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Field Data on the Presence of Spiders Preying on Western Corn Rootworm (*Diabrotica virgifera virgifera* LeConte) in Szeged Region, Hungary

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The western corn rootworm (WCR), *Diabrotica virgifera virgifera* LeConte, is a new pest of corn in Europe. Future management may include the use of natural enemies. Our study focused on the determination of density and species composition of spiders in corn fields, as well as in the adjacent corn field margins, during the peak flight period of WCR adults. An additional objective was to test different sampling methods, used for spider collecting, in corn fields and in adjacent corn field margins. The field study was conducted in July and August, 1999, in experimental corn plots, as well as in the adjacent field margins, owned by the Cereal Research Institute, Szeged, in Southern Hungary. Spiders were collected by individual plant search and by sweep nets. Number of spiders /m^2 was significantly higher, whereas /m^3 was significantly lower in the corn plots compared to the adjacent field margins. Remnants of WCR adults were found in theridiid [*Theridion impressum* L. Koch, *T. pictum* (Walckenaer), *Enoplognatha latimana* Hippa and Oksala] and agelenid (*Agelena* sp.) webs. We observed that individuals of both families were able to kill 1–5 adult beetles within 90 minutes.

Keywords: *Diabrotica virgifera virgifera,* western corn rootworm, spider enemies of *Diabrotica.*

Spiders occur in practically every agricultural habitat. Therefore, it is assumed that a few spider species may potentially serve as natural enemies of the WCR. Except for the previous publication by Tóth et al. (1998), no studies have identified a species of spider that preys on WCR. A study by Bogya and Mols (1996), which reviews 457 articles, provides a list of the known prey of spiders living in agroecosystems. According to the list, *Phidippus audax* (Hentz) and *Misumena vatia* (Clerck) preys on *Diabrotica undecimpunctata* Barber in America (Roach, 1987; Lockley et al., 1989; Young, 1989). A review (63 ref.) by Kuhlmann and Burgt (1998) lists all known natural enemies of *Diabrotica* species. This paper provides two additional studies that discuss spiders as predators. One of the studies (Johnson, 1996) notes the predation of *Ph. audax* on *D. undecimpunctata,* and the second study (Stoewen and Ellis, 1991) names only the order of spiders (Araneae) that prey on WCR eggs. According to our earlier study (Tóth et al., 1998), certain theridiid spiders (*Theridion impressum* L. Koch, *T. pictum* (Walckenaer), *Achaearanea tepidariorum* (C. L. Koch), *Enoplognatha latimana* Hippa and Oksala) that occur in Hungarian corn fields were able to prey on the beetles in the laboratory. Whereas, the linyphiid, *Microlinyphia pusilla* (Sundevall), and the araneid, *Hypsosinga pygmaea* (Sundevall), which are frequently found in corn fields in July and August, refused to prey on WCR adults. In the same study, two *T. impressum* webs were found in a Southern Hungarian corn field that contained remnants of WCR adults.

Our present study was designed to determine the density and species composition of spiders in corn fields and in the adjacent corn field margins during the peak flight period of WCR adults. The study also included the testing of different spider sampling methods that could easily be used in cornfields, and search for WCR adult remnants in spider webs.

Materials and Methods

The field study was conducted during 21 and 22 July and 17 and 18 August, 1999, in experimental corn plots, as well as in adjacent grassy margins, owned by the Cereal Research Institute, Szeged, in Southern Hungary (46º 15 N; 20º 10 E). During the first collection period, corn was forming ears (R1 stage), and in the second collection period, corn was in the milk stage (R2). The density of corn was 80,000 plant/ha, and the average height/plant was 2.2 m. The margin cover along the corn fields, which mainly consisted of monocotyledonous plants, was 100%, and the average height of the vegetation was 0.7 m.

Spiders were collected by individual plant search and sweep nets in the corn, and by sweep nets in the adjacent field margin. During the plant search, 800 corn plants were examined from the brace roots to the tassels. Leaf sheaths and husks were left intact. Examination of each plant took 30 seconds to complete. Sweeps consisted of 20 strokes in 10 replicates in both habitats. Because it was impossible to move the net in a horizontal direction in the corn, sweeping was accomplished by vertical strokes between corn rows. The sweep net had a diameter of 40 cm, where the length of the handle measured 50 cm. Thus, each sweep net stroke was calculated to be 2 m in length.

Due to the different sampling methods that were used, direct comparison of the number of individuals was not possible. An indirect comparison, by examining the number of individuals/m^2 and m^3, was still feasible with specific restrictions. Our assumption was that a horizontal stroke provided an underestimation of spider abundance/0.8 m^2 or 0.25 m^3; a vertical stroke 0.126 m^2 or 0.25 m^3; and the plant search determined spider abundance/0.125 m^2 or 0.275 m^3. The potential numbers of individuals/m^2 and m^3 were compared with a two sample *t*-test. A correlation analysis was used to compare the family composition of the samples.

In addition, 16 theridiid webs (space web, family Theridiidae) and 2 agelenid webs (tunnel web, family Agelenidae) were collected and examined under a microscope to determine whether WCR remnants were present. Furthermore, alive beetles were placed into 5 theridiid and 2 agelenid webs every 10 minutes for 90 minutes, and the reaction of each spider was recorded.

Results

There was a strong correlation (R = 0.907) between family composition *(Table 1)* obtained by the individual plant search and vertical sweeps in the corn. The correlation between family composition in the adjacent field margins and individual plant search in

Table 1

Number of individuals collected in corn fields and in the adjacent field margins (Szeged, 21–22 July, 1999 and 17–18 August)

Family	Individual search, corn, 800 plants	Vertical sweeping, corn, 10 x 20 strokes	Horizontal sweeping, margin, 10 x 20 strokes
Theridiidae	2	0	18
Agelenidae	1	0	2
Therid. spl.	65	15	14
Linyphiidae	30	6	6
Araneidae	16	1	4
Tetragnathidae	11	6	5
Thomisidae	9	3	12
Philodromidae	9	6	49
Pisauridae	7	0	25
Lycosidae	7	2	2
Salticidae	0	0	2
Clubionidae	2	0	0
Total	**159**	**39**	**139**

the corn (R = 0.051), as well as vertical sweeps in the corn (R = 0.235) was lower. In the case of density, calculated by m^2 or m^3 (*Table 2* and *Table 3*), no significant difference (p < 0.05) was noted between the two sampling methods. Spider density/m^2 was significantly higher in the corn, whereas the spider density/m^3 was significantly higher in the margin area.

Table 2

Number of individuals/m^2 collected in corn fields and in the adjacent field margins (Szeged, 21–22 July, 1999 and 17–18 August)

	Spider/m^2; Individual search, corn, 800 plants	Spider/m^2; Vertical sweeping, corn, 10 x 20 strokes	Spider/m^2; Horizontal sweeping, margin, 10 x 20 strokes
Theridiidae	0.02	0	0.11
Agelenidae	0.01	0	0.01
Therid. spl.	0.65	0.60^a	0.09^a
Other families	0.91	0.96	0.66
Total	**1.59**	**1.56^a**	**0.87^a**

The same letter in the superscript notes a significant difference (*t*-test; $p < 0.05$) within the row

Table 3

Number of individuals/m^3 collected in corn fields and in the adjacent field margins (Szeged, 21–22 July, 1999 and 17–18 August)

	Spider/m^3; Individual search, corn, 800 plants	Vertical sweeping, corn, 10 x 20 strokes	Horizontal sweeping, margin, 10 x 20 strokes
Theridiidae	0.01	0	0.36
Agelenidae	0.00	0	0.04
Therid. spl.	0.30	0.30	0.28
Other families	0.41^{a}	0.48^{b}	2.10$^{a, b}$
Total	**0.72^{a}**	**0.78^{b}**	**2.78$^{a, b}$**

The same letter in the superscript notes a significant difference (*t*-test; $p < 0.05$) within the row

After examining theridiid space webs, 3 different theridiid species were detected (13 Theridion impressum webs, 2 *T. pictum* webs and 1 *Enoplognatha latimana* web). Five webs contained remnants of WCR adults (4 *T. impressum* and 1 *T. pictum*). In the margin area, only one theridiid species *(E. latimana)* was detected (18 individuals). Two agelenid webs were examined in the corn and revealed that one web contained 3 dead beetles, while the other one contained only one.

We determined that individuals in both families are able to kill a minimum of 1 and a maximum of 5 WCR beetles within 90 minutes.

Discussion

The high correlation between the results obtained by plant searches and vertical sweeps suggests that the two methods are similar when collecting spiders. The two methods used in this study have potential benefits and drawbacks. Authors noted that habitat search requires a lot of labour (Sunderland et al., 1995). Habitat search is a flexible method, which signifies that when an individual increases the research time on replicates, the accuracy of information increases; however the number of replicates evaluated decreases. Vertical sweeping on the other hand is less labour-intensive and less tiresome. Therefore, this collecting technique is more suitable for extensive studies. In the case of fast-moving animals, which inhabit the upper parts of vegetation, sweeping is highly effective compared to suction methods, D-vac sampling for example (Samu and Sáros-pataki, 1995). In our case, the use of D-vac would not have been feasible in the corn, due to plant height and structure. Horizontal sweeping allowed the collection of spiders from the upper 30–40 cm of the plants, whereas vertical movement of the nets collected spiders more than likely on the backside of leaves. Both methods underestimated the absolute density of each species. Individual plant search, on the other hand, underestimated only the density of small-sized web building and each hunting spiders. The efficiency of this method can reach almost 100% in the case of larger web building spiders because these webs are satisfactorily visible in a weed-free corn stand. Hance (1992) also found that *in* *situ* habitat search is a notably suitable method when larger species are studied. We believe that studies in corn will begin with individual plant searches, followed by vertical sweeping to obtain larger quantities of information.

Density of *T. impressum* in the study plots (0.02/m^2 or 0.01/m^3 or 0.0025/plant) was very low. In contrast to our findings, Schröder et al. (1999) observed 1.6/m^2 *T. impressum* females in sugar beet, Pekár (2000) found an average of 0.73 spiders on each sunflower plant and 1.5 spiders on each Phacelia. Similarly, Szinetár (unpublished) also found a high density of *T. impressum* in Phacelia.

Our results do not allow us to draw extensive conclusions; however, we assume that due to the low spider density present in the study plots, the spider pressure on the WCR population also was low. *T. impressum* and *Agelena* species are potentially efficient predators of the WCR, based on prey behaviour. Therefore, one of the main objectives of our future studies will be to examine the major factors influencing the density of these spider species in corn.

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