Initial movements of introduced alien Western Corn Rootworms, *Diabrotica virgifera virgifera* LeConte (Coleoptera: Chrysomelidae) for colonising suitable habitats

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ABSTRACT

In the late 1980s, a new maize pest, *Diabrotica virgifera virgifera* LeConte (Western Corn Rootworm, Coleoptera: Chrysomelidae), was accidentally introduced from North America into Serbia (Baca 1994). This invasive chrysomelid beetle, *Diabrotica virgifera virgifera* LeConte (Western Corn Rootworm, Coleoptera: Chrysomelidae), was a univoltine maize herbivore with eggs overwintering in the soil of maize fields, larvae feeding on maize roots, and adults feeding on maize leaves or silk (Chiang 1973). Most damage is caused by the root destroying larvae resulting in plant lodging. In Europe, the large-scale spread of *D. virgifera* is varying much between years and regions, reaching 60 to 100 km per year (Edwards *et al.* 1999; Baufeld and Enzian 2005). Within 10 years, this invasive beetle rapidly spread throughout Central Europe (Kiss *et al.* 2005). Recently, several new spots of isolated invasions were reported in Europe, such as around Paris (France), Basel (France and Switzerland), Amsterdam (The Netherlands), and London (UK) (Kiss *et al.* 2005). Those multiple introductions raise the question on the process of initial movements of the beetle over non-native habitats for colonising maize fields, being one of the potential key factors behind the invasiveness of *D. v. virgifera* (Drake *et al.* 1989, Wittenberg 2005).

Processes of introduction are usually divided into entry, the period of adaptation and establishment, and into large-scale spread (Wittenberg and Cock 2001). The successful

INTRODUCTION

In the late 1980s, a new maize pest was accidentally introduced from North America into Serbia (Baca 1994). This invasive chrysomelid beetle, *Diabrotica virgifera virgifera* LeConte (Western Corn Rootworm) is a univoltine maize herbivore with eggs overwintering in the soil of maize fields, larvae feeding on maize roots, and adults feeding on maize leaves or silk (Chiang 1973). Most damage is caused by the root destroying larvae resulting in plant lodging. In Europe, the large-scale spread of *D. virgifera* is varying much between years and regions, reaching 60 to 100 km per year (Edwards *et al.* 1999; Baufeld and Enzian 2005). Within 10 years, this invasive beetle rapidly spread throughout Central Europe (Kiss *et al.* 2005). Recently, several new spots of isolated invasions were reported in Europe, such as around Paris (France), Basel (France and Switzerland), Amsterdam (The Netherlands) or around London (UK) (Kiss *et al.* 2005). Those multiple introductions raise the question on the process of initial movements of the beetle over non-native habitats for colonising maize fields, being one of the potential key factors behind the invasiveness of *D. v. virgifera* (Drake *et al.* 1989, Wittenberg 2005).
adaptation period and establishment is depending on a) the ability to colonise suitable habitats or hosts, b) a small minimum viable population size, c) the fitting of climate parameters, and d) a high intrinsic rate of increase as we know from many classical biological control cases in weeds (Wittenberg and Cock 2001, Wittenberg 2005). After entry and establishment, the successful spread and the development of high populations as well as the likelihood of economic and environmental impact can be summarised a) in reproductive mechanisms, b) in dispersal mechanisms, c) in a tolerance of environmental factors, d) in a low mortality due to the low impact by indigenous natural enemies, (Toepfer and Kuhlmann 2005), and e) in the availability of suitable hosts or food webs (Wittenberg 2005).

In this study we aimed to investigate the colonisation process of small populations of the alien *D. v. virgifera* from the site of introduction towards suitable habitats, such as maize, by applying mark release - recaptures techniques.

**MATERIAL AND METHODS**

In order to investigate initial colonisation movements of *D. v. virgifera* adults from unfavourable areas into maize fields, mark release - recapture techniques were applied. Two non-maize areas were chosen as release areas for marked beetles in southern Hungary in 2003 and 2004, i.e. an 80 ha steppe and a 60 ha lucerne field. In each area, two maize plots of 10 x 10 m were established 300 m apart from a centred release point. Moreover, all non-crop and crop habitats were recorded in longer distances around the release points. About 6000 beetles were marked with orange, yellow or pink fluorescence powders (Radiant Color, BE and Fiesta Colours Swada, UK) and released in each of 5 releases in two years, respectively, which totals in 60,000 released beetles. For recapturing beetles, non-baited yellow sticky traps (Pherocon AM, Trece Inc., USA), were placed in four circles (30, 100, 200, 300 m) around the centred release point, totalling in more than 500 traps in each of the two study areas. In addition, in each of 1000, 1500, 2000, 2500 and 3500 m distant circles, 16 transparent sticky pheromone traps were placed (PAL traps with a lure of the females' sex pheromone Recemic 8-methyl-2-decyl propanoate; Toth et al. 2003). All traps were changed before each release. Every second day, beetles were recollected from the traps and their vectors of movement were recorded, i.e. distance and direction (geo-referenced by GPS, Garmin, USA). Mean vectors of movement were analysed for their concentration by the Raleigh Test, and circular-circular or circular-linear correlations were applied to analyse the factors behind the movement directions (Batschelet 1981, Services 2004)

**RESULTS AND DISCUSSION**

*D. v. virgifera* was actively spreading over more than 100 hectares of non-maize areas, and few marked beetles were even found up to 2500 m far from the release point. This underlines the known phenomena that *D. v. virgifera* is a very active flyer and is able to actively overcome longer distances (Onstad et al. 1999, Spencer et al. 1999). However, no consistent major vectors of directed movements were found, as only 4 mean vectors out of 10 were concentrated (*P* < 0.005, Raleigh test), meaning most movements of the released populations appeared to be not directed.
Preliminary results of circular correlations revealed that the few concentrated movements of the released *D. v. virgifera* populations were slightly directed towards maize fields within 1500 m distance around the release point (*P* = 0.014, *t* = 2.5, df 116). However, no significant correlations were found with the two 300 m distant maize plots suggesting that more distant maize fields were also influencing beetle movements. A directed movement of released *D. v. virgifera* was proven towards flowering lucerne fields (*P* = 0.006, *t* = 2.9, df 45), but not towards sunflower fields (*P* > 0.05, df 142). However, marked beetles were found in nearly every flowering habitat, and it is suggested that introduced adults in non-maize areas will find and feed on pollen sources of many plants (Moeser and Hibbard 2005). This is probably also the reasons why only about 3.7 % (s.d. 4.3 %) of the spreading beetles in this study colonised the 300 m distant maize plots.

In conclusion, accidentally introduced *D. v. virgifera* will probably find and use many different flowering plants as a food source and may find maize field for oviposition in a second step.

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