Mihályi 1963).

Characteristics of collected biting mosquito species

Culex pipiens molestus Forskal, 1775: This flies from the end of May to October. In winter it is observed in lower numbers, because the fertilized female mosquitoes spend the winter in apartments, cellars, etc.). It prefers human blood to that of warm-blooded animals. It is active throughout the night. It lays its eggs wherever the temperature and oxygen content of the water are suitable (barrels of rainwater, pools, discarded tyres, ditches, reedy lakes, etc.). It is a multivoltine species.

Aëdes vexans Meigen, 1830: This species appear after the flooding of the river. It flies from April until the end of October. It is a cosmopolitan species. Its imagos migrate far away. Some stained individuals have been found as far as 22 km from the breeding site. Its number of generations depends on the

number of floodings (Mihályi 1963).

Culex modestus Ficalbi, 1890: This flies from June until early October. It is a thermophilic species; its larvae develop in sunny waters with rich vegetation. It is a multivoltine species (Mihályi 1963).

Aëdes dorsalis Meigen, 1830: This flies from early April until September. It favours alkaline waters and lowland pastures. Its larva is a lover of salt and develops in sunny, shallow lakes or temporary pools. It has 2-3 generations per year (Mihályi 1963).

Aëdes sticticus Meigen, 1838: This flies from early April until September after floods. It lives in forests. Its larvae favour shady waters, and develop in forests on flood areas. The number of generations (2-5) depends on the number of floods and the rainfall. Its eggs are laid on ground and on blades of grass (Mihályi 1963).

Aëdes annulipes Meigen, 1830: This flies from the end of April until the end of July. It has a painful bite. It lives in forests, but its larvae prefer sunny waters. The imagos live in the edges of forests and green woods. It is a univoltine species; it develops only one generation per year (Mihályi 1963).

Theobaldia annulata Schrank, 1776: This flies from spring until late autumn. It plays only a minor part in the damage caused by mosquitoes. It lives outdoors, indoors, in forests and in reedy areas. Its larvae primarily prefer polluted water (Mihályi 1963).

Aëdes cantans Meigen, 1818: This flies from the middle of April until the end of July. This species is not found in forests on flood areas. It has only one generation per year. It is a forest mosquito. It mainly favours marsh-woods. Its larvae prefer shady water (Mihályi 1963).

Aëdes cinereus Meigen, 1818: This flies from April until the end of August. It inhabits reedy areas, greenwoods and brushwoods. It is absent from forests on flood areas and the alkaline waters of the lowland. It has 2 or more generations per year (Mihályi, 1963).

Aëdes rossicus Dolbeskin, Gorickaja and Mitrofanova, 1930: This flies from April until August. It lives in the forests on flood areas of the Rivers Danube and Tisza. It has 1 or more generation per year (Mihályi 1963).

Aëdes caspius Pallas,1771: This flies from the end of April until early October. It is a typical species of the steppes and meadows of the lowland. It does not enter houses. Its larvae tolerate salt and develop in the temporary, sunny lakes of the lowland. The numbers of its generations depend on the floodings of its breeding areas (Mihályi 1963).

Aëdes rusticus Rossi, 1790: This flies from the middle of April until the end of June. It plays a small part in the springtime mosquito problems. It can be found in forests and forest clearings. It has only 1 generation per year (Mihályi 1963).

Aëdes flavescens Müller, 1764: This flies from early April until the middle of August. It is an early spring species. It tolerates salt and develops in alkaline pools on sunny meadows in lowland areas. It has a spring and a summer generation (Mihályi 1963).

Aëdes excrucians Walker, 1856: It flies from the middle of April until the end of July. It plays a small part in the springtime mosquito problems. Its larvae favour colder water. It has 1 or 2 generations per year (Mihályi 1963).

Culex hortensis Ficalbi, 1899: This flies from early April until the end of October. It favours sunny and watery meadows or reedy lakes. In the daytime it hides in hollows or caves. It does not like human blood (Mihályi 1963).

Anopheles messae Falleroni, 1926: This flies from May until the end of September. It is a characteristic species in warm-watered swamps on the lowland. It does not like polluted water. It prefers sunny, shallow water overgrown with vegetation. Its imagos swarm and mate only outdoors (Mihályi 1963).

Anopheles hyrcanus Pallas, 1771: This flies from May until September. It lives outdoors, mainly in reedy lakes. It likes fresh water. This mosquito is sensitive to the salinity of water. It seldom attacks humans (Mihályi 1963).

Undetermined species: The identification of the collected mosquito species was not always easy because the species were collected by human-trap, and were sometimes damaged during collection, so that their determining features were not recognizable. These individuals were included in the quantitative determination, but were not included in the qualitative determination of distribution.

Some of the examined factors relating to the appearance of biting mosquitoes

The most important factors in the development of biting mosquitoes are still shallow water and the appropriate temperature. Some genera require other breeding water conditions too (humidity, salt content, organic substance content, pH, light conditions, light-shade relationship, etc.) (Mihályi 1963). In 1999 we observed the water level of the River Tisza, the average daily temperature and the daily rainfall (Fig. 2). The temperature was suitable for the development of mosquitoes from May until the end of September. Our examinations were performed in this period (Fig. 3). In Szeged, the mosquito season started with the appearance of the

Aëdes species in the middle of May and finished with a predominance of the *Culex* species at the end of September. In low numbers, the individuals of the *Aëdes* genus could be found in October. The individuals of the *Culex* genus spend the winter in the form of imagos.

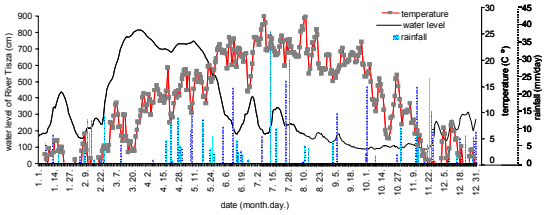

Fig. 2. Water level of River Tisza (cm), daily average temperature (ºC) and daily rainfall (mm) in Szeged in 1999

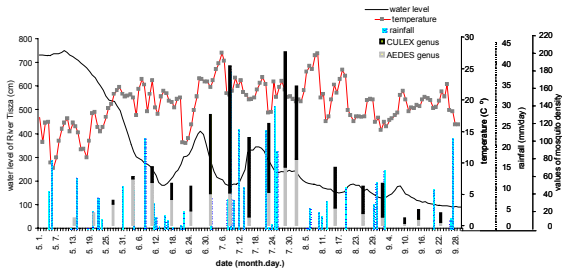

Fig. 3. Water-level of River Tisza (cm), daily average temperature (ºC), daily rainfall (mm) and average mosquito density (ind./hour) in Szeged from May to September in 1999

Water level of the River Tisza: River Tisza rises in the Carpathians. When it descends to Pannonia, it becomes a typical lowland river. River Tisza has two maxima and two minima annually. For the appearance of mosquitoes, the first maximum is more important. It occurs in April as a result of snow melting in the Carpathians. The second maximum occurs at the end of November and is of minor interest for mosquito control. The number of mosquitoes does not depend on the water level of the Tisza, but after the springtime-flood the *Aëdes* mosquito larvae begin to develop in the pools of the flood area (Branka 1984, Mihályi 1963).

Temperature: The temperature reaches the value necessary for the development of mosquito larvae between early May and the end of September. In early May there is a strong fall in temperature during the night, but the eggs of the *Aëdes* species laid on the ground on flood areas in the course of earlier years open in response to the warm daytime. The imagos of the *Culex* genus lay their egg-rafts on the surface of the breeding water after the cessation of the sharp nightly fall in temperature, in the middle of June (Mihályi 1963).

Rainfall: In summer, the mosquitoes breed in temporary water (pools, barrels of rainwater, pools in gardens, etc.), formed in consequence of rainfall (Mihályi 1963). In summer, the multivoltine mosquito species favour the temporary pools.

Results and Discussion

After the springtime flood, there is a humid period along the River Tisza. When the temperature reaches the minimum necessary for the development of mosquitoes (in May), the larvae hatch out from the eggs. The distribution is shown in Fig. 4. In general, the progress of the flood coincides with an increase in daily average temperature. Few mosquito species are present in the flood area. Far from the River Tisza, the local conditions may result in a more diverse mosquito species composition. We found numerous woods-favouring *Aëdes sticticus* and salt-favouring *Aëdes dorsalis* individuals besides *Aëdes vexans* individuals (Table 1).

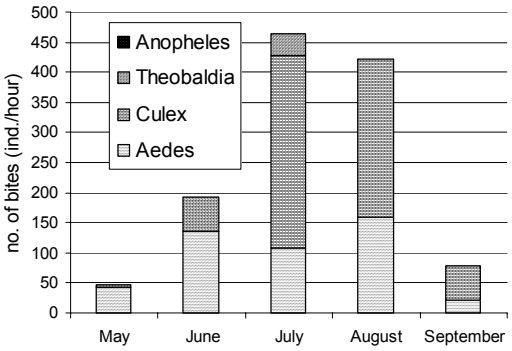

Fig. 4. Numbers (ind./hour) of individuals of biting-mosquito genera collected in Szeged from May to September in 1999.

After the stabilization of the optimal temperature, the individuals of *Culex* genus emerged in force in the middle of June. They became dominant during the dry summer. *Culex pipiens molestus* dominated at nearly all sampling sites, with the exceptions of sites 3 (Gyálarét) and 10 (Kállay Park). The greatest number (3934 ind./hour) was measured at sampling site 6 (Kossuth L. Avenue). This was followed by sampling site 4 (Hattyas), with a mosquito density of 2412 ind./hour, and sampling site 9 (Újszegedi Víztorony Square), with 1722 ind./hour. The salt-tolerant *Aëdes dorsalis* was observed at all sampling sites. The degree of alkaline character of the breeding sites is a feature of this phenomenon. Low numbers of individuals were

Table 1. Numbers of Culicidae species (ind./hour) collected during blood-sucking at collecting sites in Szeged in 1999.

No.	Sampling sites / Mosquito species	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	Total	%
(1)	Aëdes annulipes Meigen	102	84	-	18	14	264	-	-	36	276	-	794	5.9
(2)	Aëdes cantans Meigen	-	30	96	6	12	80	6	-	-	66	36	332	2.4
(3)	Aëdes caspius Pallas	30	18	-	-	12	18	-	-	-	-	-	78	0.6
(4)	Aëdes cinereus Meigen	66	24	-	-	-	6	-	-	-	-	-	96	0.7
(5)	Aëdes dorsalis Meigen	42	18	90	144	90	646	18	-	12	48	54	1162	8.6
(6)	Aëdes excrucians Walker	-	-	-	-	6	6	-	6	-	-	-	18	0.13
(7)	Aëdes flavescens Müller	-	-	-	18	-	6	-	-	6	-	-	30	0.22
(8)	Aëdes rossicus D. G. M.	-	42	42	12	-	-	-	-	-	-	-	96	0.7
(9)	Aëdes rusticus Rossi	-	-	-	-	-	6	-	-	-	60	-	66	0.41
(10)	Aëdes sticticus Meigen	78	42	162	72	166	226	6	-	66	78	168	1064	7.85
(11)	Aëdes vexans Meigen	96	120	552	204	42	84	6	-	72	174	18	1368	10.1
(12)	Culex hortensis Ficalbi	-	-	-	-	-	-	-	-	12	-	-	12	0.09
(13)	Culex modestus Ficalbi	204	24	18	528	132	260	-	12	90	6	90	1364	10.1
(14)	Culex pipiens molestus Forskal	336	294	66	1386	500	1998	24	48	1260	222	222	6356	46.9
(15)	Theobaldia annulata Schrank	6	18	-	-	12	252	-	-	108	-	-	396	2.9
(16)	Anopheles messae Falleroni	-	12	-	-	-	-	-	-	-	-	-	12	0.09
(17)	Anopheles hyrcanus Pallas	-	-	-	12	-	-	-	-	-	-	-	12	0.09
(18)	Not determined	-	30	36	12	24	82	-	-	60	30	24	298	2.2
	Total	960	756	1062	2412	1010	3934	60	66	1722	960	612	13554	100

1= Dorozsma; 2 = Dorozsma (Sziksós-Lake); 3 = Gyálarét; 4 = Hattyas; 5 = Móraváros; 6 = Kossuth L. Av;
7 = Olajbányász Square; 8 = Dóm Square; 9 = Víztorony Square; 10 = Kállay Park; 11 = Szőreg

collected at sampling sites 8 (Dom Square) (66 ind./hour) and 7 (Olajbányász Square) (60 ind./hour). The distribution of the individual numbers can be seen in Fig. 5.

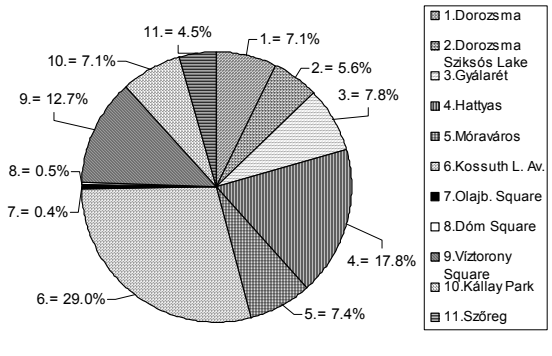

Fig. 5. Frequency distribution (%) of mosquito species collected in Szeged in 1999.

In the middle of summer, the individuals of the *Theobaldia* genus appeared in lower numbers, but at sampling site 6 (Kossuth L. Avenue) they were more significant (252 ind./hour).

Few individuals from the *Anopheles* genus could be collected with the human-trap method. We suggest that the individuals of this genus prefer the blood of animals to human blood. Two individuals of *Anopheles hyrcanus* were collected in Szeged. In earlier examinations, this species was not observed in the Tisza basin, but most recently it has been found in the mosquito assemblage of the Tisza Lake (Szabó 2003, personal communication).

In 1999, *Culex pipiens* (46.9%) was the dominant species in Szeged, with *Culex modestus* (10.1%) and *Aëdes vexans* (10.1%) as subdominant species. Other species appeared in lower numbers: *Aëdes dorsalis* (8.6%), *Aëdes sticticus* (7.85%), *Aëdes annulipes* (5.9%), *Theobaldia annulata* (2.9%) and *Aëdes cantans* (2.4%).

This result can be explained by he impact of urbanization (the presence of communal waste, the application of chemical fertilizers, the presence of polluted water, weekly chemical mosquito treatment etc.). In the modified environment, the dominant species appeared at all collecting sites.

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