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SCIENTIFIC NOTE

POPULATION DYNAMIC OF *AEDES VEXANS* AND *OCHLEROTATUS STICTICUS* IN FLOODED AREAS OF THE RIVER DRAVA IN OSIJEK, CROATIA

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ABSTRACT. Populations of adult mosquitoes occurring in the Osijek area in eastern Croatia were monitored from May 1995 to September 2000 with Centers for Disease Control–style traps baited with dry ice. A total of 106,663 adults was caught, ranging from 0 (several times) to 21,120 in May 1995. The mosquitoes captured represented 18 species. *Aedes vexans* was the most abundant, followed by *Ochlerotatus sticticus.* Both of these species have breeding sites in flooded areas in the areas surrounding Osijek. Furthermore, these 2 species comprised 86% of total adult mosquitoes collected. The life cycles of these species and their abundances were positively correlated with water level. The peak occurrence of these species was in late spring to early summer. During 6 years, adult mosquito populations were significantly correlated with the water level of the Drava River.

KEY WORDS Population dynamics, flooded areas, inundation, *Aedes vexans, Ochlerotatus sticticus*

Aedes vexans (Meigen) occurs throughout the Holarctic region and also is found in the Pacific Ocean region. The most suitable breeding areas for this species are areas that are flooded periodically, where its eggs can be found year around (Horsfall et al. 1988). *Aedes vexans* is abundant throughout Europe, including Germany (Becker 1989), Hungary (Mihaly 1963), Bohemia (Minar and Kramer 1980), Croatia (Merdić 1993), France, Italy, and Yugoslavia (Petrić et al. 2000), where this species represents the main problem confronting local mosquito control agencies.

The mosquito problem that currently exists in the area of the city of Osijek is mainly caused by seasonal flooding and partial inundation of the area between the bed and dike of the Drava River (Fig. 1). The overflow area remains flooded for several weeks after the decrease in the water level of the river, and this supports the development of abundant populations of floodwater mosquitoes. The city of Osijek is situated close to a large overflow area and floodwater species hatching from this site are capable of reaching (by dispersing 30 km) all parts of the city (Horsfall et al. 1988). The water level of the Drava River increases in April from snowmelt and after heavy rains in the summer and spring. The results shown in this study are a part of the ongoing mosquito surveillance activities implemented in the city of Osijek starting in 1995.

The city of Osijek is a center of eastern Croatia, Slavonia, and Baranya. Osijek is situated on the right bank of the Drava River, 25 km upstream from the mouth of the Danube River (Fig. 2). Three large rivers that produce floodwater areas border Slavonia and Baranya and part of Pannonian plain.

Mosquitoes were sampled at 9 locations within the city of Osijek. The distance between breeding sources was from 500 m to 10 km, and the distance between trap sites was approximately 2.5 km. Traps were operated twice monthly during May, June, July, August, and September from 1995 through 2000 for a total of 531 trap nights. Traps were operated continuously for 24 h to provide some sampling of diurnal adult mosquitoes.

Data dealing with the water level of the Drava River in the city of Osijek were obtained from the State Meteorological Centre of the Republic of Croatia, Zagreb.

Altogether, 106,663 mosquitoes representing 18 species were collected from 1995 through 2000 (Table 1). Of the overall total, 81,991 were *Ae. vexans* (76,87%) and 9,349 were *Ochlerotatus sticticus* (Meigen) (8,76%). Together these floodwater species comprised 86% of mosquitoes caught in the city.

During 1995, the number of *Ae. vexans* and *Oc. sticticus* sampled was exceptionally high (Fig. 3). The main cause for these abundant populations was the fact that the river flooded the overflow area adjacent to Osijek during June. In 1996, the overflow areas were flooded during 3 short periods (Fig. 4), which resulted in the production of 3 generations of *Ae. vexans* and 2 generations of *Oc. sticticus.* For both species, the most numerous was the 1st generation. In 1997, 3 characteristic generations of both *Ae. vexans* and *Oc. sticticus* (Fig. 5) occurred after increases in the water level of the river and flooding of overflow areas. During 1998, fewer mosquitoes were collected in comparison to the other years (Fig. 6). The water level of the river that year varied only by 0 to 50 cm. In 1999, numbers of *Ae. vexans* remained equal throughout the season (Fig. 7), whereas *Oc. sticticus* showed population characteristics more typical of a normal season. The water level in 1999 was 6 times above the critical value, and remained high from mid-May through mid-June. At the beginning of the 2000 season, the number of species collected was notable

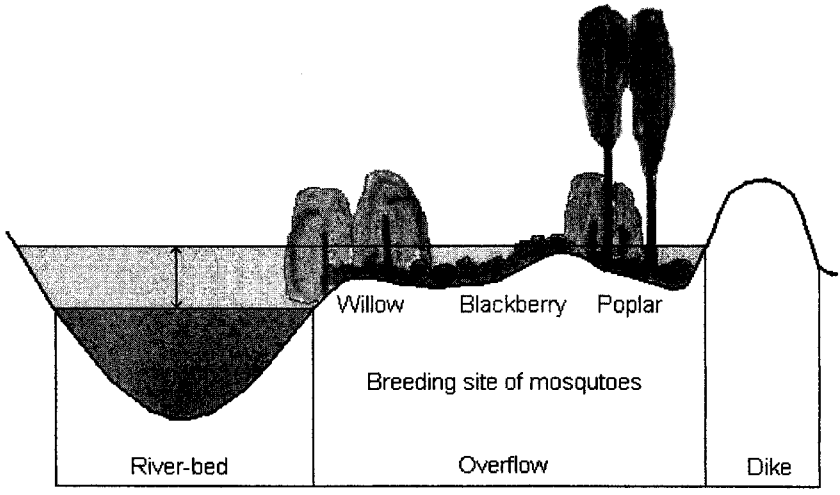

Fig. 1. Scheme of flooding. Arrow shows the range in water level.

because of the high water level during April (Fig. 8). From mid-June 2000 until the end of the season, the water level did not exceed the critical value, which resulted in decreased production of *Ae. vexans* and no *Oc. sticticus.*

Overflow areas that were created by building a dike to prevent flooding of some large areas near Osijek also created conditions favorable for the production of floodwater mosquitoes. Because the river follows a zigzag direction and the dike was

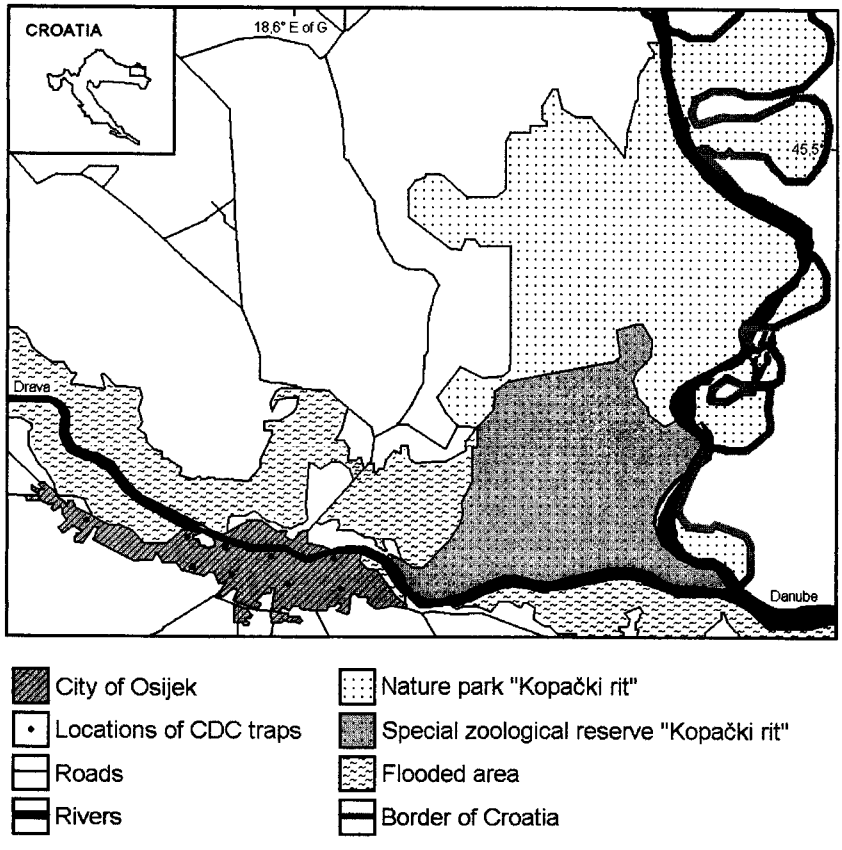

Fig. 2. Map of the city of Osijek and its surroundings.

Table 1. Presence of mosquito species from 1995 to 2000 in the area of the city of Osijek.

Species	1995	1996	1997	1998	1999	2000
Aedes vexans	+	+	+	+	+	+
Ochlerotatus sticticus	+	+	+	+	+	+
Oc. cantans	+	+	+	+	+	+
Oc. excrucians	+	+	+	+	+	+
Ae. cinereus	+	+	+	+	+	+
Anopheles maculipennis complex	+	+	+	+	+	+
Coquillettidia richardii	+	+	+	+	+	+
Culex pipiens complex	+	+	+	+	+	+
Culiseta annulata	+	+	+	+	+	+
Oc. rusticus group		+	+	+	+	+
Oc. caspius	+	+		+	+	+
An. claviger	+	+		+	+	+
An. hyrcanus	+	+			+	+
Ae. rossicus	+	+			+	+
Cx. modestus	+				+	
Oc. cataphylla	+					
Uranotenia unguiculata	+					
Cx. teritans				+		

built in a straight direction, the distance between the river and the dike varies. The elevation of the land also varies, as indicated by the different vegetation zones associated with the floodplain. The most suitable zone for oviposition is the middle zone, which is flooded several times each year. In this zone, vegetation is mostly *Phragmites communis* and *Phalaris arundinacea* (Becker 1989). In suburban Osijek, a water level of approximately 200 cm creates overflow conditions, resulting in the flooding of the overflow areas. The water level ultimately determines the extent of flooding and depending upon depth, the number of species that may hatch from preexisting egg beds. The optimal conditions for *Ae. vexans* and *Oc. sticticus* occur when water levels fluctuate. Such was the case in 1997, when the Drava overflowed 3 times, and each time a new generation of mosquitoes was produced. A persistent high water level does not produce large broods of either *Ae. vexans* or *Oc. sticticus* because

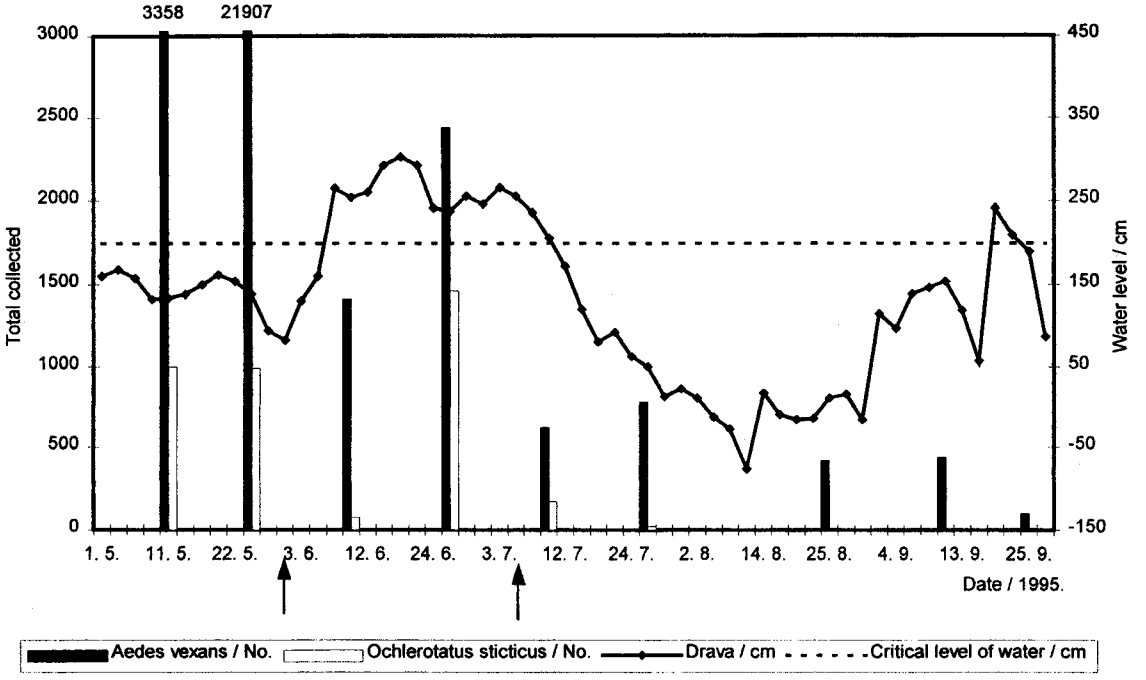

Fig. 3. Dynamics of *Aedes vexans* and *Ochlerotatus sticticus* and water level of the Drava River (arrows show date of air treatment) in 1995.

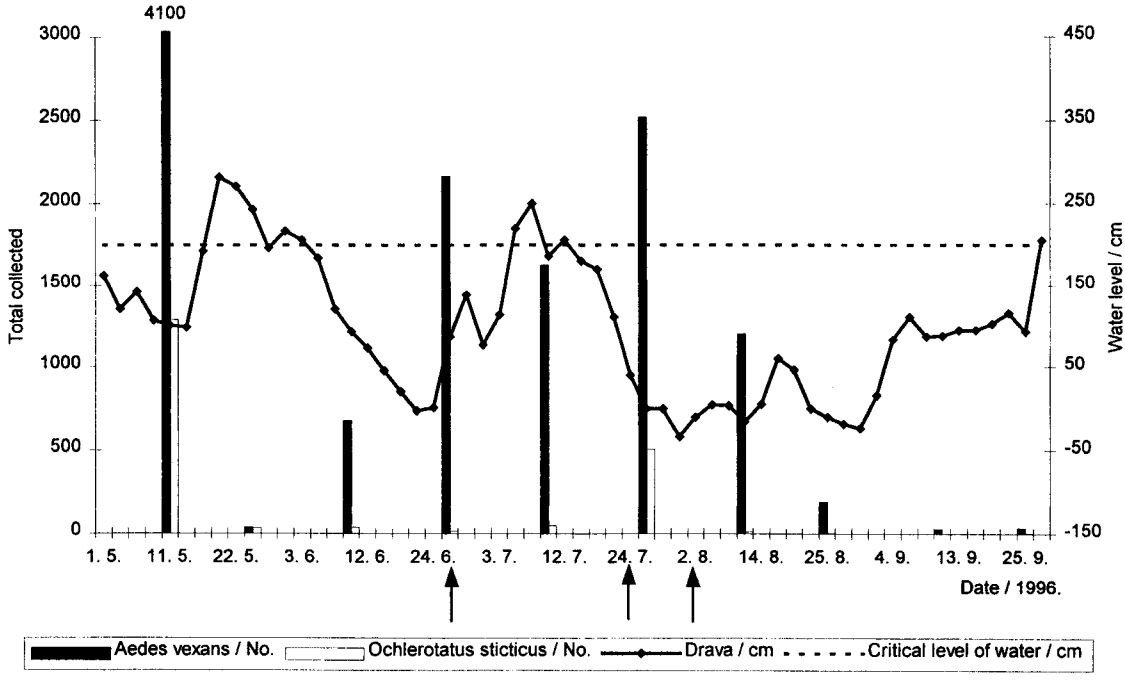

Fig. 4. Dynamics of *Aedes vexans* and *Ochlerotatus sticticus* and water level of the Drava River (arrows show date of air treatment) in 1996.

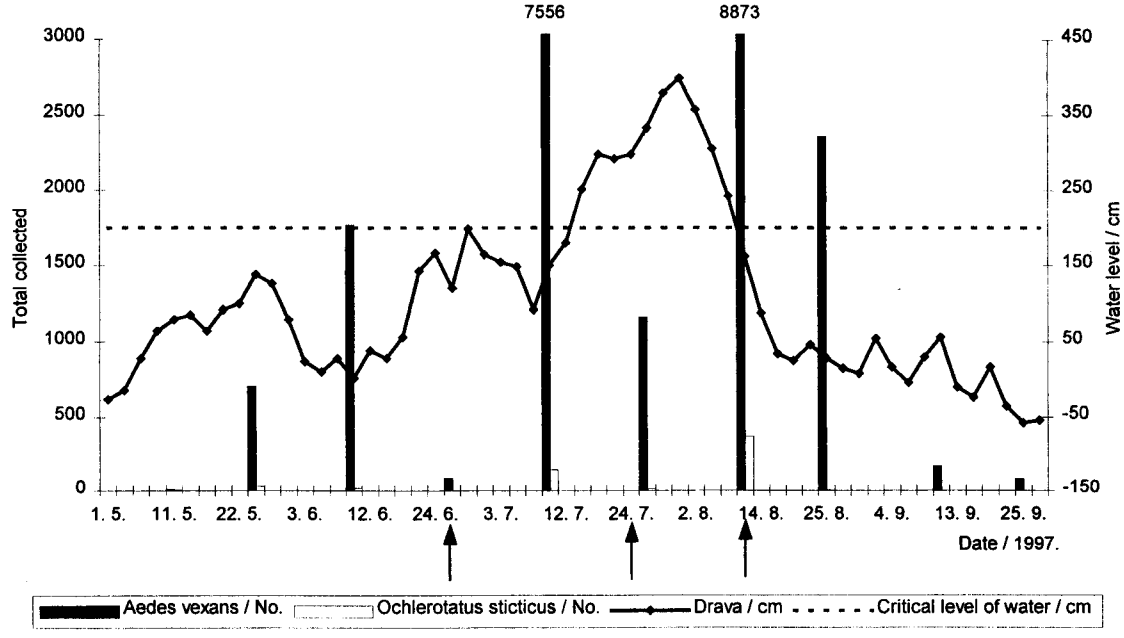

Fig. 5. Dynamics of *Aedes vexans* and *Ochlerotatus sticticus* and water level of the Drava River (arrows show date of air treatment) in 1997.

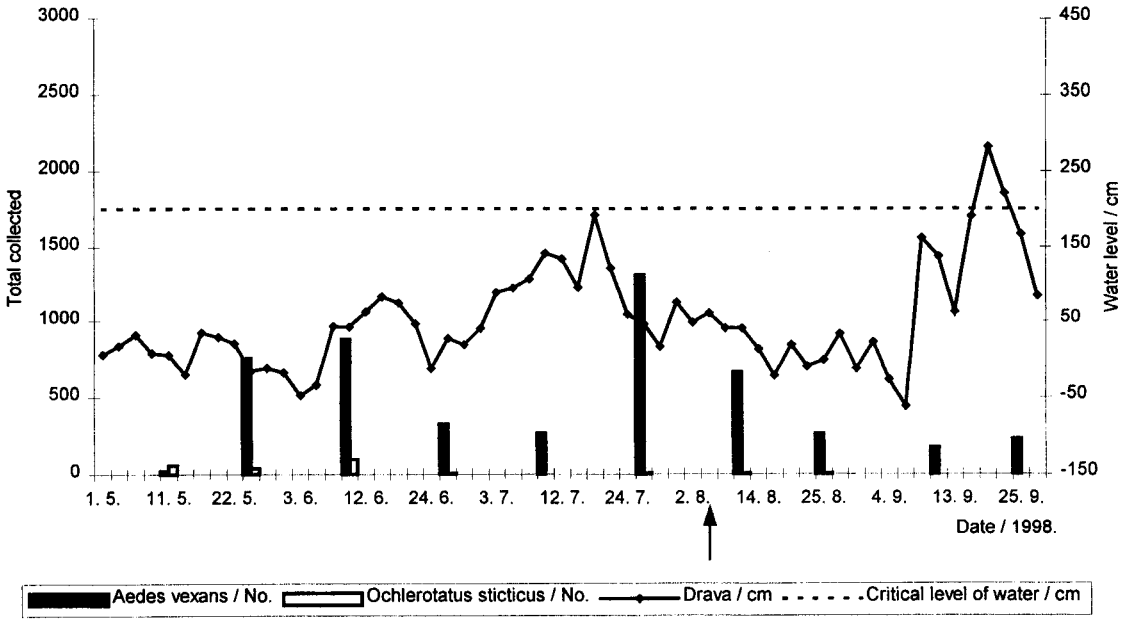

Fig. 6. Dynamics of *Aedes vexans* and *Ochlerotatus sticticus* and water level of the Drava River (arrows show date of air treatment) in 1998.

natural enemies of mosquito larvae become established with stable water level conditions. Extremely low water levels in 2000 did not lead to the development of 2nd and 3rd generations of mosquitoes. Other than in 2000, mosquito populations were characterized by at least 1 springtime generation. After the spring flood, the number of generations varied depending upon subsequent water fluctuations of the Drava River.

Most emerging adult mosquitoes do not remain

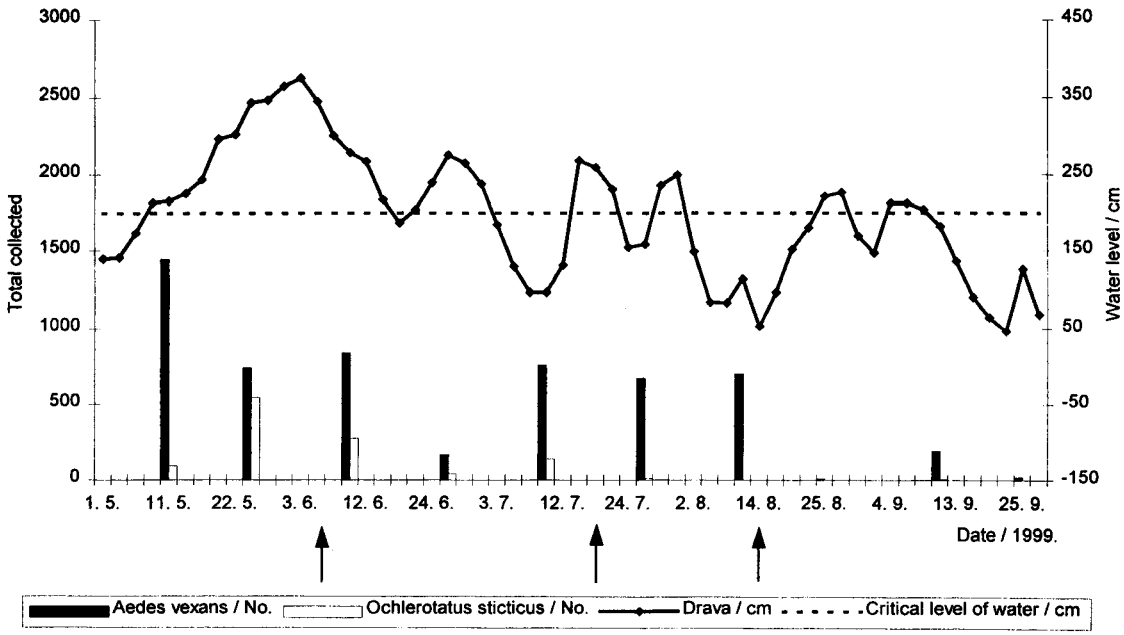

Fig. 7. Dynamics of *Aedes vexans* and *Ochlerotatus sticticus* and water level of the Drava River (arrows show date of air treatment) in 1999.

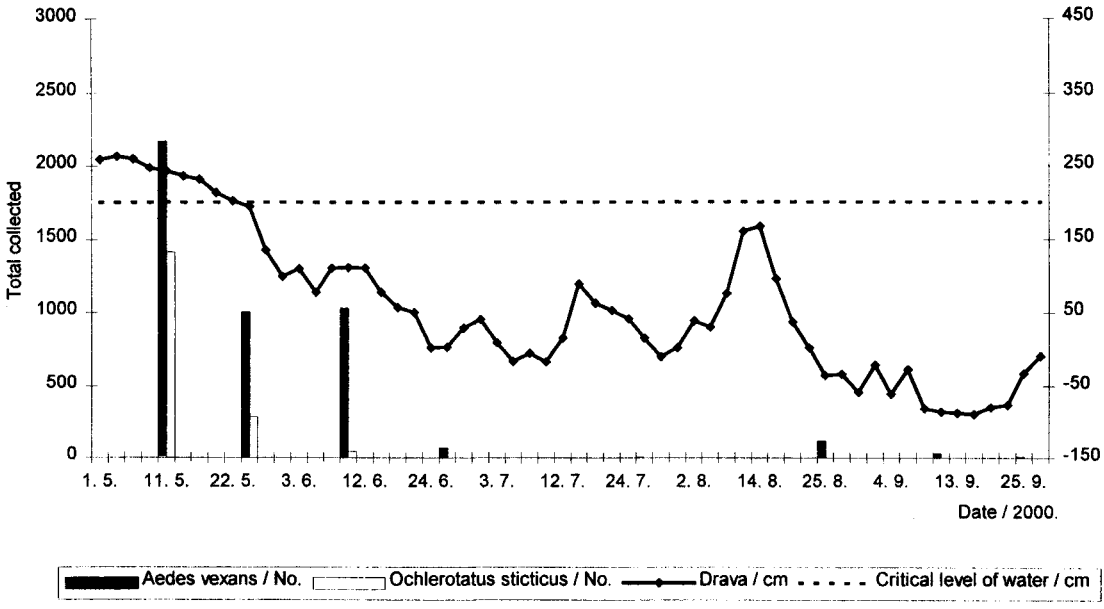

Fig. 8. Dynamics of *Aedes vexans* and *Ochlerotatus sticticus* and water level of the Drava River (arrows show date of air treatment) in 2000.

on the floodplain. Unfortunately, their dispersal quite often is in the direction of the city. Historically, dispersing host-seeking females usually attack those residents who live closest to the floodplain.

Until 1999, the primary method used to control mosquitoes in this area was aerial application of adulticides. However, this method of mosquito control has been prohibited in Croatia by law. Overall, aerial application of pesticides provided only temporary control within the city, and had little impact on controlling mosquitoes at their breeding sites. Consequently, mosquito control activities probably did not influence the results of this work.

We would like to extend our gratitude to the city government in the city of Osijek, which helped us in financing the monitoring and examination of mosquitoes in the area of the city. Thanks to their help, making a scientific base for further control of mosquitoes was possible.

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