Diabrotica virgifera virgifera LeConte in confrontation mood: simultaneous geographical and host spectrum expansion in southeastern Slovenia

Hans E. Hummel [1,2], Sven Dinnesen [3], Tenio Nedelev [3], Spela Modic [4], Gregor Urek [4] & Christian Ulrichs [3]

[1] Justus-Liebig University Gießen, Department of Organic Agriculture
[2] Illinois Natural History Survey, Division of Biodiversity and Ecological Entomology
[3] Humboldt University Berlin, Urban Horticulture
[4] Agricultural Institute of Slovenia

Abstract: *Diabrotica virgifera virgifera* LeConte (Coleoptera: Chysomelidae), im deutschsprachigen Raum als Westlicher Maiswurzelbohrer bekannt, ist ein von der Neuen Welt nach Europa eingeschleppter Schädling. Er gelangte in mindestens drei Einwanderungsschüben, die durch molekulargenetische Untersuchungen unterscheidbar sind, nach Europa. Innerhalb der letzten eineinhalb Jahrzehnte wurde, mit Ausnahme von Dänemark, die gesamte Fläche Südost- und Zentraleuropas vom Käfer besiedelt. In mehreren osteuropäischen Ländern ist die ökonomische Schadensschwelle bereits überschritten. Bis 2006 galt *Zea mays* als einzige bekannte europäische Wirtspflanze. Allerdings deuten neueste Beobachtungen in Ostslowenien vom August 2006 auf kleine Zahlen von Käfern am Ölkürbis *Cucurbita pepo* und damit auf eine Ausdehnung des Wirtsspektrums von *D. v. virgifera* hin. Der Käfer tritt in kleinen Zahlen als Besucher von Ölkürbisblüten mit einer Häufigkeit von 0,1 % auf. Er ist aber auch in geringer Häufigkeit in Kairomon- und Pheromonfallen in Ölkürbisfeldern südlich von Gaberje in Ostslowenien anzutreffen. Dieses Ergebnis stellt den zukünftigen Wert des Fruchtwechsels in Frage, der bisher als eine der wirksamsten und nachhaltigsten Methoden des integrierten Pflanzenschutzes galt.

Key words: *Diabrotica v.virgifera* LeConte, invasive insect pests, *Zea mays*, oil pumpkin *Cucurbita pepo* in Europe, monitoring, Metcalf trap

[1,2] H.E. Hummel, Justus-Liebig University, Department of Organic Agriculture, Karl-Gloeckner-Strasse 21C, D - 35394 Giessen, Germany; E-mail: hans.e.hummel@agrar.uni-giessen.de;
Illinois Natural History Survey, Division of Biodiversity and Ecological Entomology,1816 S.Oak Street, Champaign, ILL. 61820, USA
[3] S. Dinnesen, T. Nedelev, Ch. Ulrichs, Humboldt-University Berlin, Urban Horticulture, Lentzeallee 55, D-14195 Berlin, Germany; E-mail: christian.ulrichs@agrar.hu-berlin.de
[4] S. Modic, G. Urek, Agricultural Institute of Slovenia, Hacquetova 17, 1001 Ljubljana, Slovenia; E-mail: gregor.urek@kis.si; spela.modic@kis.si

Diabrotica virgifera virgifera LeConte, in its original North American habitat also known as western corn rootworm beetle, actively continues its expansion to new territories and uses *Homo sapiens* as its prime vector. It took only 15 years to spread to and occupy the southeastern and central parts of Europe, so far with the exception of Denmark where it has not been documented as of 2007. Economic thresholds have been reached and surpassed only in Southeast European countries like Slovakia, Hungary, Serbia, Eastern Croatia, Romania and Northern Italy. But both, the area affected and the severity of symptoms are increasing. Model calculations by a number of authors (Baufeld & Enzian, 2005 a and b; Hongmei Li & al. 2006, CLIMEX model) indicate a definitive propensity of *D. v. virgifera* to expand its currently occupied territory to regions with moderate temperatures and *Zea mays* cultivation. East Africa and Eastern Asia are included in the list of potential candidates for future inadvertent introduction. In most discussions it is tacitly and erroneously assumed that *Z. mays* is the only or the only important host of *D. v. virgifera*. Our recent observations in Eastern Slovenia on the oil pumpkin *Cucurbita pepo* indicate, however, that this simplifying assumption is not

longer strictly valid. It has to be modified in light of new evidence. Here, we report a few field experiments conducted in August of 2006 clarifying the host status of *C. pepo* in a European country.

Materials and Methods

A field of *C. pepo* of 2 x 0.14 ha was available in a fertile agricultural area located 1-2 km south of the village of Gaberje near Lendava in East Slovenia.

Both Metcalf sticky cup traps (Levine & Metcalf, 1988) and nonsticky large capacity (Vario) traps have been established at canopy height of the oil pumpkins (about 0.6 m above ground) and at a minimum distance of 20 m from each other. Lure pads made from cellulose fibre loaded with exactly 10 mg of MCA (4-methoxy-*trans*-cinnamaldehyde) or 0.1 mg of sex pheromone (8-methyl-decane-2-ol propanoate) have been added as attractant sources. Sticky traps including the lures were monitored and changed daily.

Pumpkin blossoms served as "natural traps" (see Rhodes & al. 1980) in which beetles could be easily observed at the bottom and counted. The number of open blossoms varied from day to day. After the presence of beetles was established (table 1), kairomone and pheromone traps were added and evaluated (table 2). The effectiveness and specificity of the attractants have been described in detail by Metcalf & Metcalf (1992).

Results

Modic & al. (2006) provide clear evidence of a ten- to twentyfold increase of population densities of *D. v. virgifera* between 2004 and 2006 in East Slovenia (Modic & al. 2006). This quantitative population increase is well documented through systematic trapping on a weekly basis. Additional counting in blossoms of *C. pepo* and trapping of *D. v. virgifera* in kairomone baited Metcalf traps confirm the presence of beetles in Slovenian oil pumpkin fields. Table 1 and 2 show our results obtained in August 2006.

Table 1: Oil pumpkin blossoms and their occupancy by *D. v. virgifera* in 2006 near Gaberje, East Slovenia, as determined by visual inspection

Date	# of *C. pepo* blossoms sampled	# of *D. v. virgifera* found[1]
July 30 – Aug. 17	3015	0
Aug. 18	683	3
Aug. 19	240	1
Aug. 20	200	0
Aug. 21	290	0
Aug. 22	590	2
Aug. 23 – Aug. 29	1236	0
Total numbers	6254	6

[1]) in addition to *D. v. virgifera*, only honey bees are visiting the blossoms while they are open. Average occupancy of blossoms was 13.6 %.

Table 2: Oil pumpkin field traps baited with plant kairomones and sex pheromones and number of *D. v virgifera* trapped from Aug. 28 to 29, 2006

no. of traps	Trap type	# of *D. v.* virgifera[1]
2	Control traps unbaited with lure	0
1	Vario sex pheromone trap	0
4	Metcalf sticky traps baited with MCA	5 females
4	Metcalf sticky traps baited with sex pheromone	1 male
Totals:		6 *D. v. virgifera*, 83 % females

[1]) 83 % of the beetles are females, in accordance with the prevailing sex ratio observed at the end of August under Illinois conditions

Discussion

The appearance of beetles on *C. pepo* coincides with the main searching period of females for fresh vegetable matter and oviposition sites. In contrast to the situation in Illinois, no beetles were seen on the numerous developing immature oil pumpkins. In Slovenia, *D. v. virgifera* is currently still in the "adaptation phase" to fully accept *C. pepo* as a host plant with its – from the perspective of *D. v. virgifera* – unusual set of secondary plant volatiles. Rapid progress of the beetles is expectable.

R.L. Metcalf in his graduate seminars at the University of Illinois frequently pointed out the importance of microevolution in progress. He predicted the gradual host shift of *D. v. virgifera* from *Z. mays* to the soybean, *Glycine max*, which 15 years later was fully confirmed by Spencer & al. 2005.

Based on pollen analysis in insect guts, Moeser & Vidal (2001) reported *D. v. virgifera* feeding in extremely low numbers on the related pumpkin *C. maxima* growing in Hungarian *Z. mays* fields as weeds. This seems to be the first hint in the literature for a beginning host shift in Europe. In contrast, the situation in the midwestern US has been studied extensively by Rhodes & al. 1980, by Metcalf & Metcalf (1992) and their associates at the University of Illinois, Urbana- Champaign, where *D. v. virgifera*, and their relatives *D. virgifera howardi* and *Acalymma vittatum* are found in locally high and damaging densities in horticultural crops including *C. maxima* and *C. pepo*. Later, Spencer & al. (2005) developed a scenario of expansion for the "rotation resistant corn rootworm" under the conditions of an agricultural pest management system characterized by annually alternating maize and soybean. Here in Europe, for the last 4 years *D. v. virgifera* has also been sought in pumpkin fields near the Agricultural Field Research Station Cadenazzo, Contone, Ticino, Switzerland, but could not be found. In 2002 and 2005, the first author also sampled two field sites in Serbia and in the Slavonia region of eastern Croatia, respectively, with equally negative results. However, in the long run all European sites with *Cucurbita* spp. can expect problems with *D. v. virgifera*.

Conclusions

We are currently witnessing the expansion of the host spectrum of *D. v. virgifera* from *Z. mays* to *C. pepo* in Southeastern Europe. The consequences may not be very well visible at present. But as time goes on and as *D.v.virgifera* gets more firmly established, it is important to be prepared and to think prospectively. Pest managers will find it harder and harder to cope with a pest whose aggressive expansion drive, both in space and time, and in host plants selected, should never be underestimated. Oil pumpkins are of regional importance in Southeast Europe as sources of health food and vegetable oil. Chrysomelid beetles can carry bacterial and viral plant diseases and can, under unfavourable circumstances, cause total loss of a pumpkin field. Once *D.v.virgifera* becomes established, new dangers emerge for a profitable branch of oil pumpkin production. Warnings of *D.v.virgifera* in progress have been voiced earlier (Hummel 2003a, 2003b and 2003c, Hummel & al. 2005, Wudtke & al. 2005, Hummel & al. 2006) but have light-handedly been disregarded. This present, quite urgent warning call, however, is not merely pointing toward territorial expansion in a "quantitative" sense but voices concerns of an impending "quality" shift of *D. v. virgifera* to accept *new* host plants, with all associated negative consequences for crop rotation and crop protection.

Acknowledgements

The authors wish to thank DAAD for a travel and subsistence grant to S. Dinnesen and T. Nedelev. Mrs. B. Kuhn, Berlin, Mrs. E. Sumner, and Dr. D.F. Hein gave valuable advice in data handling and programming matters. Schwarz Foundation, Heilbronn-Neckarsulm, supported the field experiments in Slovenia with a generous grant. The Ministry of Agriculture, Forestry and Food, the Ministry of Higher Education, Science and Technology, project no. V4-0110- 04, and the Phytosanitary Administration of the Republic of Slovenia, Ljubljana, facilitated the experiments by providing support, transportation to and permission to enter farmers' fields at the village of Gaberje. Mario Bertossa, Cadenazzo, Switzerland, Dr. F. Baca, Belgrade, Serbia, and university lecturer Dr. R. Bazok, Zagreb, Croatia, kindly invited the first author for some field excursions and experiments between 2002 and 2006.

References

BAUFELD, P. & S. ENZIAN (2005a): Western corn rootworm *(Diabrotica virgifera virgifera)*, its potential spread and economic and ecological consequences in Germany. pp.149-154. – In: British Crop Protection Council. Plant Protection and Plant Health in Europe: Introduction and Spread of Invasive Species. Alton, Hampshire, UK.

BAUFELD, P. & S. ENZIAN (2005 b): pp.285-302. – in: VIDAL, S., U. KUHLMANN & C.R. EDWARDS (eds.): Western Corn Rootworm. Ecology and Management. CABI Publishing, Wallingford, UK.

HONGMEI LI, C.R. EDWARDS & D. XUE (2006): Predicting the possibility for establishment of the western corn rootworm, *Diabrotica v. virgifera*, in different world regions based on the CLIMEX model. Poster and abstract 016 presented to IWGO 22nd Conference Vienna, Austria, Nov. 5-8, 2006

HUMMEL, H.E. (2003 a): *Diabrotica virgifera virgifera* LeConte (Coleoptera: Chrysomelidae) – An entomological challenge to Europe and its maize production. – Comm. Agr. Appl. Biol. Sci, Ghent University **68** (4a): 27-28

HUMMEL, H.E. (2003 b) Introduction of *Diabrotica virgifera virgifera* into the Old World and its consequences. – Comm.Agric.Appl.Biol.Sci.,Ghent University **68** (4): 45-57

HUMMEL, H.E. (2003 c): Round table discussion at the special section on *Diabrotica.* – Comm. Agric. Appl. Biol. Sci., Ghent University **68** (4): 105-106

HUMMEL, H.E., T. KISTNER & C. ULRICHS (2006): Blattkäfer des *Diabrotica* spp. (Coleoptera: Chrysomelidae) – Komplexes als Schädlinge gartenbaulicher Kulturen einschließlich Gurkengewächsen (Cucurbitaceae). Abstract und Poster für 43. wissenschaftliche Arbeitstagung der Gartenbaulichen Gesellschaft e. V., Potsdam, Febr.22-25, 2006; BHGL Schriftenreihe **24**: 131.

HUMMEL, H.E., M. BERTOSSA, D.F. HEIN, A. WUDTKE, G. UREK, S. MODIC & C. ULRICHS (2005): The western corn rootworm *Diabrotica virgifera virgifera* en route to Germany. – Comm. Agr. Appl. Biol. Sci., Ghent University **70** (4): 677-686

LEVINE, E. & R.L. METCALF (1988): Sticky attractant traps for monitoring corn rootworm beetles. – Illinois Nat. Hist. Survey Rep. **279**: 1-2

METCALF, R.L & E.R. METCALF (1992): Plant Kairomones in Insect Ecology and Control. – Routledge, Chapman and Hall, New York

MODIC, S., M. KNAPIC, Z. CERGAN & G. UREK (2006): Spread and population dynamics of *Diabrotica virgifera virgifera* in Slovenia. – Abstract and poster 022 displayed at 22nd IWGO Conference Vienna, Austria, Nov. 6-8, 2006

MOESER, J. & S. VIDAL (2001): Alternative food resources for adult *Diabrotica virgifera virgifera* in southern Hungary. pp. 19-24. – in: Venice proceedings. XXI IWGO Conference, VII *Diabrotica* subgroup meeting, Veneto Agricoltura (ed.) Legnaro, Padova,Venice, Italy, Oct. 27-Nov. 3, 2001

RHODES, A.M., R.L. METCALF & E.R. METCALF (1980): Diabroticite beetle response to Cucurbitacin kairomones in *Cucurbita* hybrids. – J. Amer. Soc. Horticultural Sci. **105**: 838-842.

SPENCER, J.L., E. LEVINE, S.A. ISARD & T.R. MABRY (2005): Movement, Dispersal and Behavior of Western Corn Rootworm Adults in Rotated Maize and Soybean Fields. pp.121-144. – in: VIDAL & al. eds.,CABI Publishing, Wallingford.

WUDTKE, A., H.E. HUMMEL & C. ULRICHS (2005): Der Westliche Maiswurzelbohrer *Diabrotica virgifera virgifera* LeConte (Col.: Chrysomelidae) auf dem Weg nach Deutschland. – Gesunde Pflanzen **57**: 73-80