

Mosquito prevalence in the Komárno and Nové Zámky regions of southern Slovakia

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Abstract

Several regions of southern Slovakia, particularly the flood plains of the River Danube and the River Váh are affected by swarms of mosquitoes every year. This has a serious impact on local health, especially among agricultural and forestry workers. It is also a serious threat to tourism in the Komárno area. In a study in 33 localities between 2001 and 2003, a total of 22 species of mosquito were found and control was attempted.

Introduction

Although there has been a great deal of research on mosquitoes in Slovakia, few articles have been published on mosquitoes in the districts of Komárno and Nové Zámky (southern Slovakia). Of these, the most important are those by Trpiš (1956; 1960; 1962a, b) and Halgoš (1994).

However, these districts are important because they experience annual flooding. Abutting the River Danube, where it is joined by the rivers Váh, Nitra, Žitava and Hron, the area is often flooded in spring by melting snows in the Alps and by very heavy rainfall elsewhere in the country. Alluvial forests in the Danube flood plain are dependent on these floods. At the same time, these forests also serve as breeding grounds for mosquitoes and the increase in the number of mosquitoes is perceived as an indicator of the growth of the softwood trees.

The aim of this study was to find the range of mosquito species breeding in these flood plains. To achieve this, the areas of the greatest increase in the numbers of mosquitoes was focused upon. As a result, it was possible to suggest ways of making an early assessment of such increases, their progression and appropriate ways of reducing mosquito numbers.

Material and methods

The study area is shown as the shaded region in Figure 1. Pre-imaginal stages of mosquitoes were collected with a plankton net. Larvae were fixed in 80% ethyl alcohol and pupae were reared to obtain adults. Larval density was determined using a wooden frame 25 x 25 x 50 cm. Adults were collected in a 0.5 m diameter entomological sweep net or from human bait using an electric suction device. In 2003 some mosquitoes were caught in CDC traps placed in pig, cow, or other domestic animal shelters situated near the inundated plains of the Nitra, Danube, Ipel and Hron rivers. Permanent preparations were made of some larvae and males. Abundance was determined after 10 sweeps of the entomological net or by human-bait collections for periods of 10 minutes at times when mosquitoes were normally active. Captured adult mosquitoes were stored at -18°C until processed.

A five-degree quantitative scale of abundance was used for both larvae and adults: in mass > abundant > less abundant > isolated specimens > very rare. The biting problem caused by mosquitoes was classified according to an increasing degree of severity as 3rd, 2nd and 1st degrees of affliction. Mosquito control was attempted using several Slovakian registered insecticides, which were applied with a ULV H.D. generator, mainly in the flooded areas. These included Reslin 25 SE (containing S-biomethrin, Permethrin, Piperonyl butoxide), Aqua Reslin Super and Kontakt® (containing cypermethrin and produced by Agrochemix Bratislava, Slovakia) (Brestovský *et al.*, 1999).

Results and discussion

With respect to mosquito incidence, the districts of Komárno and Nové Zámky can be divided into three zones: (A) the Danube flood plain upstream and downstream of the dam, (B) the flood plain of the river Váh, and (C) the flood plains of the rivers Žitava and Nitra.

The study focused on the following localities:

A. Danube flood plain upstream and downstream of the dam

1. The locality of “Starý les” and surrounding inundation area known as the “Lyon Arm”

This locality consists of typical alluvial forest. Its character is linked to the regular regimen of seepage ground water and flooding when levels of the Danube rise. The occurrence of 3rd and 4th instar larvae of *Aedes cinereus*, *Ae. rossicus*, *Ae. vexans* and *Ochlerotatus sticticus* was discovered in flooded pits several metres in depth at the beginning of August 2001. According to the five-degree quantitative scale of abundance used they were all classified as “less abundant“. Other 3rd and 4th instar larvae found in the area of the “Lyon Arm” were classified as “very rare” and identified as those of *Anopheles maculipennis* s.l., *Culex modestus*, *Cx. territans* and *Cx. pipiens*. The incidence of adult mosquitoes present at this time was estimated as *Ae. vexans* - in mass, *Ae. rossicus* - in mass, *Oc. sticticus* - abundant, *Ae. cinereus* - less abundant, *Oc. dorsalis* - less abundant and *Oc. cantans* - isolated specimens.

In 2002, the study commenced at the beginning of July (July 2), when the area was partially covered with flood water and partially with seepage of ground water. Small numbers of 3rd and 4th instar larvae of *Ae. rossicus*, *Ae. vexans* and *Oc. sticticus* occurred in pits containing water up to 1 m in depth. Adult mosquitoes present at this time were *Ae. rossicus* - rare, *Ae. vexans* - rare, *Oc. sticticus* - rare and *Oc. cantans* - isolated specimens.

When inspected again on August 23, 2002 the flood water had subsided and only the pits and some other depressions contained water. However, according to mud sediments on the surrounding vegetation, the floods had reached a depth of 9 m at their peak on August 16. The heavy flooding had evidently washed away any larvae present and only a few specimens of *Ae. vexans* remained.

The situation was different around the villages of Čičov and Kľučovec where depressions and pits extending for several kilometres from the reservoir/lake were still flooded to a depth of 1 m. Here there was increased abundance of *Ae. vexans* and *Oc. sticticus* causing a 3rd degree affliction.

Further study took place in this locality on 4 September 2002 and enormous numbers of mosquitoes were found in the flooded zone. An estimated 1st - 2nd degree affliction was found directly in front of the dam and also in the vicinity of Čičov and Kľučovec. The development of larvae on the latter area took place in seepage waters. The 1st and 2nd degree of affliction in the area upstream of the dam affected the villages Okoličná na Ostrove, Veľké Kosihy and Zlatná na Ostrove, and was connected with the migration of mosquitoes from their natural hatching places for the purposes of obtaining a bloodmeal. In 2003 we did not record an increase in the number of mosquitoes at this locality. We were only able to collect only a few specimens of *Ae. rossicus*, *Ae. vexans* and *Oc. sticticus*.

2. The Danube inundation near Patince - the area in front of the embankments

The area on both sides of the embankments was chosen as the next locality in the Danube River flooded zone. The area was chosen because it contains an important holiday resort the thermal swimming pool at Patince. Mosquito hatching places found in the Komárno District are typical almost for the whole section of the Danube flood plain up to the boundaries of the Nové Zámky District. There is an alluvial poplar forest strongly affected by anthropogenic activity where it fronts the dam area near the new port. One part of this area consists of the heavily overgrown former arm of the Danube River with its shallow natural depression, where rain and seepage water gathers. There was about 40-50 cm of water and thick cover of plants and shrubs on 3 August 2001 in this depression. Water was relatively warm (21°C), and contained 4th instar larvae of *Ae. vexans* - in mass, *Ae. cinereus* / *rossicus* (the species cannot be reliably identified in the larval stage) - in mass, *Oc. sticticus* - in mass, *Oc. dorsalis* - less abundant.

Another sampling in the former Danube arm near the dam (where the discharge channel connects the dam with the new port) recorded *Ae. vexans* - in mass, *Oc. sticticus* - in mass, *Cx. pipiens* - less abundant and *An. maculipennis* s.l. - rare.

Another collection on 18 September 2001 detected 3rd and 4th instar larvae of *Ae. vexans* - in mass, *Ae. cinereus/rossicus* - in mass, and *Oc. sticticus* - in mass. Almost 20% of pre-imaginal stages consisted of pupae. These

mosquitoes, typical for late summer, were found in the discharge channel of the road connecting the embankments with the new port. Larvae of *An. maculipennis* s.l. and *Cx. pipiens* occurred there. Some *Aedes* / *Ochlerotatus* species were also found, notably *Ae. vexans* - mass abundance, *Oc. sticticus* and *Ae. cinereus* / *rossicus* - less abundant.

The alluvial forest, which contains large numbers of poplars, is heavily affected by anthropogenic activity in the area in front of the embankments near the new port. One part of the above area is formed by the overgrown shallow natural depression in the former arm of the Danube River in which rain and flood water gather.

The first sampling here took place on 2 July 2002. The locality was completely dry and offered no opportunities to mosquitoes. The next sampling was done on 10 July 2002. Species found were *Ae. rossicus*, *Ae. vexans*, *Oc. sticticus*, *Oc. cantans* and *Oc. annulipes* - all rare. The locality was heavily waterlogged after the decline of floods on 30 August 2002. The surrounding plantation indicated signs of flood up to the height of several metres and the increase of mosquito prevalence threatened to be catastrophic. *Aedes vexans* and *Ae. rossicus* accounted for 90% of the mosquitoes present, with *Oc. sticticus* making up the other 10%.

A 3rd degree of affliction situation was found on 4 to 7 September 2002 when more than 200 mosquitoes, most of them either *Ae. vexans* or *Ae. rossicus*, attempted to bite a man within a minute. Monitoring on 12 September indicated a 1st degree of affliction before there was a reduction in mosquito abundance following insecticidal applications. Because of the increased occurrence, the adult mosquito population was also sampled during October.

3. The Holiday Resort in Patince - the area behind the dam

There are areas of standing thermal water near the thermal well in which a few larvae of *Cx. pipiens* and *An. maculipennis* s.l. occurred in cold sections. Monitoring of the attack by mosquitoes on humans for several hours in the morning and again in the evening (in August) indicated that *Ae. vexans*, *Ae. rossicus* and *Oc. sticticus* (10-20 individuals per hour) created a considerable nuisance. The invasion of adult mosquitoes probably comes from the inundation areas upstream and downstream of the dam (including standing waters associated with the Roman Lake and new the swimming pool area). Because the nuisance caused by biting mosquitoes in this holiday resort has an impact on tourists, the employment of insecticidal sprays is necessary.

Taking into account the vicinity of the Roman Lake to the holiday facility, monitoring of mosquito breeding was done in accessible parts of the lake, which is fringed with dense growths of reeds (*Phragmites australis*), sedge (*Carex* sp.) and cattail (*Typha* sp.). Early morning and evening sampling revealed the existence of adult *An. maculipennis* s.l. - less abundant, *Cx. modestus* - less abundant, *Cx. territans* - less abundant. Pre-imaginal stages of these species were found in the drainage channel situated approximately 100 m northwest of the holiday facility.

As opposed to the results of sampling in August increased occurrence of pre-imaginal stages was found in water connected to the thermal well. Larvae of *Cx. pipiens* - abundant, and *An. maculipennis* - rare, occurred in peripheral sections.

A more intensive invasion of the holiday resort by adult *Ae. vexans*, *Ae. rossicus* and *Oc. sticticus* was detected by attacks on a volunteer (10-15 bites per minute) on the evening of 18 September and morning of 19 September, 2001. It is thought that adult mosquitoes flew in, particularly from the flooded area behind the embankments, from hatching places in front of the embankments (the Roman Lake "Rimské Jazero", and standing waters near to the swimming pool. With respect to the mass occurrence of mosquito adult and pre- imaginal stages it was recommended that insecticides should be used to prevent oviposition of the third generation of mosquitoes. Halgoš & Petrus (1995) reported the increased occurrence of the third and fourth generation of mosquitoes in the surroundings of Bratislava in autumn months.

The thermal swimming pool at Patince, Virt, Iza and the city of Komárno, all in the area behind the embankments, were monitored in 2002. Insecticidal spraying was applied directly in the area of the thermal swimming pool on 12 September 2002. The number of adult mosquitoes detected fell to a minimum in the next days (13, 14 and 15 September). Evidence of the absence of mosquito adults in Komárno was obtained on 12, 14 and 15 September and can be explained by successful applications of insecticide.

Samples taken in August to October 2001 and 2002 showed the occurrence of *Ae. vexans* - in mass, *Cx. pipiens* - less abundant and *An. maculipennis* s.l. - rare near the embankments of the discharge channel near the road connecting the embankments with the new port in the former Danube arm, From a health point of view, *An. maculipennis* s.l. and *Cx. pipiens*, even if they are ornithophilic forms, are of major importance because they are active at night in enclosed areas. *Anopheles* and *Culex* belong to genera in which the adult females hibernate. In natural conditions they may also be numerous and active indoors in winter because of central heating. *Culex pipiens* is anthropophilic in our conditions. It hatches in containers filled with rain and in water in pools and human artefacts.

4. Rimské Jazero (The Roman Lake) - the area behind the embankments

Pre-imaginal stages of the following mosquito species were obtained in the accessible parts of the Roman Lake: *An. maculipennis* s.l. - less abundant, *Cx. modestus* - less abundant, *Cx. territans* - less abundant and *Cx. pipiens* - less abundant. These species were present also in the drainage channel situated approximately in 100 m northwest from the holiday facility. A similar composition of the mosquito community was found there in 2001 and 2002.

B - The flood plain of the River Váh

There was very heavy rainfall in Slovakia during 2001, especially in the north and central parts in the second half of July. This resulted in very high water levels, especially in the River Váh, where levels up to 1m behind the embankments affected the entire Váh flood plain. There were only small areas of standing water remaining on August 3d after the decline of flood but some of these were the result of long-term rains. Older larvae (3rd and 4th instars) and pupae occurred in about equal proportions. The species present were *Ae. vexans* - in mass, *Ae. cinereus / rossicus* - abundant, and *Oc. sticticus* - abundant. These huge numbers of adult anthropophilous species sheltering in riparian vegetation are of great significance.

The studies in the Váh flooded area were carried out in the area between Vrbová nad Váhom and Komárno. Taking into account the absence of protected areas as well as the mass occurrence of anthropophilic species the application of insecticides registered in the Slovak Republic was recommended. The drainage channel in the area behind the dam supports abundant riparian vegetation. The water temperature was 23°C and contained 4th instar larvae of *An. maculipennis* s.l. - less abundant, *Cx. pipiens* - abundant and *Culiseta annulata* - less abundant.

Increased precipitation in the first two-thirds of September resulted in forming of new and replenishment of old larval sites in the inundation zones of the rivers Váh, Žitava and Nitra. A relatively high level of river water and underground water seepage, especially in front of the dam, contributed to formation and replenishment of larval sites in which 3rd and 4th instar larvae and pupae of *Ae. vexans* - abundant, *Ae. cinereous / rossicus* - less abundant, and *Oc. sticticus* - less abundant were found on September 15 and 18 2001. Abundance of adult mosquitoes is also of great significance, especially those belonging to *Ae. vexans*. This species shelters in riparian vegetation and comprised 80% of all mosquitoes in this type of harbourage. These studies in the Váh valley were carried out between Vrbová nad Váhom and Komárno. The drainage channel in the area behind the dam supports abundant riparian vegetation and the water at a temperature of 14°C supported 4th instar larvae of *An. maculipennis* s.l. - less abundant, *Cx. pipiens* - abundant. As opposed to previous samplings in August, larvae of the species *Cx. hortensis* and *Cx. territans* were rarely encountered.

The months of May - July of 2002 was exceptionally dry and there was almost absolute absence of pre-imaginal stages of mosquitoes in localities that were monitored also in 2001, during visits at this period (15 May, 13 June, 1 July, 10 July 2002). The situation changed dramatically after floods in August that reached a peak of 836 cm at Komárno on 18 August. The very high level of water in the Danube in turn increased the level of the River Váh and caused extensive flooding north of the Danube. Water in the River Váh rose to the level of the river banks and associated embankments and overflowed in some areas. This created ideal breeding grounds, especially for the most abundant *Aedes* and *Ochlerotatus* species in residual pools of water remaining after the floods had subsided. It equalled the worst record of the past hundred years in the Danube and Váh (Kolárovo 18 August 2002 - 678 cm) and resulted in a very large increase in the number of mosquitoes.

This sharp rise in mosquito abundance was recorded in the Váh River basin from Komárno to the village of Dedina Mládeže in the area in front of and outside the dam on 30 August 2002. A calamitous occurrence of mosquitoes occurred in the villages of Kava, Vrbová nad Váhom, Kolárovo, Komoča, Zemné and Dedina Mládeže. The 3rd degree

of mosquito affliction was found in the whole section of Váh, especially in the inundation zone. There were many seepage and rain depressions in front of the dam containing many pre-imaginal mosquitoes. Adult *Ae. vexans* - in mass, *Ae. rossicus* - in mass (in spite of it being a relatively rare species in southwest Slovakia), and *Oc. sticticus* - less abundant were also recorded.

The 3rd degree of mosquito affliction was experienced in the whole section of Váh again on 4 September 2002. Pools in the field behind the dam dried out but those in front of the dam remained and continued to support enormous numbers of mosquito larvae and pupae. Pupae comprised approximately 60% of pre-imaginal stages. Adults were still present at extremely high densities, with approximately 200 mosquitoes per minute attempting to bite a single person. Drying pools behind the dam contained pupae only, but pools in front of the dam also contained earlier instars and are evidence of a persisting calamitous mosquito situation.

The next insecticide applications were on 14 to 21 September 2002 at a time when a spell of unusually warm weather was producing conditions favourable for larval development. By 2 October the warm weather had given way to rain and though there were still plenty of developing larvae, conditions were not so favourable for adult activity. Adult densities and activity continued to be curtailed during October, when the first frost signalled the end of the mosquito season.

C - The flood plains of the rivers Žitava and Nitra

A water meadow on the edge of the village of Martovce at the confluence of the rivers Nitra and Žitava was chosen for the study of mosquitoes. Despite the fall in the level of the River Nitra, attacks by adult mosquitoes on a volunteer reached 30-40 per minute in the afternoon. As the seasonal floods in the Nitra and Žitava valleys occur at the same time as those in the Váh River basin, the situations are almost identical. During a visit on 3 August 2001 sediment on vegetation revealed that part of the meadow had been extensively inundated during the earlier floods and was therefore suitable for floodwater mosquito development. Many similar situations are to be found on both shores of the Žitava River. A survey revealed the presence of *Ae. vexans*, *Ae. rossicus* and *Oc. sticticus* - in mass. A heavily eutrophicated village pond situated behind the dam contained a thick deposit of mud. No pre-imaginal stages were found there.

Studies in 2002 were made in the same place as in 2001. On 2 July 2002 adult *Ae. vexans* and *Oc. sticticus* were present. By 30 August densities of *Ae. vexans* and *Ae. rossicus* were similar to those in the Váh River basin. The situation remained unchanged during subsequent investigations in the locality of Landor and in a branch of the Nitra River on 7 and 14 September where the situations resembled those in the Žitava River basin (at Martovce).

There is little previous information on these areas but, as opposed to our findings on the species spectrum, Trpiš, (1962) found an additional 15 species during 10 years of intensive research covering the whole of Podunajská nížina (Podunajská lowland). The extinction of these is probably connected with significant anthropogenic changes. Jalili *et al.* (1999), investigating the situation following floods, especially in the Morava River basin, found many details concerning time changes in mosquito communities. Similar findings were obtained in the Ipel River basin (Brestovský & Jalili, 2002).

In 2003 we did not record an increase in the number of mosquitoes at the flooded area of the River Danube. This was due to a dry and hot summer season, with an apparent decrease of ground water and appearance of mosquito breeding sites.

We collected [and preserved] only a few samples of *Ae. vexans*, *Ae. rossicus* and *Oc. sticticus*. In contrast to the Danube flood plane an increase in the number of mosquitoes was observed along the River Váh in June, July and September. In the inundation of the River Stara Nitra we recorded extremely high pest mosquito densities in May and June.

Conclusion

This study of mosquitoes was carried out in flooded zones of the Danube and its tributaries, the Váh, Nitra and Žitava, in the Komárno and Nové Zámky Districts of south-west of Slovakia between 2001-2003. Several regions in this part of Slovakia, particularly flood plains, are affected by swarms of mosquitoes every year. This has a serious impact on

local health, especially among agricultural and forestry workers. It is also a serious threat to tourism in the Komárno area.

The following species were found in the study area: *Anopheles maculipennis* s.l., *An. claviger* (Meigen), *Aedes cinereus* Meigen, *Aedes rossicus* (Dolbeskin, Gorickaja & Mitrofanova), *Aedes vexans* (Meigen), *Ochlerotatus annulipes* (Meigen), *Oc. cantans* (Meigen), *Oc. caspius* (Pallas), *Oc. cataphylla* (Dyar), *Oc. dorsalis* (Meigen), *Oc. excrucians* (Walker), *Oc. flavescens* (Muller), *Oc. leucomelas* (Meigen), *Oc. punctor* (Kirby), *Oc. sticticus* (Meigen), *Coquilletidia richiardii* (Ficalbi), *Culex pipiens* Linnaeus, *Cx. modestus* Ficalbi, *Cx. hortensis* Ficalbi, *Cx. territans* Walker and *Culiseta anullata* (Schränk).

Aedes vexans, *Ae. rossicus* and *Ae. sticticus* were the most significant and worst nuisance in the swarms caused by the Danube, Váh, Nitra and Žitava floods in August and September. It is also clear that the rise in the number of mosquitoes was the direct result of these floods which reached a record level, especially in 2002. Floods caused a great increase in the number of mosquitoes in the period from the late August until mid-October. Biting problems were principally due to *Ae. vexans*, *Ae. rossicus* and *Oc. sticticus*. The great increase in the number of mosquitoes was regularly monitored and relevant measures to minimize the nuisance they caused were proposed. In 2003 we did not observe an increase in the number of mosquitoes in River Danube flood plain. This was due to an exceptionally dry and hot summer, which caused a decrease of ground water and a consequent dearth of mosquito breeding sites.

We collected only a few samples of mosquitoes belonging to *Ae. vexans*, *Ae. rossicus* and *Oc. sticticus*. In contrast an increase in the number of mosquitoes was registered along the River Váh in June, July and September. In the inundation of the River Stará Nitra we recorded mass occurrence of mosquitoes in May and June. It is necessary to continue the study and subsequent monitoring of mosquitoes with respect to their medical and veterinary importance in the case of mass occurrence on the territory of the Komárno and Nove Zámky districts (southern Slovakia) in the following years.

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Figure1. Study area

