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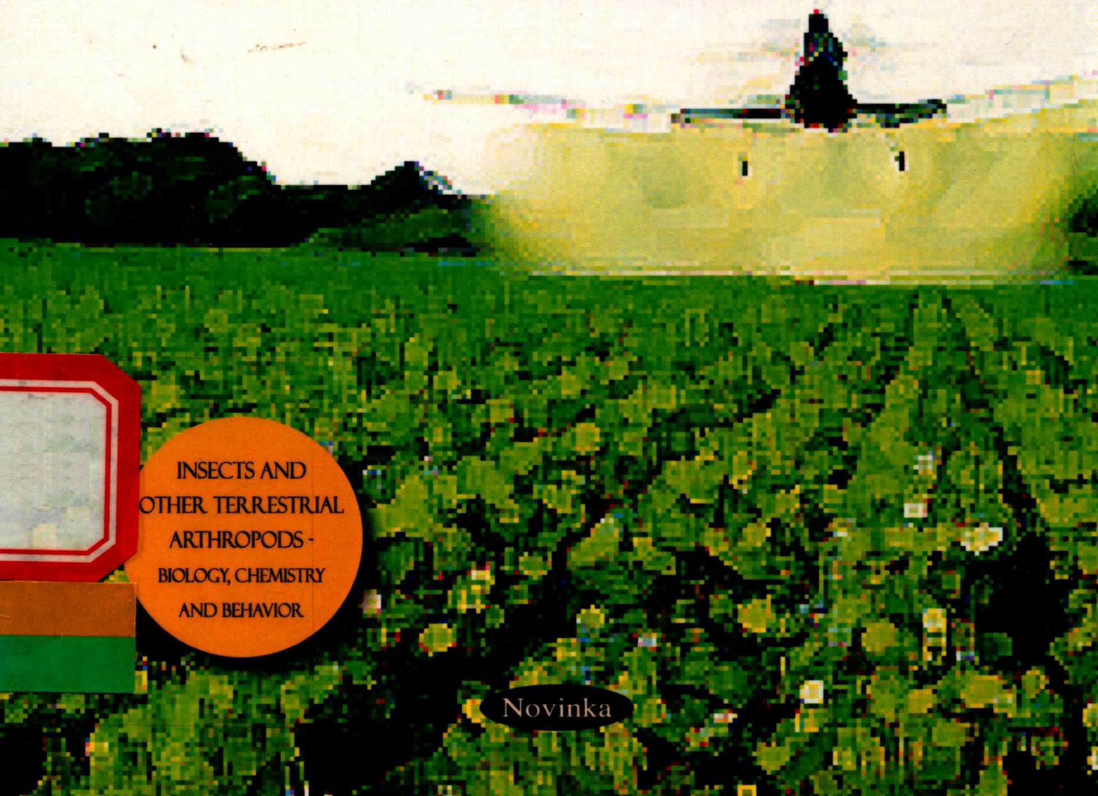
Pheromone Applications in Maize Pest Control



Insects and Other Terrestrial Arthropods - Biology, Chemistry and Behavior

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INSECTS AND OTHER TERRESTRIAL ARTHROPODS:
BIOLOGY, CHEMISTRY AND BEHAVIOR

PHEROMONE APPLICATIONS IN MAIZE PEST CONTROL

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PREFACE

In this chapter we intend to show that the potential use of the pheromones (scouting, monitoring, or optimal timing of insecticide application) depends on both the pest and the pheromone. The case of the three most important corn pests for the region of South Eastern Europe: wireworms, western corn rootworm (WCR), *Diabrotica virgifera virgifera* LeConte, and European corn borer (ECB) *Ostrinia nubilalis* Hubn. will be discussed.

Before any decision on control measures against wireworms, possible damages should be predicted. By using pheromone traps, the eight most important European species of the genus *Agriotes* in western part of Croatia five species were found. The distribution and population level of these species was established on 2 fields in central Croatia between 2001-2005. Beside pheromones on the same fields, larvae were sampled by soil sampling and by bait traps. The use of pheromone traps for wireworm pest management is attractive because of the clarity of the data they yield. There are several possibilities to use pheromones in developing IPM against wireworms: (1) monitoring and investigation in wireworm biology and ecology; (2) use of pheromones as decision tool for predicting damages and necessity for the control; (3) distribution modeling; and (4) trapping of males as a control option. There are numerous options, but all of them require further work before consistent interpretation of results could be possible.

WCR is an invasive species found for the first time in Europe in 1992. The first finding of sex pheromone of WCR dated in 1973. After the first finding the pheromone lure was produced by European scientists and pheromone trap for monitoring purposes was designed. This trap was used in Croatia for monitoring in the period between 1996 and 2006. Each year the traps were set up in corn fields (between 30-140 fields/year). Together with pheromone the yellow sticky traps (Pherocon AM or Multigard) were installed. Pheromone traps showed to be more suitable for monitoring and prediction of population increase, but, for the scouting purposes, yellow sticky traps showed to be more acceptable.

The investigation carried out in Croatia from 2002 to 2004 showed that the time of the flight of the ECB in Croatia was very variable and has changed considerably since previous years. The type E of commercial pheromone lure showed higher attractiveness than Z or E/Z types in North West Croatia. In North Croatia, E/Z and E pheromone types showed to be more attractive than Z type. Pheromones should not be used to determine intensity of the infestation, but to set the period of the maximum incidence of the moth, on the basis of which information the period of the application of insecticides is set.

CONTENTS

INTRODUCTION

Pest management continues to be an important challenge for agricultural producers. The past few decades have witnessed a general acceptance of the necessity for considering ecology in developing pest management systems. Growers are constantly faced with the dilemma of producing a high quality pest free crop within economical means, without endangering the environment and the workers safety. Therefore, integrated pest management (IPM) was developed 50 years ago as a system approach that provides an ecologically based solution to pest control problems. IPM is defined as a sustainable approach to managing pests that combines biological, cultural, physical, and chemical tools in a way that minimizes economic, health and environmental risk. According to Cuperus, et al. (2000), the original philosophy of IPM attempted to develop a system based upon a fundamental understanding of plant/pest interactions that maintained pest populations at sub-economic levels. Later on, Kogan (1998) suggested three levels of integration: single pest management approach, integration of multiple species and methods for their management in a crop and integration of multiple species within the context of total cropping system. Pest monitoring, scouting and detection of proper application time are very important elements of the IPM. The basic tools for developing IPM systems include: agricultural control, mechanical control, host plant resistance, biological control, reproductive manipulation, chemical and regulatory control.

Monitoring in insect pest management can be used to determine the geographical distribution of pests or to asses the effectiveness of control measures. But in its widest sense monitoring is the process of measuring the variables required for the development and use of forecasts to predict pest outbreaks (Conway, 1984). A great deal of research effort is directed at developing sampling techniques and devices, particularly insect traps that may be used for monitoring (Dent, 2000).

Since the first insect sex pheromone, bombykol from silkworm moth (*Bombyx mori*) was found (Butenandt et al., 1959), the pheromones of large number of insect species have been discovered. Sex pheromones belong to the group of semiochemicals. According to Suckling and Karg (2000), semiochemicals are the odors that trigger specific behavioral response in the organism. Over the last few decades, extensive research on insect pheromones has resulted in the chemical and/or behavioral elucidation of pheromone components well over 3000 insect species, with much of the work concentrating on sex pheromones of economically important pests (Blomquist et al., 2005). There are several approaches in which pheromones can be used in pest management for the purpose of monitoring, scouting, optimal timing or for control. Monitoring the number of insects caught is the most widespread use of pheromones and there are many different ways in which this information can be used. Flight activity can be recorded as the basis for timing of insecticide application or other control tactics. Trapping can be used for efficiently monitoring the frequency or dispersion of insects or even their population traits such as insecticide resistance and for the detection of low pest densities, for example, in biosecurity quarantine programs. Pheromone lures can also provide the basis for various direct control options. The group of direct control options using attractants includes mass trapping, "attract and kill," "attract and infest," and mating disruption tactics.

Maize is one of the most important field crops worldwide. In Europe it is sown on almost 14 millions of ha (FAOstat). Maize is usually attacked by a range of different pests, but the main corn pests in Europe as well as in North America are wireworms (family Elateridae), western corn rootworm (WCR) (*Diabrotica virgifera virgifera* LeConte) and European corn borer (ECB) (*Ostrinia nubilalis* Hubn.). In order to conduct successful control of the mentioned pests farmers are using a large amount of insecticides. IPM is widely adopted in European agricultural practice, mainly in fruit production and in vegetables. It is still not utilized in filed crop production at larger scale. Therefore there is a space and need to intensify the implementation of integrated pest management (IPM) in maize production.

In this chapter we intend to show that the potential use of the pheromones in corn pest's management depends on both: the pest and the pheromone. The case of the three most important corn pests for the region of south east Europe: wireworms (family Elateriadae), western corn rootworm (*Diabrotica virgifera*

virgifera LeConte), and European corn borer (*Ostrinia nubilalis* Hubn.) will be described.

Chapter 1

CASE STUDY: WIREWORMS AND POTENTIAL USE OF PHEROMONES

1.1. INTRODUCTION

The harmful species of wireworms in Croatia belong to the genus *Agriotes*. The four main *Agriotes* species in Croatia have been described in the literature. The decision for the wireworm control should be made prior to the sowing. Therefore the key of the success in wireworm control is to have a good decision tool for the prediction of damages and the need for control measure. The knowledge on *Agriotes* species in Croatia until 2000 was limited on the data available on key species, harmfulness on different crops and the possibilities of the control (Kovačević, 1960; Maceljski & Bedeković, 1962; Maceljski, 1975). The same literature reported that the most abundant species in eastern regions of Croatia are *Agriotes ustulatus* Schall. and *Agriotes sputator* L. The species *Agriotes lineatus* L. together with *Agriotes obscurus* L. were reported as the most abundant species in western regions. *Agriotes brevis* Cand. was not mentioned. For a number of years the Faculuty of Agriculture, Department for Agricultural Zoology has been conducting research on possibilities of controlling wireworms, but fundamental research on the click beetle fauna has not been carried out. A lot of research was conducted in Vojvodina and Serbia (Čamprag, 1997) and some research was conducted in the eastern part of Croatia by Štrbac (1983). But, systematic research was missing. Considering the lack of basic data on the fauna, the control is not modified to the predominant species on each particular field (or region). It is known that harmfulness varies from species to species. Species also differ in their biology and habits. These facts could have an impact on the control method.

The first results on the isolation of *Agriotes* sex pheromone were published by Yatsnin et al. (1980). It was geranyl-isovalerate isolated from *A. litigiosus*. Later on sex pheromones from females of other species were isolated: Geranyl butonate from *A. sputator* (Yatsinin et al.,1986); geranyl hexanoate and geranyl octanoate from *A. obscurus* (Borg-Karlson et al., 1988); E,E- farnesyl-acetate from *A. ustulatus* (Kudryatsev et al., 1993); geranyl octanoate and geranyl butirate from *A. lineatus* (Yatsinin et al., 1996); geranyl hexanoate from *A. sordidus/rufipalpis* (Toth et al., 2001) and geranyl butyrate and E,E, farnesyl buyrate from *A. brevis* (Toth et al., 2002). In ex SSSR different authors (Pristavko, 1988; Balkov, 1988; Balkov & Ismailov, 1991, cit. Čamprag, 1997) investigated the possibilities of the pheromones for the forecast purpose. The main species they studied were *A. gurgistanus*, *A. reiteri*, *A. lineatus* and *A. sputator*. For the first time Furlan et al. (1996, 1997) suggested the potential suitability of sex pheromone traps for implementing IPM strategies against *Agriotes* populations. Subsequently, Furlan et al. (1999) reported on the efficacy of the new *Agriotes* sex pheromone traps in detecting different species and populations. The first practical implications of the use of the new traps in Italy were described by Furlan et al. (2001). Numerous authors reported on the first results of monitoring click beetles conducted in different European countries (Toth et al., 2001a; Karabatsas et al., 2001; Gomboc et al., 2001; Furlan et al., 2001a). The main conclusion raised from all these investigations, was that the sex pheromone traps were confirmed to be a sensitive tool for detecting the key wireworm species present in one area. These traps proved to be a much more sensitive tool than soil sampling and bait traps for larvae. For all investigated species (8 species from the genus *Agriotes*) traps were able to detect wireworm populations below those that can be reliably detected using soil sampling and bait trapping. Yatsinin & Rubanova (2001) reported on the work on possibilities to use sex pheromone traps for control of wireworms by mating disruption of males. They found that there are some components which could be added to synthetic pheromones to obtain synergistic effects and improve the effect of mating disruption or mass trapping.

The studies conducted in Croatia aimed at: (1) identifying the key species in the Central Croatia, (2) evaluating the seasonal abundance of adults and larvae of *Agriotes* species in Central Croatia, and (3) assessing the effectiveness of new sex pheromone traps regarding the soil sampling and bait trapping of larvae.

1.2. Materials and Methods

Pheromone traps for the most important European species of the genus *Agriotes* were used for monitoring Individual YALTOR funnel traps (Furlan et al., 2001a) were baited with the synthetic sex pheromones for one of the *Agriotes* species (Toth et al., 1997; Toth et al., 1998). Pheromone traps for seven most important species were set up in two fields in North West Croatia in 2001 and 2002. In 2003, 2004 and 2005 pheromone traps for five most abundant species were set up in the same fields (Oborovo and Čazma). Seven most important European species involved into research in 2001 and 2002 were *A. lineatus*, *A. sputator*, *A. obscurus*, *A. brevis*, *A. ustulatus*, *A. sordidus* and *A. rufipalpis.* In the period between 2003- 2005 five species, *A. lineatus*, *A. sputator*, *A. obscurus*, *A. brevis* and *A. ustulatus* were monitored. Both fields are situated in North West Croatia. The yearly average temperature for this region: 11.7˚C (2001); 12.3˚C (2002); 11.8˚C (2003); 11.2˚C (2004); 10.7˚C (2005), total rainfall: 822.3 mm (2001); 979.8 mm (2002); 594.1 mm (2003); 918.4 mm (2004); 906.0 mm (2005). The latitude of the locality Oborovo is 45˚41'29.25" N and 16˚15'55.84" E. The latitude of the locality Čazma is 45˚46'19.47" N and 16˚33'42.34" E. The predominant soil type in Oborovo is pseudogley soil, while in Čazma it is gley soil. The fields in Oborovo were planted with the maize or soybean (depending on year), while the fields in Čazma were planted with potato each year. The distance between the traps for different species was at least 30 m. The monitoring period for *Agriotes brevis*, *A. sputator*, *A.lineatus* and *A. obscurus* varied depending on the year and locality, but it was between April 1st and August 31st. The monitoring period for *A. ustulatus* was between April 15th and August 1st. The traps were inspected once a week. All beetle specimens were removed from the traps at each observation. Every 30 days pheromone caps were replaced. Adult population density on observed localities was classified according to Furlan et al. (2001a) as follows: High= more than 500 adults/ trap/season; Medium= between 50 and 500 adults/trap; Low= less than 50 adults /trap /season; NO= no specimens;

Based on the total individual number of five species and the individual number of each particular species, the dominance was calculated for each field and year. The dominance was calculated with Balogh's formula (cit. Balarin, 1974). The results (eudominant, dominant, subdominant, recedent, subrecedent) were classified according to Tischler and Heydeman (cit. Balarin, 1974).

In order to establish the presence of the larvae in the period between 2001 and 2005, field soil bait traps and soil samplings were made. Fifty soil bait traps were placed each year in autumn and spring in a grid 20 m x 30 m covering the area where the pheromone traps were set up. Soil bait traps were made and used according to the description given by Chabert and Blot (1992). The traps were placed in the fields in March and in October. After 15-20 days they were removed and checked by hand-sorting the contents. After hand sorting bait traps were processed in Tullgren funnels. Soil samples were taken 1-2 m away from the soil bait. They were 11 cm in diameter and 30 cm deep (covering 0.0095 sqm). After the collection soil samples were processed by putting soil cores into Tullgren funnels.

1.3. Results and Discussion

By using pheromone traps for the eight most important Europen species of the genus *Agriotes,* in the north western part of Croatia, five species were found. *Agriotes sordidus and A. rufipalpis* were not captured at any locality in 2001 and 2002. Therefore, the pheromones for those 2 species were not operated in 2003-2005.

The species ***A. lineatus*** was found in high population at both localities and in all the years except at locality Oborovo in 2005. The swarming period for this species started early in spring (April) and lasted through the whole period of monitoring until mid of August (Figure 1). The similar results were obtained in Hungary (Toth et al., 2001a), in Slovenia (Gomboc et al., 2001) and in Netherland (Ester at al., 2001).Out of 22 weeks of monitoring adults were captured in 14 to 19 weeks. The peak of flight was clearly visible only in few cases. At locality Oborovo in 2001 and in 2004 it was the end of May what is similar to the results obtained in Hungary (Toth et al., 2001a), Slovenia (Gomboc et al., and Netherland (Ester et al., 2001). At locality Čazma in 2004 the peak of appearance was in August. Generally, adults of *A. lineatus* could be captured during the whole vegetation season, between April and August. It corresponds with the data on the biology of this species. *A. lineatus* over-winters as adult and are active during the whole season. Maximal weekly captures of adults of *A. lineatus* in Croatia in some years were very high. They exceeded 700 beetles/ trap/ week in Oborovo in 2001 and in Čazma in 2002 and 2004. In Hungary and in Slovenia maximal weekly captures reached 100 and 140 beetles per week respectively (Toth et al., 2001a; Gomboc et al., 2001). Comparing the investigated localities somewhat higher population was established at locality Čazma. In three, out of five years of investigation, total capture of *A. lineatus* exceeded 3,000 beetles. The appearance of *A. lineatus* in Croatian literature was always related to humid and cold climatic conditions (Maceljski, 2001). However, warmer soil conditions are usually recorded at locality with higher capture (Čazma) than at locality Oborovo and this statement could be discussed.

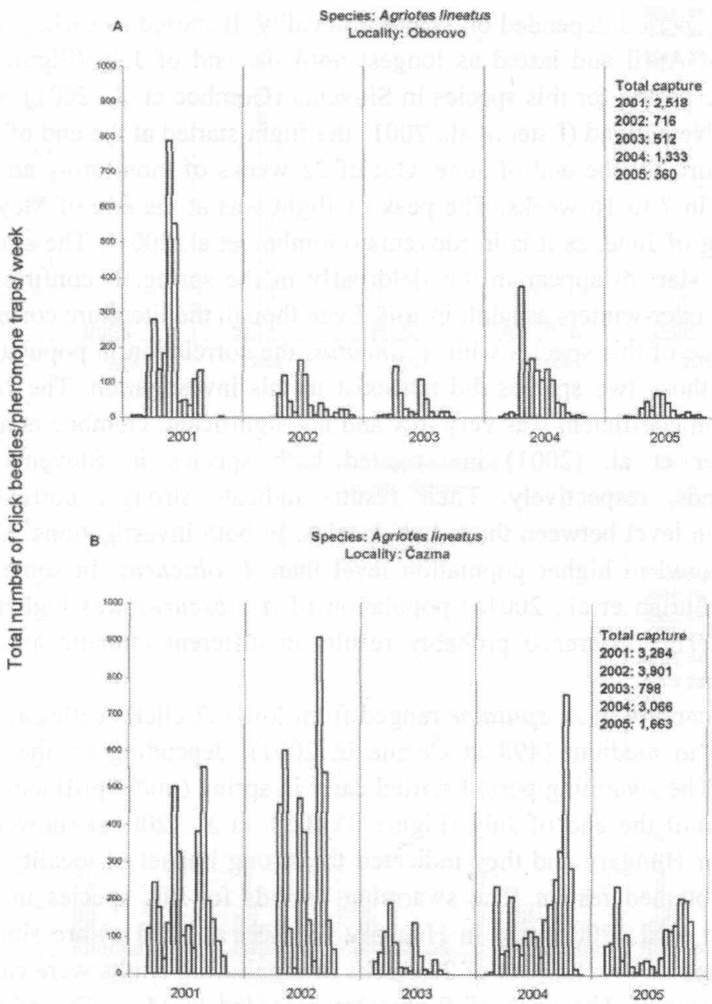

Figure 1. Seasonal dynamics (total weekly captures of beetles in pheromone traps between April 1st and August 31st) of the species *Agriotes lineatus* observed in years 2001-2005 at locality Oborovo (A) and Čazma (B).