

AN OUTBREAK OF *SIMULIUM ERYTHROCEPHALUM* (DE GEER, 1776) IN THE REGION OF NOVI SAD (SERBIA) IN 2006

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ABSTRACT – During the past decades, *Simulium (Boophthora) erythrocephalum* (De Geer, 1776) proved to be an extremely aggressive anthropophilic blackfly species in the province of Vojvodina, Serbia. Prior to 2006, last outbreaks in Vojvodina occurred after severe flooding of the Danube and the Tisza River in the springs of 1965 and 1970.

The extremely elevated level of the Danube in the spring of 2006 (which exceeded the average perennial values for the last sixty years) and cold weather at the time created suitable conditions for another outbreak of *S. erythrocephalum*. Situated on both banks of the Danube, the city of Novi Sad with numerous villages in the vicinity represents a particularly endangered region.

The abundance of adult populations of blackflies was recorded on a weekly basis by dry ice-baited traps. Positive captures were recorded at 26 out of 28 localities during the season of the outbreak. Estimation of the biting risk was calculated for each trapping result.

The presence of adult *S. erythrocephalum* females was continually recorded in traps during the season from April to mid-July. Periods with frequent cases of elevated biting risks extended from April to the end of June.

Recorded clinical cases of patients suffering from bites were in correlation with the periods of elevated risk of being bitten by *S. erythrocephalum*. The majority of bites were recorded below the knees, which reflects the typical biting habit of this species.

KEY WORDS: Simuliidae, black flies, *Simulium erythrocephalum*, outbreak, clinical cases

INTRODUCTION

On the basis of the number of species with the potential for massive reproduction, the frequency of outbreaks of different blackfly species, and consequent enormous damage during the last century, Serbia and especially the province of Vojvodina can be considered as one of the most endangered parts of Europe (ŽIVKOVIĆ, 1970; ŽIVKOVIĆ AND BURÁNY, 1972). Outbreaks of *Simulium* (*Simulium*) *colombaschense* (Scopoli, 1780) were recorded several times during the last century in Serbia, in 1923, 1934, and 1950, these outbreaks causing about 2300, 11000, and 800 deaths, respectively, among domestic animals (mostly cattle) (SIMIĆ AND ŽIVKOVIĆ, 1958). *Simulium* (*Byssodon*) *maculatum* (Meigen, 1804) caused a nuisance and the loss of several hundred chickens in the district of Banat (Vojvodina) in 1958 (ŽIVKOVIĆ, 1958). During the outbreaks of *Simulium* (*Boophthora*) *erythrocephalum* (De Geer, 1776) in 1965 and 1970 in the province of Vojvodina, a number of people suffered from bite consequences, particularly in 1970, when more than 2000 clinical cases were recorded (ŽIVKOVIĆ, 1967b; ŽIVKOVIĆ AND BURÁNY, 1972; BURÁNY ET AL., 1972).

Earlier studies in the country confirmed that among 16 blackfly taxa that suck the blood of domestic animals, the following ones bite humans as well: *S. maculatum*, *Simulium ornatum* (s.l.) [probably *Simulium* (*Simulium*) *ornatum* Meigen, 1818 (complex)], *Simulium* (*Simulium*) *reptans* (Linnaeus, 1758), *S. colombaschense* and *S. erythrocephalum* (ŽIVKOVIĆ, 1970).

Recent studies showed that the most abundant species in the region of Novi Sad (province of Vojvodina) are *S. ornatum* (complex), *S. erythrocephalum*, and *Simulium* (*Wilhelmia*) *balcanicum* (Enderlein, 1924) (IGNJATOVIĆ-ČUPINA ET AL., 2003). In all of these species anthropophilic preference has been recognized (IGNJATOVIĆ-ČUPINA ET AL., 2006). Extensive investigation of blackfly breeding sites in the region confirmed that the largest breeding sites of *S. erythrocephalum* and *S. balcanicum* are in the Danube River (IGNJATOVIĆ-ČUPINA, 2003). Their immature stages were found only occasionally in smaller water courses of the region. On the other hand, *S. ornatum* (complex) represents the dominant blackfly taxon in streams of the Fruška Gora Hills, but it has never been found in the Danube.

Simulium erythrocephalum was described as a highly aggressive species, one with a remarkable anthropophilic preference (ŽIVKOVIĆ, 1970; RIVOSECCHI, 1978). Although females of this species attack in massive swarms and the list of hosts includes a range of birds and mammals, deaths of domestic animals were not recorded in the past (ŽIVKOVIĆ, 1971). Females of *S. erythrocephalum* generally bite parts of the body poorly covered by hair (usually the head and ventral body parts) in cattle and uncovered body parts, mostly the legs, in humans (ŽIVKOVIĆ, 1967b, 1970). Consequences of bites can be very severe, depending on the number of bites and individual sensitivity of the host (KRSTIĆ, 1966; BURÁNY ET AL., 1972). In some cases, bitten people required special medical care. The consequences of bites are particularly painful and irritating, expressed as serious dermatitis with cutaneous haemorrhagic lesions, edema, and itching that can persist for a rather long period. These symptoms are sometimes followed by febrile conditions, exhaustion, or other less serious consequences (KRSTIĆ, 1966; ŽIVKOVIĆ AND BURÁNY, 1972; BURÁNY ET AL., 1972; RIVOSECCHI, 1978).

Lowland rivers with muddy or sandy bottoms, low or moderate current velocity, and low oxygen content have been described as typical breeding sites of *S. erythrocephalum* (ŽIVKOVIĆ, 1971; RIVOSECCHI, 1978). Within the frontiers of former Yugoslavia, breeding sites of this species were detected in the Drava River in Croatia and in the Danube and its tributaries (the Tisza, Tamiš,

Karaš, and Karašica Rivers) and a few small water courses in Serbia (ŽIVKOVIĆ, 1967b, 1969). Despite frequent records of *S. erythrocephalum*, the population density of immature stages in the part of the Danube passing through the Pannonian plain was usually lower than in some other smaller water courses. It was also recorded that the species is of lesser abundance compared to some other species that breed in the Danube (ŽIVKOVIĆ, 1967a; 1971).

Recent extensive studies of blackfly breeding sites demonstrated that *S. erythrocephalum* is the dominant blackfly species in the section of the Danube River flowing through the region of Novi Sad. Highly abundant populations of immature stages of this species have been recently detected in the Danube, but immature stages were also found in a small affluent stream, outside the main breeding sites (IGNJATOVIĆ-ČUPINA, 2003).

High and constantly rising water levels and cold rainy weather during the spring and first half of summer represent suitable ecological preconditions for outbreaks of *S. erythrocephalum*. Coincidence of such hydrological and ecological factors occurred in Serbia after severe flooding of the Danube and Tisza Rivers in 1965 and 1970. Massive appearance of adults of this species and aggressive biting of humans were then recorded in settlements along those rivers (ŽIVKOVIĆ, 1967b, 1971; ŽIVKOVIĆ AND BURÁNY, 1972).

Suitable hydrological and ecological conditions reappeared during the spring of 2006, entailing enhancing a new outbreak of this blackfly species. Approximately 122,500 hectares of land in Serbia were flooded, 112,000 ha were affected by high levels of underground water, and 5,500 ha were affected by landslides. With 50,000 ha of flooded land, the southern part of the Bačka district (where the region of Novi Sad is located) represented one of the most endangered parts of the province of Vojvodina.

Until the spring of 2006 our attempts to obtain official morbidity data of blackfly bites on humans were unsuccessful, since no records of the kind were kept by medical institutions in the region. An increasing number of bitten patients seeking medical help was recorded in the region of Novi Sad starting from April 2006. Such a situation imposed the need for a more careful approach to the identification of bite symptoms and closer collaboration between entomologists and medical experts.

MATERIAL AND METHODS

The region of the city of Novi Sad (latitude: 45°18' N; longitude: 19°51' E; altitude: 76-84 m) is situated on the banks of the Danube River, which divides it into two parts: the flat northern part on the left bank of the Danube and the rolling southern part on the slopes of the Fruška Gora Hills on the river's right bank.

Samples of adult blackflies were collected using dry ice-baited traps of the NS-2 type (PETRIĆ ET AL., 2000). This type of a trap, based on carbon dioxide as a non-specific attractant for blood-sucking insects, has been employed for more than a decade in monitoring adult mosquito populations and has proved effective in monitoring blackfly populations as well (ČUPINA ET AL., 2002).

The traps were employed at weekly intervals during the season from April to September of 2006, starting when the average daily temperature exceeded 10°C for a continual period of 10 days.

They were set up from the afternoon to the following morning. The chosen sites were usually shaded places around trees or shrubs about 1,5 m above the ground and always in the same predetermined position. Location of the traps was 28 sites all over the region of Novi Sad: 15 traps were situated at sites along the right bank of the Danube including the villages on the slopes of the Fruška Gora Hills, and 13 were located on the left bank of the Danube, including the urban area. All traps were set up in the same places as during three previous seasons of monitoring.

Captured adults were preserved and identified on the basis of their morphological features. Specimens were compared with adults reared from immature stages and identified according to descriptions given in available identification keys (KNOZ, 1965; DAVIES, 1968; RIVOSECCHI, 1978; YANKOVSKY, 2000).

Abundance of adult populations of *S. erythrocephalum* during the last four seasons (2003-2006) was compared and discussed in relation to air temperature and fluctuation of the level of the Danube River. Official data were provided by the RHSS [Republic Hydrometeorological Service of Serbia (<http://www.hidmet.sr.gov.yu>)].

Estimation of the risk to humans of being bitten was based on capture results for each locality, according to the previously proposed scale (IGNJATOVIĆ-ČUPINA ET AL., 2006). Critical values for the number of *S. erythrocephalum* females in a trap were defined for each category of biting risk. The risk of being bitten by this blackfly species was deemed moderate if 3-9 females were trapped, high if 10-21 females were trapped, very high if 22-40 females were trapped, and extremely high if 41 or more females were caught in the trap, representing 1-2, 3-5, 6-10, and 11 or more possible bites on humans during five hours of afternoon exposure, respectively.

Clinical cases of blackfly bites on humans were recorded at the Clinical Center of Vojvodina, Department of Dermatology and Venereology during the 2006 season. Available data for each patient consisted of the date of patient reception, the place (locality within the region) where bites possibly occurred, the number of bites, and the body part bitten. The recorded data of clinical cases were compared with the expected situation estimated on the basis of trap sample size.

The results were statistically processed and analyzed using the SPSS statistical package, version 10, for ANOVA analysis.

RESULTS AND DISCUSSION

Adults of the following three blackfly species with previously confirmed mammophilic behavior were caught in dry ice-baited traps in the region of Novi Sad during the 2006 season: *S. ornatum* (complex), *S. erythrocephalum*, and *S. balcanicum*. Adults of other species – *Simulium* (*Eusimulium*) *velutinum* (Santos Abreu, 1922), *Simulium* (*Eusimulium*) *aureum* (Freis, 1824) *Simulium* (*Nevermannia*) *lundstromi* (Enderlein, 1921) and *Simulium* (*Wilhelmia*) *equinum* (Linnaeus, 1758) – were captured rarely and in significantly lower numbers.

Simulium erythrocephalum was the most abundant species in the region of Novi Sad in 2006 (Fig. 1). Females of this typically Danubian species were continually caught in traps from the beginning of April to mid-July. After this period, the presence of adults was not recorded until the end of September, when only a few specimens were captured in traps.

Significantly higher numbers of females were recorded in the first and second week of April, third and fourth week of May, and second and third week of June, indicating massive emergence of three generations in the spring of 2006.

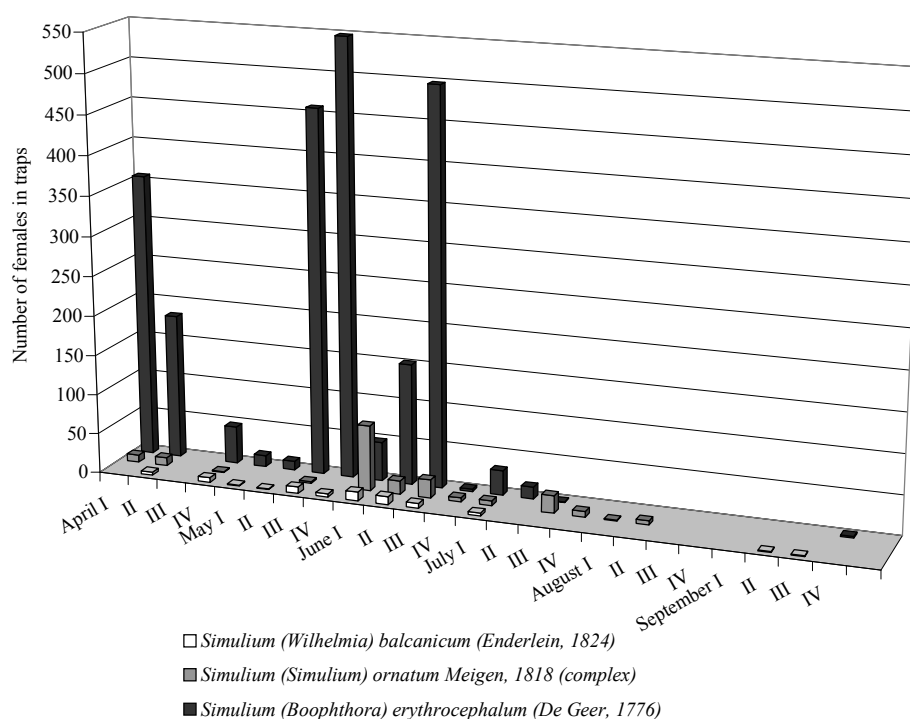


Figure 1. Seasonal occurrence of most abundant mammophilic blackfly species caught in dry ice-baited traps in the region of Novi Sad during the 2006 season.

Seasonal activity of *S. balcanicum* was similar to that of *S. erythrocephalum*, but the former species was recorded in significantly lower numbers, indicating that ecological conditions during the 2006 season were not quite adequate for its reproduction.

Simulium ornatum (complex) was recorded from the first days of April until the beginning of August. The low population density of this usually very abundant species in the region was a consequence of well targeted larvicide treatments of their breeding sites.

Comparing air temperatures during the last four years (Fig. 2), we noticed that during the period from March to July 2006, when massive emergence of adults of *S. erythrocephalum* occurred, average monthly temperatures were not significantly different from those recorded in the same months during the two previous years (2004 and 2005). At the same time, the average monthly temperatures in 2006 were quite similar to the perennial values calculated for the period 1961-1990.

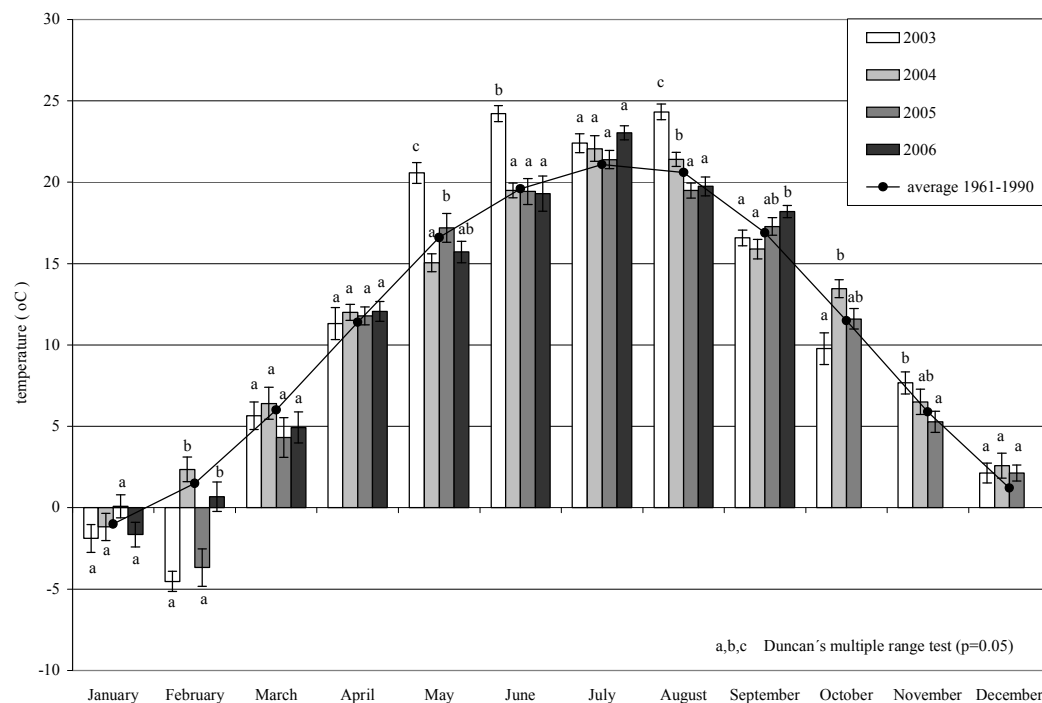


Figure 2. Average monthly temperatures in Novi Sad during the years 2003-2006 and average values for the period 1961-1990 (data source: RHSS).

During the spring and summer of 2003, significantly higher average monthly temperatures than those recorded in the following years (2004-2006) were observed in May, June and August.

Since temperature data for the spring of 2006 and the period 1961-1990, do not differ significantly, it can be stated that air temperature during the ongoing 2006 season was not an exclusive factor inducing the massive appearance of *S. erythrocephalum*, being not significantly different from those recorded during previous seasons, when no outbreaks of this blackfly species were recorded.

Permanently high levels of the Danube River and consecutive periods of severe flooding characterized the spring of 2006. During the period from March to June, the average monthly levels of the Danube significantly exceeded the perennial values and those recorded during the previous three years (Fig. 3). At a water level above 250 cm, the Danube begins to flood in the region of Novi Sad. In view of this fact, the period from March to July of the last three years (2004-2006) can generally be considered as a period of high floods. A particularly high water level characterized the spring and early summer of 2006.

Fluctuation of the Danube proved to have an important influence on the population density of *S. erythrocephalum*, as was demonstrated over the last four seasons of our research (Figs. 4 and 5).

In conditions of low water in 2003, the population density of *S. erythrocephalum* was generally low throughout the entire season (Fig. 4). The highest number of females (42) was recorded

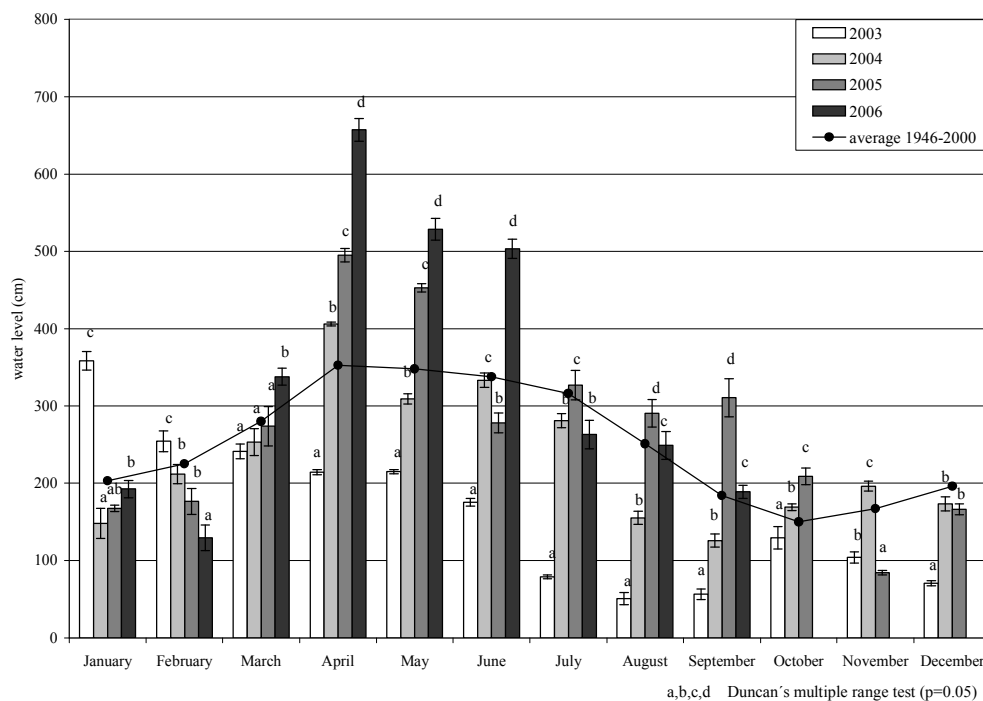


Figure 3. Average monthly levels of the Danube at Novi Sad during the years 2003-2006 and average values for the period 1946-2000 (data source: RHSS).

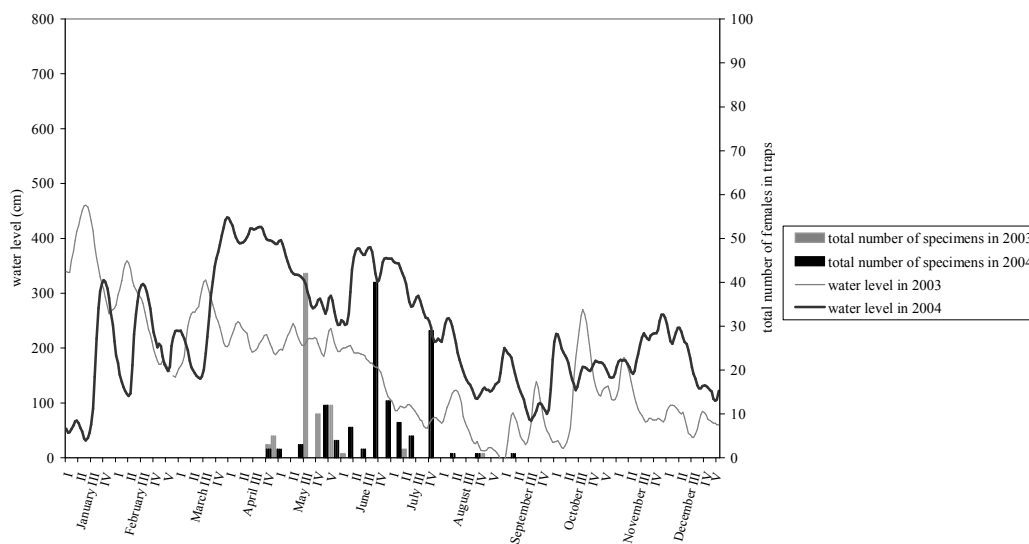


Figure 4. Seasonal fluctuations in the level of the Danube River at Novi Sad (data source: RHSS) and trapping of *Simulium erythrocephalum* in 2003 and 2004.

in mid-May, while later in the season the permanently low water level diminished the population density of subsequent generations. Only 76 specimens of *S. erythrocephalum* were caught in traps in 2003, representing only 2.56% of the total number of specimens of *S. erythrocephalum* captured over the last four years (2003-2006).

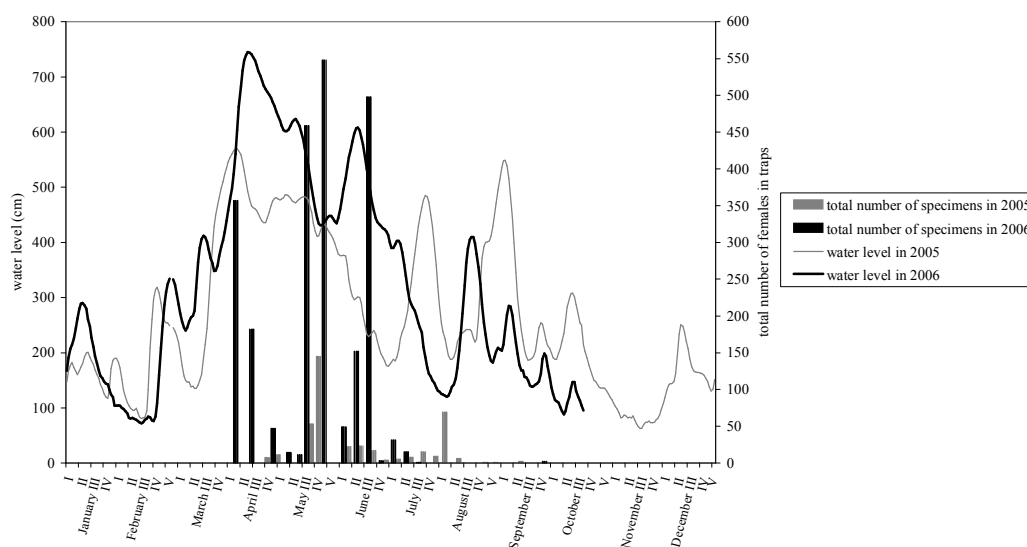


Figure 5. Seasonal fluctuations in the level of the Danube River at Novi Sad (data source: RHSS) and trapping of *Simulium erythrocephalum* in 2005 and 2006.

Water level conditions on the Danube were more suitable for the development of *S. erythrocephalum* in 2004 than in 2003, but despite frequent captures, no more than 40 specimens of *S. erythrocephalum* were captured at any of the sampling times (Fig. 4). The water level was permanently higher than 250 cm throughout a lasting long period from the 21st of March to the 3rd of August, and higher numbers of captured females were recorded, in June and July. The relatively small number of females captured in 2004 was a consequence of low population density of *S. erythrocephalum* in 2003 and the time needed for recovery of the population. The correctness of such an assertion is supported by results obtained in monitoring of immature stages at the breeding sites.

However, the number of specimens of *S. erythrocephalum* in captured traps was higher in 2004 than in 2003. A total of 130 females were caught in 2004, representing 4.37 % of specimens recorded during the period 2003-2006.

Seasonal values of the Danube's water level in 2005 were significantly higher than in 2004 and 2003 (Fig. 5). The absolute seasonal maximum (570 cm) was recorded on the 6th of April, while several peaks of levels higher than 400 cm were registered later during the season. Captures in traps were recorded from the end of April, the peak being recorded during the second half of May, after a period with water levels above 450 cm. The highest capture results were obtained on the 24th of May (145 females in traps). Higher capture values were achieved again at the beginning of August, after the flooding that occurred in July.

It was obvious that suitable water level conditions in 2005 enhanced the development of *S. erythrocephalum*, as is indicated by the higher number of specimens caught in traps during that year (398 specimens or 13.39% of the total number of captured specimens in the period 2003-2006) than during the two previous years.

The high survival rate of the overwintering generation, together with optimal seasonal conditions (especially high water levels) during the following season, led to the outbreak of *S. erythrocephalum* in 2006 (Fig. 5). An extremely high level of the Danube was recorded from the 9th to the 19th of April, when a threshold of 700 cm (defined as the second flood alert level for the city of Novi Sad) was exceeded. The absolute monthly maximum for April for the period 1946-2000 (654 cm) was surpassed for a period of 19 days (from the 8th to the 26th of April 2006). Particularly high numbers of females in traps were recorded after the water level of 450 cm was exceeded in April, May, and June. The highest number of captured females (548 specimens) was recorded on the 25th of May, in the same period as in the previous year. The increase in the level of the Danube that occurred in August had no influence on production of abundant populations.

Altogether, 2,369 specimens of *S. erythrocephalum* were caught in traps during the 2006 season, which represented 79.68% of the total number of individuals captured over the last four seasons.

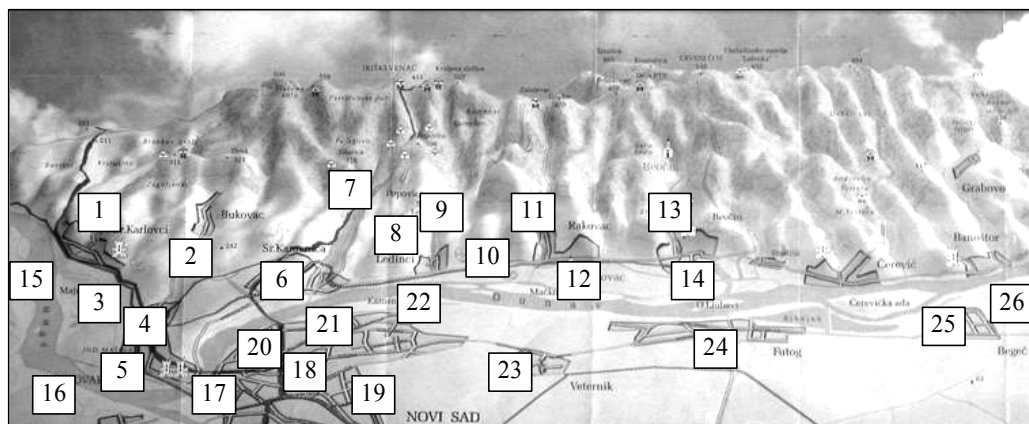
Correlation between high levels of the Danube and Tisza Rivers and massive appearance of *S. erythrocephalum* was reported by previous researchers (ŽIVKOVIĆ, 1967; BURANY ET AL., 1972; ŽIVKOVIĆ AND BURANY, 1972), but it was not possible on the basis of their results to establish the approximate threshold water level capable of inducing a calamitous outbreak on the section of the Danube flowing thorough the region of Novi Sad.

Comparison of seasonal fluctuations in the level of the Danube in the region of Novi Sad during the seasons of 2003 to 2006 demonstrated that the increasingly frequent occurrence of a water level above 250 cm during spring and early summer led to the appearance of higher population density of *S. erythrocephalum*. If the period of high water levels above 450 cm persists during spring and early summer, abundant adult populations can be expected in the following period. Later increase of the water level, as recorded in August and September of 2005 and 2006, had no influence on increase in the number of adults of this species.

Capture of adults of *S. erythrocephalum* in traps during the 2006 season was recorded at 26 of the 28 investigated localities: at 14 localities situated on the right bank and 12 on the left bank of the Danube (Fig. 6).

In 2006, localities situated on both the right and left banks of the Danube were subjected to elevated biting risk: moderate, high, very high, or extremely high (Table 1). Higher numbers of females and consequent higher biting risk were, as a rule, always recorded in the part of the region situated on the right bank of the Danube. Elevated risk to humans of being bitten was judged to exist at 22 localities: at all localities on the right side of the river and eight out of 12 on the left side.

Capture results varied depending on the period of the season and the position of the trap. Numerous cases of elevated biting risk were recorded in the period from the first week of April to the second week of July, while later on only a few specimens were caught in traps. The highest seasonal number of females in a trap (336 specimens) was recorded at the Ledinci village 1 locality



Right Danube bank:

1. Sremski Karlovci
2. Bukovac
3. Petrovaradin – Sadovi
4. Petrovaradin – village
5. Petrovaradin – Danube
6. Sremska Kamenica
7. Popovica
8. Ledinci village 1
9. Ledinci village 2
10. Šandrovac
11. Rakovac village
12. Rakovac – Danube
13. Beočin village
14. Beočin – Danube

Left Danube bank:

15. Kovilj Marsh
16. Subić
17. Novi Sad – Dunavski Park
18. Novi Sad – Futoški Park
19. Novi Sad – Jugovićevo
20. Novi Sad quay
21. Novi Sad Ribarsko ostrvo island
22. Novi Sad Kamenička ada
23. Veternik
24. Futog
25. Begeč village
26. Begeč – Danube

Fig. 6. Location of sites in the region of Novi Sad where females of *Simulium erythrocephalum* were trapped during the 2006 season.

during the first week of April, while the highest number of localities subjected to elevated biting risk (15 localities) was recorded during the third week of May. A total of 71 cases of elevated biting risk were judged to exist estimated during the season (56 cases on the right side of the Danube and 15 on the left side).

During the last four seasons (2003-2006), an increase was registered in the number of localities with positive capture results (Table 2). Localities situated on the right bank of the Danube were constantly exposed to higher biting risk than those situated on the left bank. The number of localities with elevated biting risk as indicated by the number of estimated cases of risk for each defined category peaked in 2006.

Statistical analysis of data obtained at 26 localities over four seasons of monitoring demonstrated that the average number of females captured in a trap was significantly higher in April, May,

Table 1. Number of females of *Simulium erythrocephalum* captured in dry ice-baited traps and estimated risk to humans of being bitten at different localities in the region of Novi Sad during the 2006 season.

LOCALITIES	APRIL				MAY				JUNE				JULY				AUGUST				SEPTEMBER			
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
right bank																								
Srenski Karlovci				3	1		79	18	4	20	220	1		1										
Bukovac	1				2		15		7		60													
Petrovaradin Sadovi							22	23	7	108	106													
Petrovaradin village					1		53	5	1	3	10													
Petrovaradin Danube				12			129	155	22	10	11	1												
Srenska Kamenica							5	6		2	11													
Popovica	3	1					1	260			3			2	12									
Ledinci village 1	336	134		5			1	1		1	7													
Ledinci village 2				1	3	2	7	6	1	1	3			1										
Ledinci Sandrovac	1	9			1	1	57	8	5		34	1	24											1
Rakovac village				1		1	6	1		3														
Rakovac Danube	16	38					7	8			3													
Beočin village						2		12			1		1	1										
Beočin Danube							9	7		1	22													
left bank																								
Kovilj marsh				1				9			5													
Subić				3				2		1														
NS Dunavski park								2																
NS Futoski park							6	3																
NS Jugovićevo								1																
NS quay							2				2													
NS Ribarsko island					3	1				1														
NS Kamenicka ada					4	13			1															
Veternik							1																	
Futog							12	3																1
Begec village				1			2	1																
Begec Danube				19	3		32	17	1	1			4											
Baiting risk scale:				low				moderate					high					very high					extremely high	

Table 2. Resume of distribution of localities with positive trapping results in relation to biting risk category and number of estimated cases of elevated risk to humans of being bitten by *Simulium erythrocephalum* during the seasons of 2003-2006.

YEAR	POSITION OF LOCALITIES	NUMBER OF LOCALITIES						NUMBER OF CASES OF ELEVATED BITING RISK				
		with positive capture results	with elevated biting risk	Category of biting risk				Moderate	High	Very high	Extremely high	Total
				Moderate	High	Very high	Extremely high					
2003	Right bank	5	2	2	1	1	0	4	1	1	0	6
	Left bank	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	5	2	2	1	1	0	4	1	1	0	6
2004	Right bank	10	5	4	2	1	0	7	2	1	0	10
	Left bank	3	1	1	0	0	0	1	0	0	0	1
	TOTAL	13	6	5	2	1	0	8	2	1	0	11
2005	Right bank	13	11	9	5	0	2	14	5	0	2	21
	Left bank	5	4	4	0	1	0	8	0	1	0	9
	TOTAL	18	15	13	5	1	2	22	5	1	2	30
2006	Right bank	14	14	12	8	5	8	26	11	7	12	56
	Left bank	12	8	8	3	1	0	10	4	1	0	15
	TOTAL	26	22	20	11	6	8	36	15	8	12	71

and June of 2006 than in the same months of the previous three seasons (Fig. 7). Despite variation of trapping results, the highest average value of females in a trap was recorded in April of 2006, after the period with the highest level of the Danube (15.92 females per trap with four expected bites on humans per day). Lower, but still high values were observed in May and June (9.99 and 6.75 females per trap; high and moderate biting risk; three and two expected bites on humans per day). Average values of the number of females in a trap for July, August and September of 2006 were as low as in the previous three seasons.

Medical experts at the Department for Dermatology and Venereology of the Clinical Center of Vojvodina reported an increased number of examined patients with symptoms of insect bites starting from April of 2006. By the end of July, the number of patients increased to 30,27 of which were inhabitants of the region of Novi Sad. In all cases the bites were located on the extremities, mostly the legs (below the knees). Two patients were bitten equally below and above the knees,

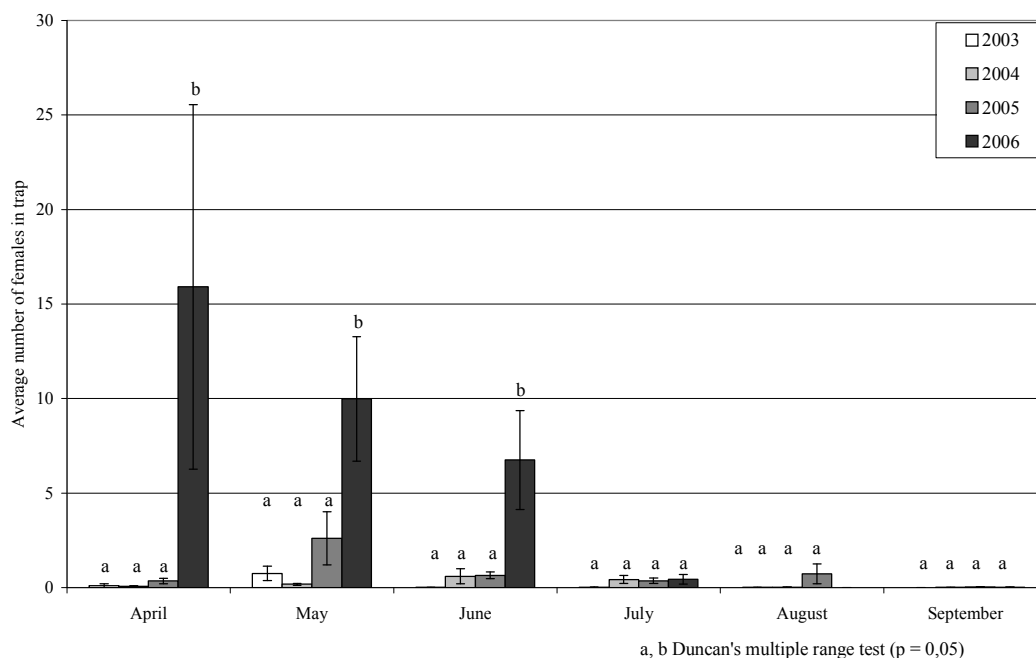
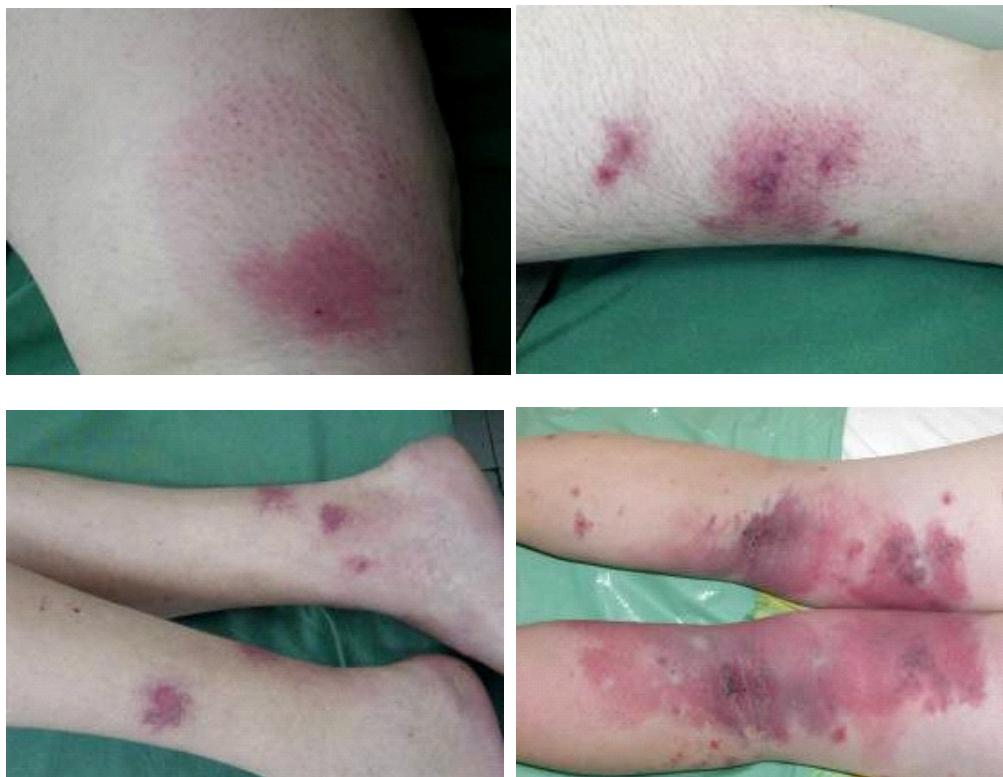


Figure 7. Average monthly number of females of *Simulium erythrocephalum* caught in dry ice-baited trap in the region of Novi Sad during the seasons of 2003-2006.

only one on the forearms. The clinical picture varied in different patients depending on the number of bites and individual sensitivity, but usually started with haemorrhagia, edema, and painful itching of the area surrounding the bitten point (Figs. 8-11). The symptoms usually persisted for a rather long period of more than a week to several weeks. In more serious cases, erythematous changes spread over a larger part of the skin surrounding the bite.

In the absence of any information about the causative agent at the initial check-up, all patients were diagnosed as *Ictus insecti* (insect bite). Soon after realizing the increasing frequency of such symptoms and due to the reports of interviewed patients, it became clear to examiners that the causative insect agents were black flies. The symptomatology of such bites completely corresponded to the clinical picture of bites caused by *S. erythrocephalum* as described earlier by KRSTIĆ (1966) AND BURÁNY ET AL. (1972) after outbreaks of this species in 1965 and 1972. Such a frequency of bite cases was unusual in the long-term practice of this medical institution.

It has to be emphasized that the Department for Dermatology and Venereology is a medical institution of tertiary protection grade, where only the most serious patients are hospitalized. Before being accepted in this institution, patients are usually examined at two less specialized medical institutions. It could therefore be presumed that the number of patients suffering from bites caused by this blackfly species was much higher but not adequately identified and registered by general practitioners. However, the number of 30 patients in 2006 was very close to the number of 37 patients examined and cured at the Clinic for Dermatology and Venereology of the city of Zemun as recorded by KRSTIĆ (1966) after the first reported outbreak of *S. erythrocephalum* in the country in 1965.



Figs. 8-11. Consequences of blackfly bites. Suspected agent: *Simulium erythrocephalum* (photo Vujanović, 2006).

All bite cases in 2006 were recorded during the period from April to July, when positive capture results indicated the existence of elevated risks of being bitten by *S. erythrocephalum* at many of the investigated localities in the region of Novi Sad.

Among 27 patients who were residents of the region, 25 were suspected of having received their bites in places where captures of *S. erythrocephalum* in traps were recorded (Table 3). Furthermore, 13 patients were residents of localities on the right bank of the Danube (Sremski Karlovci, Petrovaradin, Sremska Kamenica, and Beočin). In all of these localities, elevated biting risk was judged to exist several times during the season. Seven patients were suspected of having received their bites at localities on the left bank of the river (Begeč and Novi Sad). Five patients, residents of the Jugovićevo locality (several kilometers from the Danube's left bank), were bitten even though only one capture in a trap was obtained. A similar discrepancy was observed in patients suspected of having suffered blackfly attacks within the urban area of Novi Sad, but they could not precisely indicate a location that could be compared with trapping results. Finally, two reported bite cases occurred at localities which were not included in the monitoring program.

The number of bites per patient ranged from one to more than 10. Patients accepted in April had only two or three bites, while most of those accepted during the following months had a high-

Table 3. Patients from the region of Novi Sad with diagnosed insect bites during the 2006 season. Suspected agent: *Simulium erythrocephalum*. Data source: Clinical Center of Vojvodina, Department of Dermatology and Venereology.

Month	Localities of bite report	Number of examined patients	Date of reception	Number of bites per patient	Location of bites
April	Novi Sad	1	April 19th 2006	3	below the knees
	Sremska Kamenica	1	April 29th.2006	2	below the knees
	Petrovaradin	1	April 30th 2006	3	forearms
May	Novi Sad	1	May 12th.2006	1	below the knee
	Sremski Karlovci	1	May 20th 2006	5	below the knees
	Beočin	1	May 20th 2006	5	below the knees
	Petrovaradin	1	May 23rd 2006	2	below the knees
	Jugovićevo	2	May 27th 2006	8	below the knees
			May 27th 2006	2	below the knees
June	Sremski Karlovci	2	June 17th 2006	6	below the knees
			June 23rd 2006	6	below the knees
	Begeč	2	June 20th 2006	8	below the knees
			June 23rd 2006	7	below the knees
	Jugovićevo	3	June 20th 2006	7	below the knees
			June 20th 2006	4	below and above the knees
			June 23rd 2006	4	below the knees
	Banoštor	1	June 23rd 2006	> 10	below and above the knees
	Petrovaradin	1	June 31st 2006	2	below the knees
July	Sremski Karlovci	3	July 4th 2006	5	below the knees
			July 17th 2006	7	below the knees
			July 31st 2006	3	below the knees
	Petrovaradin	2	July 9th 2006	8	below the knees
			July 18th 2006	9	below the knees
			July 10th 2006	6	below the knees
	Novi Sad	3	July 17th.2006	5	below the knees
			July 24th 2006	8	below the knees
	Bački Jarak	1	July 15th .2006	4	below the knees

er number of bites: up to eight bites in May, more than 10 bites in June, and up to nine bites in July. The increase in the number of bitten patients and number of bites per patient can be attributed to the fact that the daily period of feeding activity of adult females of *S. erythrocephalum* coincides with human outdoor activity. The fact is that members of the local population usually spend much more time outside during late spring and summer, thereby increasing the time of exposure to black-fly bites. Estimation of the biting risk to humans in this study was calculated on the basis of a hypothetical five-hour period of exposure in the afternoon before sunset. However, since no exact information about the duration of patient exposure is available, an adequate comparison of the estimated and recorded bite cases could not be achieved.

It has to be emphasized that the data obtained at the clinic were related to the date when patients were accepted for examination, not to the date when bites occurred. Many of the patients

reported that the bites occurred late in the afternoon, one or a few days before medical examination. Lack of this information can explain why some of the bite cases were recorded later than the estimate of elevated biting risk.

The results of this study indicate that a higher biting risk existed at localities along the banks of the Danube, especially ones close to the abundant breeding sites on the right bank, in rural or semirural localities, where the majority of patients were bitten. In such habitats, the biting risk to humans can be estimated quite accurately.

According to ŽIVKOVIĆ (1971), *S. erythrocephalum* has a fairly high potential for flight in search of a blood meal, which was defined within the range of 20-30 km from the breeding sites. It is still unclear when the spreading of females occurs in local ecological conditions. Our results indicate that females can rapidly invade localities at short distances (up to 5 km) from the breeding sites in search of a blood meal. This hypothesis was confirmed by our records of females in traps positioned close to the Danube and at sites within the urban area or in the surrounding hills. The spatial distribution of adults at urban localities distant from the main breeding sites was irregular, and the biting risk could not be predicted with satisfactory confidence there.

CONCLUSIONS

Suitable ecological and hydrological conditions, especially the extremely high level of the Danube River during the spring of 2006, provoked the massive appearance of adults of *S. erythrocephalum* in the region of Novi Sad, creating a situation that could be characterized as an outbreak.

Comparing the level of the Danube and the abundance of adult populations in the region during last four years, we were able to demonstrate that one to two months of a water level above 450 cm in the spring and early summer can increase size of the *S. erythrocephalum* population. On the other hand, a high water level during the second half of summer has no influence on size of the adult population. Massive emergence of three generations of *S. erythrocephalum* was recorded during the season from April to June: during the first and second week of April, third and fourth week of May and second and third week of June, respectively.

The number of localities where females of *S. erythrocephalum* were captured and the number of localities with cases of elevated biting risk were significantly higher in 2006 than during the three previous years. Significantly more cases of elevated biting risk in each category from moderate to extremely high were also recorded in 2006. The part of the region close to breeding sites on the right bank of the Danube generally was more endangered by blackflies than localities on the opposite bank. Despite high variation of trapping results at different localities, the average monthly numbers of females recorded in April, May, and June of 2006 were significantly higher than in the previous three seasons.

High population density of *S. erythrocephalum* caused frequent appearance of symptoms typical of the bite of this species during the period from April to July of 2006. The majority of patients were residents of the Novi Sad region, where elevated biting risk had been estimated earlier.

In order to obtain a more detailed picture of the flight behavior of this species, the research program should be continued and carried out at greater distances from the breeding sites.

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