Review Article

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Current Status of *Diabrotica virgifera virgifera* LeConte, 1868 (Coleoptera: Chrysomelidae) in Romania

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Abstract: The Western corn rootworm *Diabrotica virgifera virgifera* is an invasive alien species originating from the area currently occupied by Mexico and Guatemala, a habitat where the species feeds mainly on host plants of the family Poaceae. In 1992, this species was first recorded in Europe (near Belgrade airport), and in 1996, the species was observed in Nădlac, Romania, near the border with Hungary. For about 20 years it has spread in 21 counties. The current distribution and trends of invasion, the life cycle of the species in the conditions of the western part of Romania, and the alternative host plant species are presented and discussed in this paper.

Key words: Invasive alien species, distribution, impact, host plants, maize

Introduction

The western corn rootworm *Diabrotica virgifera virgifera* LeConte, 1868 (Coleoptera: Chrysomelidae) is an invasive alien species originating in Mexico and Guatemala, where it feeds mainly on host plants of the family Poaceae, which show a great diversity in the native range (Branson & Krysan 1981). The beetle was accidentally introduced in Europe (Serbia, near Belgrade airport, 1992) (Baça 1994) and attracted the attention of many experts, being a threat to the maize crops (Vidal et al. 2005). In 1996 the species was reported in Romania in Nădlac, near the border with Hungary (Vonica 1996).

The maize crops occupy a large part of all arable agricultural lands in Romania and this is, in fact, the largest surface cultivated with this plant species in the European Union. Currently, about 29 insect species are considered to affect maize in Romania, but only two of them have economic importance: *Tanymecus dilaticollis* Gyllenhal, 1834 (Coleoptera: Curculionidae) and *Ostrinia nubilalis* (Hübner, 1796) (Lepidoptera: Crambidae). Since its introduction in Romania, *D. v. virgifera* has also become a significant risk factor to maize production.

After the introduction of *D. v. virgifera* in Romania the species was subject to different studies related to its distribution (Vonica 1998, 2000, Pălăgeşiu et al. 2001, Gogu 2001, Hancu et al. 2003, Cean 2004, 2005, Oltean et al. 2004, Crişan et al. 2009, Grozea et al. 2009, 2015, Ciobanu et al. 2011), natural enemies (Grozea et al. 2007, 2008, 2009), life cycle (Grozea 2003a, Ciobanu et al. 2007), and control (Ciobanu et al. 2007, Popov et al. 2008, Grozea 2010). A monitoring programme was initiated, following the monitoring protocol established in 1995 by Berger (1996). The species was also a subject of awareness raising activities (brochures or agricultural reviews) (Perju 1995, Bărbulescu 1999, 2002, 2005, Grozea 2003b, Perju et al. 2005).

The aim of this paper was to review the current distribution and some biological traits of *D. v. virgifera* in Romania.

Materials and Methods

The review of distribution of *D. v. virgifera* was made based on published data. The study of species behaviour in laboratory and field conditions was

carried out in the period 2009-2015 in the western part of Romania (Lugoj and Jimbolia in Timiş County and Curtici and Macea in Arad County). The alternative hosts of the species were studied in the maize crops and in the surroundings. The frequency was expressed by the number of adults which visited the plant in one hour, and were expressed in time ranking by community estimated variance of binomial distribution where S is the standard error of the replicate parameter estimates (CHAO 1984). The research area included the counties of Teleorman, Giurgiu, Dîmboviţa, Călăraşi and Constanţa (Drăgăneşti-Vlaşca, Naipu, Ciocăneşti, Fundulea and Amzacea), localities where, according to the area monitored, a variable (1-4) number of pheromone traps were placed.

Results and Discussion

Distribution and impact in Romania

Untill 2013, the species was reported in 21 counties of Romania: Arad, Timiş, Caraş Severin, Mehedinţi, Bihor, Satu Mare, Sălaj, Hunedoara, Cluj, Alba, Sibiu, Gorj, Dolj, Vîlcea, Olt, Bistriţa Năsăud, Mureş, Harghita, Maramureş Argeş, Braşov and Prahova (Fig. 1) (Vonica 1998, 2000, Manole 1999, Gogu 2001, Pălägeşiu et al. 2001, Hancu et al. 2003, Cean 2004, 2005, Oltean et al. 2004, Crişan et al. 2009, Grozea et al. 2009, 2015, Ciobanu et al. 2011). The pheromone trapping of *D. v. virgifera* conducted by Manole et al. (2017) confirmed the presence of the species in three new counties: Teleorman, Giurgiu and Dîmboviţa (Fig. 1), which demonstrates a spreading of the species to south and south-east of the country compared with the distribution registered until 2013 (Manole et al. 2017).

The distribution and spread of *D. v. virgifera* in Romania seems to be closely related to the food resources, but at the same time is strongly correlated with the climatic conditions (Grozea 2010, Grozea et al. 2011, Ciobanu et al. 2011) The species it not yet reported from the south-east part of country (Dobrogea region). Probably, this is due to the negative influence of the arid climate there. At present, 21 years after the species introduction

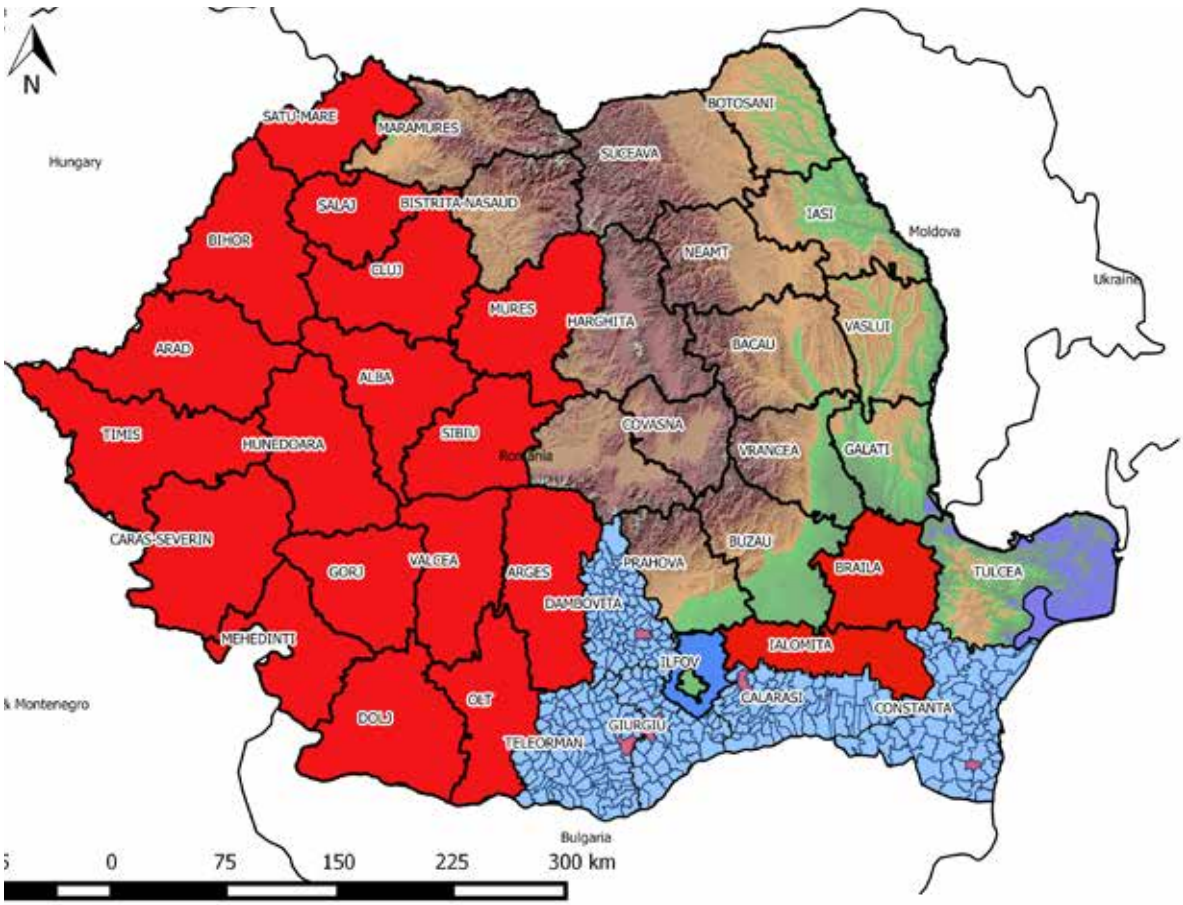

Fig. 1. The current distribution of *Diabrotica virgifera virgifera* in Romania (© Traian Manole 2017); The red colour indicates the distribution of the species until 2013, while the blue colour shows the new counties of spreading in 2016 according to Manole et al. (2017)

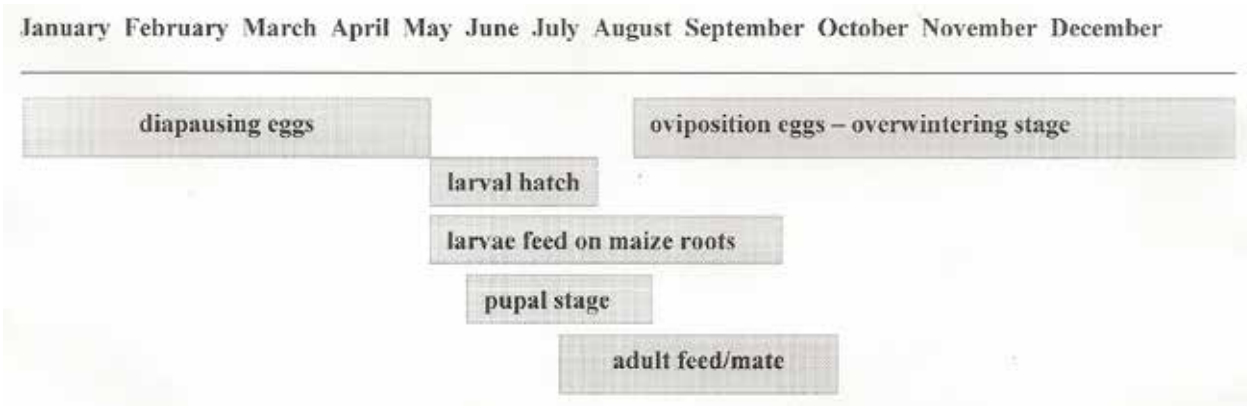

Fig. 2. The life cycle of *Diabrotica virgifera virgifera* under the climatic conditions in Romania (Timiş and Arad counties)

in our country, we can report that the damages by *D. v. virgifera* in all infested regions are relatively small and mainly localised in the western part of country. According to the Iowa scale 1-6 (Ostlie & Noetzel 1987), the root injury had an average of 0.565 (in comparison, the attack in Iowa in 2002 was around 1.241, Ivezic et al. 2006) and even when the symptoms of attacks from larvae are visible ('goosenecking'), the crop damages are still hard to estimate. At national level, even at the higher densities in the western part of Romania, the impact of the species on maize crops are small in comparison with other pests as *Tanymecus dilaticollis*, *Ostrinia nubilalis* and *Agriotes* spp.

Life cycle under climatic conditions in western Romania

Our study showed that in Romania the hatching of the larvae began during the period end of April – middle of May. Larval stage development continued from May to June and at the end of May – beginning of July the insect was in the pupal stage. At the end of June, first adult beetles appeared and the adult emergence continued in July and August. The feeding behaviour was correlated with the maize seeding period which was strongly modified in most regions because of lack of precipitation in the key month favourable for maize planting (end of April). At the end of August, when the maize crops finished the vegetation processes, the adult females return in the soil for laying eggs (Fig. 2).

Alternative hosts in Romania

In Europe, the alternative hosts of *D. v. virgifera* were studied by Clark & Hibbard (2004), Moeser & Vidal (2004), Oyediran et al. (2004), etc., but all of the studies focused on larval feeding behaviour. Some of these studies were carried out in laboratory conditions. In Romania, Fora & Lauer (2013) reported nine weed species from the family Poaceae, which were visited by the adults of *D. v. virgifera* and used as alternative host plants.

Our study focused on the adult feeding behaviour on wild plant species (mostly weeds and aromatic plants), which were distributed in the maize crops or in the close surroundings. As a result, we found that beside the preferred host *Zea mays,* 46 alternative host species from 11 botanical families were visited by adults of the species. The list of plants and the frequency of these visits during the flowering period are presented in Table 1. Thirty-seven plant species were registered as new food resources for the adults of *D. v. virgifera* for Europe and for Romania. The most visited plants in the flowering period were the species *Echinocystis lobata*, *Glycine max*, *Cucurbita pepo*, *Chenopodium album*, *Convolvulus arvensis*, *Achilea millefolium*, and *Hypericum perforatum*, which usually accompany the roadsides of the maize crops (Table 1).

Conclusions

In Romania, *D. v. virgifera* is distributed mostly in the western part of the country where the area occupied by maize is considerably large and the climatic conditions are favourable to the insect development. The pest is spreading to the southern counties and expending its food spectrum by using new alternative host species.

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Table 1. Alternative hosts species of *Diabrotica virgifera virgifera* adults on maize crops in Romania. f – the number of adults which visit the plant in one hour; S – standard error

Order	Family	Species	f	S
Caryophyllales	Amaranthaceae	*Amaranthus retroflexus* L.	10	0.47
		Amaranthus caudatus L.	8	2.61
		Amaranthus hybridus L.	8	2.61
	Chenopodiaceae	*Chenopodium multifidum* L.	2	2.27
		Chenopodium hybridum L.	7	2.20
		Chenopodium album L.	23	3.02
		Atriplex tatarica L.	14	3.02
Fabales	Fabaceae	*Glycine max* (L.) Merr.	28	3.09
		Phaseolus vulgaris L.	12	3.02
Polygonales	Polygonaceae	*Rumex acetosella* L.	5	0.91
		Polygonum lapathifolium L	8	2.61
		Polygonum convolvulus L.	9	2.97
Apiales	Apiaceae	*Conium maculatum* L.	12	3.02
		Heracleum sphondylium L.	4	1.07
Theales	Hypericaceae	*Hypericum perforatum* L.	20	3.02
Malvales	Malvaceae	*Malva sylvestris* L.	10	3.02
Cucurbitales	Cucurbitaceae	*Cucurbita pepo* L.	34	3.02
		Echinocystis lobata (Michx.) Torrey et A. Gray	29	3.06
Solanales	Convolvulaceae	*Convolvulus arvensis* L.	24	3.02
		Ipomoea batatas (L.) Lam.	16	3.02
		Calystegia sepium (L.) R. Br.	4	1.07
Asterales	Asteraceae	*Achilea millefolium* L.	22	3.02
Poales	Poaceae	*Zea mays* L.	40	3.06
		Festuca pratensis Hud.	1	2.67
		Lolium perenne L.	4	1.07
		Poa annua L.	15	3.02
		Poa pratensis L.	12	3.02
		Dactyllis glomerata L.	6	1.68
		Aspera spica-venti (L.) Beauv.	5	0.91
		Bromus tectorum L.	6	1.68
		Bromus inermis Leysser	6	1.68
		Agropyron cristatum (L.) Gaert.	8	2.61
		Elymus repens (L.) Gould.	6	1.68
		Triticum aestivum L.	11	3.02
		Avena fatua L.	2	2.27
		Agrostis stolonifera L.	5	0.91
		Agrostis gigantea Roth	9	2.97
		Phleum pratense L.	6	1.68
		Stipa pulcherrina C. Koch	3	1.77
		Eragrostis pilosa (L.) Beauv.	2	2.27
		Cynodon dactylon (L.) Pers.	4	1.07
		Echinochloa crus-galli (L.) Beauv.	6	1.68
		Digitaria ischaemum (Sch.) Mühl.	4	1.07
		Paspalum distichum L.	8	2.61
		Paspalum paspalodes (Michx.) Scrib.	9	2.27
		Setaria pumila (Poiret) Sch.	6	1.68
		Sorghum halepense (L.) Pers.	10	3.02

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