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Distribution of *Diabrotica virgifera virgifera* LeConte in Serbia in 1998

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In order to monitor the spread and population density of *Diabrotica virgifera virgifera* LeConte in the Serbian territory, Hungarian Csalomon pheromone traps were used as the primary monitoring tool in 1998. Out of 515 locations, adults were detected at 437 locations. Compared to 1997, the western corn rootworm population increased. In 1998, the area infested by *D. virgifera virgifera* was approximately 61,400 km^2. The population increased at a slower rate than in previous years, probably due to extremely hot and dry weather. A population of economic importance was recorded on an area that measured 14,000 km^2. Within this area, 455.13 km^2 (45,513 ha) of damaged corn was reported. The estimated corn yield loss varied from 1% to 70%, but in most fields, the estimated yield loss was approximately 30%. Control recommendations, based on the number of captured WCR adults, are being considered for 1999 in monoculture corn as well as in continuous corn.

Keywords: *Diabrotica virgifera virgifera,* western corn rootworm.

In Serbia, corn production covers 1.4 million to 1.7 million ha of land. A majority of the corn production hectares are in continuous corn. Ever since corn was introduced into Yugoslavia, corn production problems were caused by domestic flora and fauna. However, these problems are not always economically important. Widespread continuous corn cropping systems allow certain pest populations, such as *Tanymecus dilaticollis* Gyll, to increase (Camprag, 1994). The presence of a new insect species, the western corn rootworm (WCR) (*Diabrotica virgifera virgifera* LeConte), that is one of the most destructive corn pests in North America, has generated questions among European corn producers. Although this pest is associated only with damage in continuous corn or corn followed by corn in Europe, WCR populations are a growing concern throughout all areas under corn production. In Serbia, continuous corn is grown on approximately 300,000 to 500,000 ha continuous corn in cropping systems, favourable climatic and soil conditions, and the regulation of natural enemies have allowed the WCR species to establish itself in Serbia (Camprag, 1998). The spread of the WCR population, as well as its density, have been monitored in Serbia since 1993. The purpose of this paper is to present data obtained in 1998, that depicts the spread and potential problems of *D. virgifera virgifera* LeConte in Serbia.

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Materials and Methods

a) Monitoring of D. virgifera virgifera

In 1998, Serbian territory was divided into two zones. The first zone consisted of all territories where WCR populations were established.

Experts from extension services determined the density of the population in specific territories, which was used to determine if protective measures were required for the following growing season. In order to determine if WCR populations were present, as well as measuring the WCR density, Csalomon pheromone traps were used as the primary monitoring tool. These traps have proven to be efficient and very reliable in monitoring WCR adults (Tóth et al., 1996; Tóth et al., 1997).

In 1998, damage occurred in parts of this zone. The total area and number of fields damaged were recorded.

In 1999, areas where WCR damage was expected, were based on the number of captured adults on pheromone traps, as well as visual counts of adults on plants.

The second zone consisted of all territories where WCR populations have not been detected. In this zone, the objective was to monitor for the presence or absence of WCR adults. Experts from extension services used visual counts and pheromone traps as the primary tools in monitoring for the WCR adults.

The regional agricultural services and the Institute for Plant Protection and Environment, within the forecasting services of the Republic of Serbia, coordinated these activities.

b) Density of WCR larvae

In 1998, near Pancevo, WCR larvae were monitored in a monoculture cornfield. Larval damage has been recorded in this field for the past 3 years. Soil samples (25 x 25 cm) were extracted around randomly selected corn root masses and were evaluated in the laboratory. Larvae were extracted from the soil by washing the soil with water trough a 0.5 mm diameter sieve. Larvae present in corn roots were extracted by root dissection.

Results of Monitoring in 1998

a) Monitoring of D. virgifera virgifera

Further spread of the WCR population was recorded in 1998. During July, August and September, 515 locations were monitored with pheromone traps. WCR adults were detected in 437 locations (85% of the total locations monitored). New WCR populations were discovered in Jablanicki county, Borski county, and just north of Zajecar county. The spread of WCR adults continues along the Drina river valley down to Ljubovija. In 1998, the total area infested with the WCR population was approximately 61,400 km^2 *(Fig. 1).*

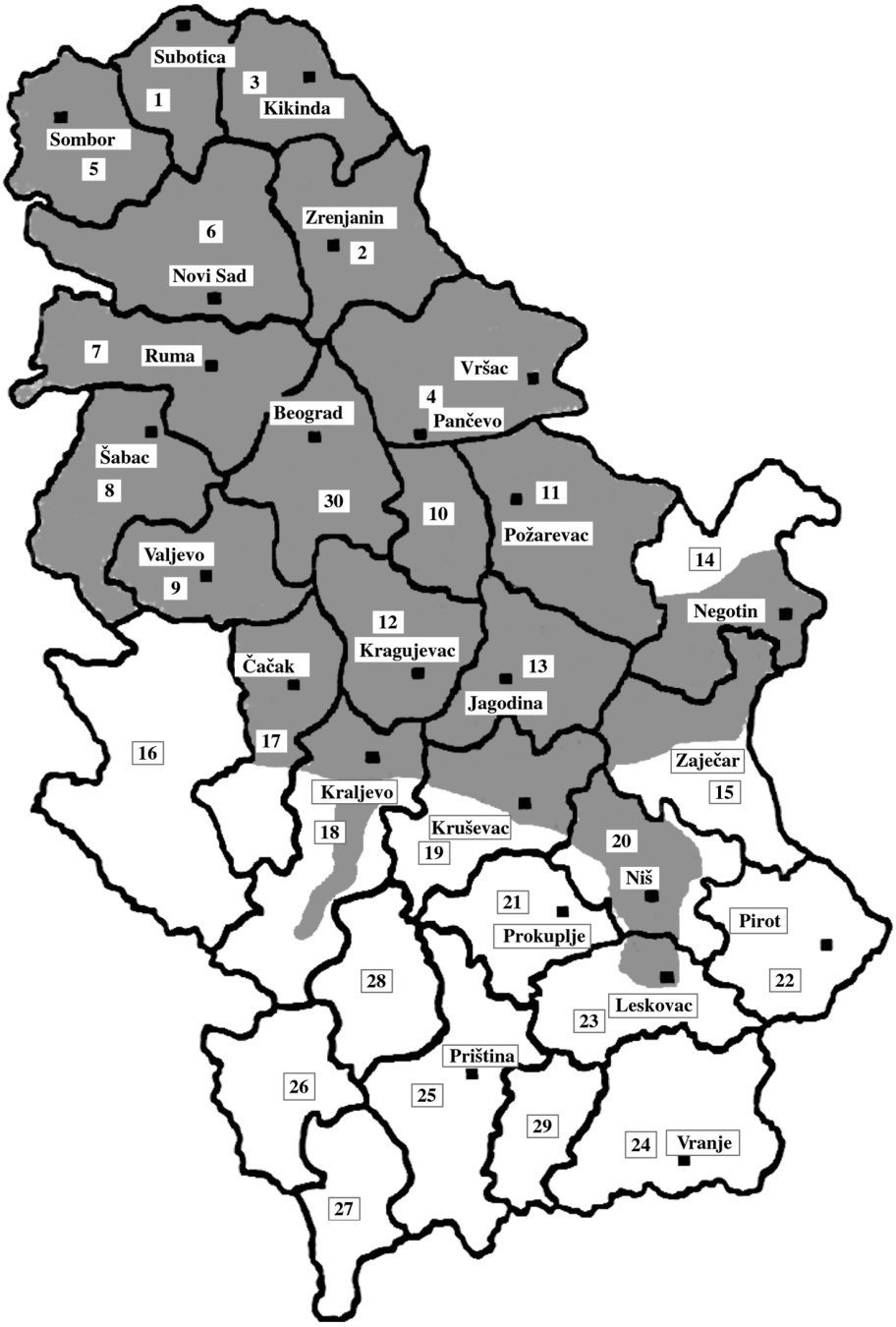

Fig. 1. Areas in Serbia infested with *D. virgifera virgifera* in 1998

Table 1

Comparative results of monitoring *D. virgifera virgifera* in Serbia (1996–1998)

County	Number of checked locations			Infested territory (%)			Max. number of adults/trap*			Damaged fields (ha)		
	1996	1997	1998	1996	1997	1998	1996	1997	1998	1996	1997	1998
Severno-backi (1**)	15	14	25	73	93	100	27	57	41	0	0	1
Srednje-banatski (2)	41	41	23	85	100	100	296	234	380	0	30	138
Severno-banatski (3)	15	25	26	93	88	100	300	96	180	0	0	0
Juzno-banatski (4)	27	25	25	100	100	100	377	320	370	9933	5010	34.243
Zapadno-backi (5)	14	9	25	71	100	100	29	223	165	0	0	0
Juzno-backi (6)	59	8	26	32	100	100	194	300	200	1	115	2.000
Sremski (7)	24	26	44	100	100	100	305	360	383	84	285	6.507
Macvanski (8)	55	20	101	74	100	100	352	173	273	0	0	20
Kolubarski (9)	21	44	14	76	82	100	200	100	183	0	0	
Podunavski (10)	13	27	18	85	100	100	186	182	372	3	0	25
Branicevski (11)	53	36	8	92	100	100	316	368	350	0	4	2.491
Sumadijski (12)	3	5	10	0	100	80	0	–	32	0	0	
Pomoravski (13)	24	35	12	100	89	100	9	43	300	0	0	0.3
Borski (14)	4	0	4	0	–	25	0	–	30	0	0	0
Zajecarski (15)	7	–	11	0	0	64	0	0	271	0	0	0
Zlatiborski (16)	7	–	5	0	0	0	0	0	0	0	0	0
Moravicki (17)	17	–	13	47	–	100	54	74	150	0	0	0
Raski (18)	14	2		0	100		0	56		0	0	0
Rasinski (19)	14	22	17	0	91	100	0	110	113	0	0	0
Nisavski (20)	20	19	20	0	58	75	0	2	12	0	0	0
Toplicki (21)	0	4		–	0		–	0		–	0	0
Pirotski (22)	14	38	10	0	0	0	0	0	0	0	0	0
Jablanicki (23)	9	17	14	0	0	92	0	0	6	0	0	0
Pcinjski (24)	7	13	10	0	0	0	0	0	0	0	0	0
Kosovski (25)	4	–		0	0		0	0		0	0	0
Pecki (26)	8	–		0	0		0	0		0	0	0
Prizrenski (27)	4	24		0	0		0	0		0	0	0
Kosovsko-mitrovacki (28)	4	12	20	0	0	0	0	0	0	0	0	0
Kosovsko-pomoravski (29)	12	6	20	0	0	0	0	0	0	0	0	0
Grad Beograd (30)	10	10	14	100	100	100	300	380	180	766	215	100

*Maximum number of adults collected on one trap per week

**Numbers in parenthesis corresponds to the numbers on the map – *Fig. 1, Fig. 2*

The monitoring results in 1998 indicated that the WCR population dispersal rate was slower than in previous years. This result was primarily due to extremely high temperatures and drought conditions experienced in 1998. Despite this fact, the WCR population in Serbia has increased in number *(Table 1).*

Out of 30 Serbian counties, the WCR population has infested the following 15 counties: Severno-backi, Srenje-banatski, Severno-banatski, Juzno-banatski, Zapadno-backi, Srem, Macva, Kolubarski, Podunavski, Branicevski, Pomoravski, Moravicki, Rasinski and Belgrade City.

In 1998, a higher degree of WCR damage was detected than noted in 1997. The area of damage in 1997 covered 14,000 km^2. WCR damage has spread in a specific direction during the past couple of years *(Fig. 2).* The total area of damage in 1998 covered 45,525.3 ha *(Table 2).* As noted in previous years, the highest number of damaged fields were in Juzno-banatski county, in villages near Pancevo *(Table 1).* The estimated corn yield loss in these fields varied from 1% to 70%, but in most fields, the estimated yield loss was approximately 30%. Damage occurred in the following 9 counties: Severno-backi, Srenje-banatski, Juzno-banatski, Srem, Macvanski, Branicevski, Pomoravski and Belgrade City.

Table 2

Registered damaged cornfields in Serbia (1992–1998)

Year	Damaged fields (ha)
1992	0.5
1993	6
1994	60
1995	275
1996	10,787
1997	5,695
1998	45,525.3
Total 1992–1998:	**62,348.8**

Based on the number of WCR adults collected on the pheromone traps in 1998, damage could be expected in 1999 throughout the counties of Zapadno-backi, Severno-banatski, Podunavski and Zajecarski. According to previous data, damage will most likely occur in locations where the capture rate is ≥ 300 WCR beetles/pheromone trap/week.

b) WCR larvae density in 1998

Timing of larval hatch and the density of larvae in the soil is critical in determining if a soil applied insecticide is needed to protect corn root systems. In the past, larval hatch was assumed to occur during the last two weeks of May, thus, most larvae were expected to be present around mid-June. In 1998, a detailed study of larval density was conducted. The number of larvae per kg of soil is shown in *Fig. 3.* The highest number of larvae recorded per kg of soil occurred on 22 June. Second instar larvae were readily detected

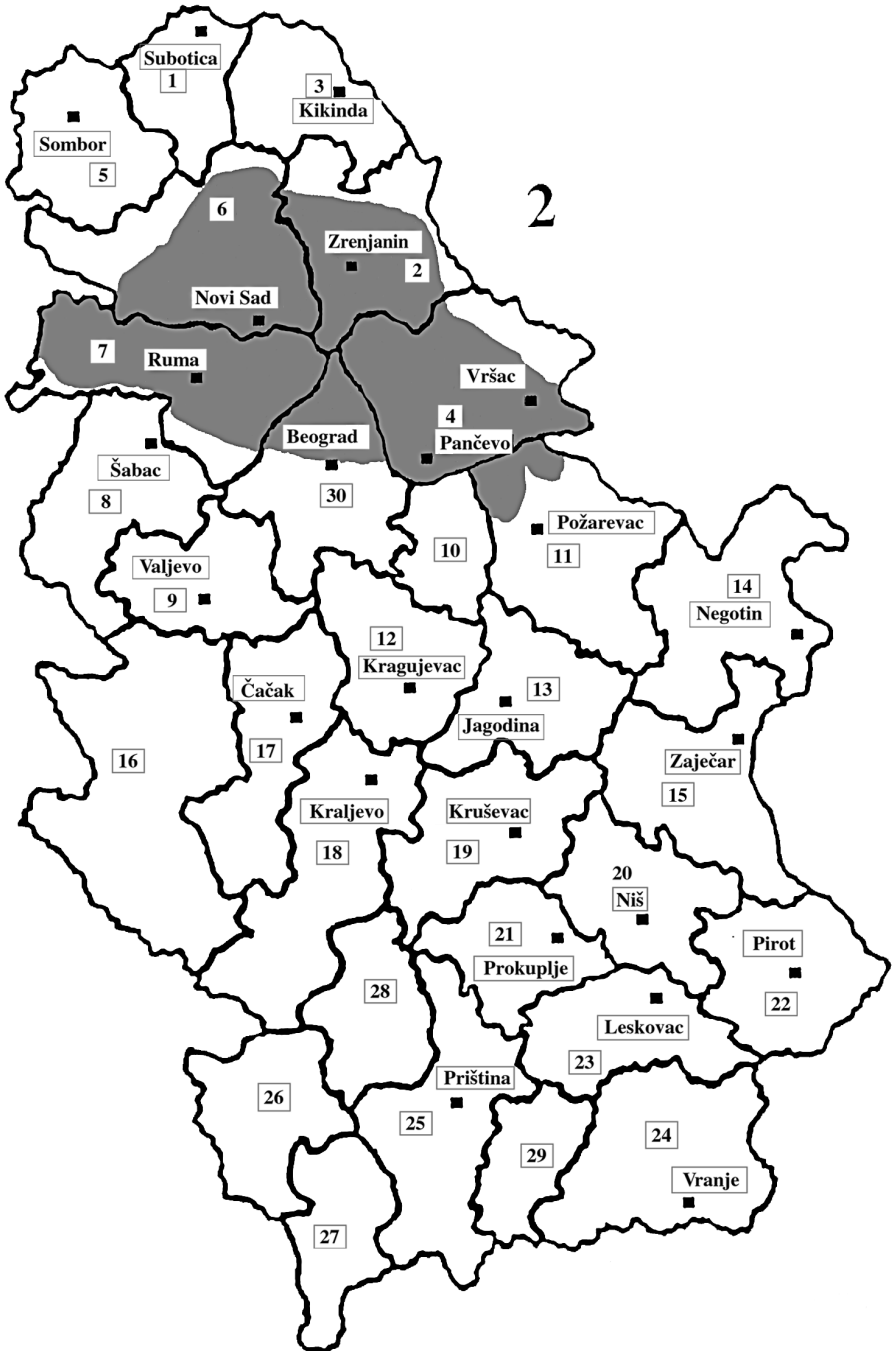

Fig. 2. Areas in Serbia with *D. virgifera virgifera* damage in 1998

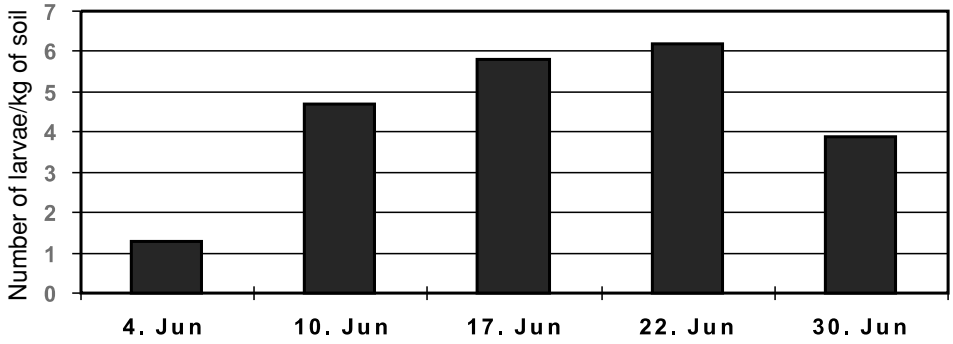

Fig. 3. Number of *D. virgifera virgifera* larvae per kg of soil in 1998

during the first two weeks of June, whereas, the highest number of third instar larvae was found on 17 June *(Fig. 4).* Pupae were first noted on 17 June. Few larvae were found in the upper 5 cm of soil. A high percentage of larvae were found in and around corn roots. Where significant damage was noted, a high percentage of third instar larvae were detected. Under harsh field conditions, extremely wet soils for example, plants with damaged root systems will began to lodge. However in 1998, these conditions were not experienced.

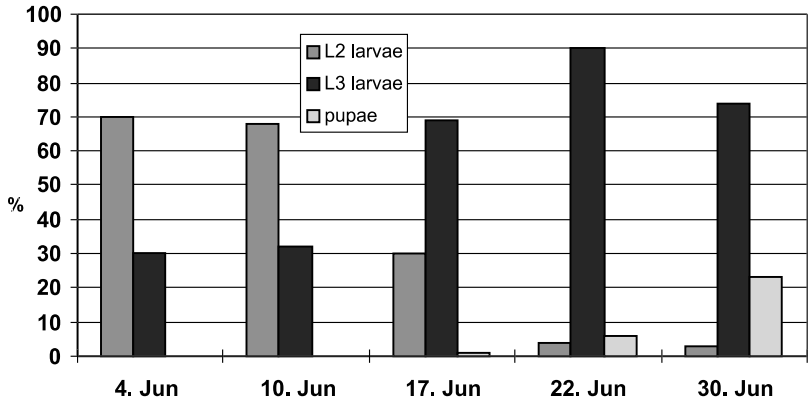

Fig. 4. Percentage of second instar larvae, third instar larvae and pupae of *D. virgifera virgifera* LeConte in 1998

Discussion

In 1992, the presence of a WCR population was discovered in the Serbian territory. More than likely this pest was imported before 1992. Due to favorable environmental and soil conditions, this pest began to multiply and become established in certain areas within Serbia. Based on these conditions, the spread of this pest was a concern in future corn production areas. During 1993, the area infested by the WCR was minor. Since that time,

the area of infestation has increased each year (*Table 1* and *Table 2*) (Sivcev et al., 1994; Sivcev et al., 1995; Sivcev et al., 1995a; Sivcev and Draganic, 1996; Sivcev, 1998). The number of damaged fields did not follow this scenario. The primary reasons in noting this fact are crop rotation and corn root regeneration, which leads to the masking of WCR damage symptoms (Stankovic et al., 1998). However, regenerated plants produce a lower yield, approximately 10–20% lower (Baca et al., 1998).

It was possible to monitor efficiently due to the successful synthesis of the pheromone *D. virgifera virgifera* LeConte produced by Miklos Tóth from the Institute for Plant Protection, Budapest. In 1995, pheromone traps of Csalomon panel type proved to be very efficient, long-lasting and highly species specific, based on tests conducted in Serbia (Tóth et al., 1996; Tóth et al., 1997; Sivcev and Draganic, 1996). During the last couple of years, it was observed that 300 or more adults collected by pheromone traps was characteristic for fields/locations where economic populations and extensive larval damage existed. Pheromone traps were only used to detect new WCR populations. As far as detecting the increase in population, experts for plant protection from agriculture services used a visual check to determine whether adult numbers exceeded the economic threshold average of 1 adult per plant (Ostlie and Noetzel, 1987; Edwards et al., 1997). From experience, it is clear that WCR manifests its destructiveness only in corn followed by corn. Significant damage generally arises from WCR larval feeding on and within corn root systems. Crop rotation proved to be the most efficient control measure. Theoretically, it is possible to introduce crop rotation without reducing the areas under corn production. However, it is clear that producers still have an interest in continuous corn cropping systems. For example, an increase in the WCR population, as well as an increase in fields that experience WCR damage, indicate that continuous corn cropping systems have not decreased. If this pattern holds, WCR damage can be expected to continually increase. American farmers, dealing with WCR populations, have decreased the number of acres in continuous corn by 40%. Most often, soil insecticides are applied to continuous cornfields; however, efficacy in root protection seldom reaches 95%. Since soil insecticide residual is present in the soil for up to 4–5 weeks after planting, late hatching WCR larvae, due to cold spring temperatures in fields of reduced tillage, may miss the window of soil insecticide activity (Edwards et al., 1997; Edwards, personal communication). In 1997, a ten day delay of larval hatch was recorded for the first time in Serbia. This delay was more than likely due to cold weather in April and May. In 1998, cold weather and heavy rains in June resulted in slower larval development (Sivcev, 1998a).

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