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Non-target noctuids from traps with synthetic *Spodoptera frugiperda* pheromone lure in the Carpathian Basin, Central Europe

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Abstract

The fall armyworm, *Spodoptera frugiperda* JE Smith (Lepidoptera: Noctuidae), is one of the most important invasive noctuid pests. Its appearance and rapid spread can be monitored with sex pheromone traps, but the catches can be confused by catches of non-target similar species. Here we present non-target catches of commercial pheromone traps of *S. frugiperda* in the Carpathian basin, which is a potential area of the pest. Sizable catches of *Cucullia umbratica* (L.), *Agrotis bigramma* (Esper), and *Allophyes oxyacanthae* (L.), common noctuids in East-Central Europe, were recorded in numerous sampling sites. Although they can be distinguished from the target species by their different morphology, it is necessary to draw the attention of agricultural experts to their possible presence in the traps to avoid misleading conclusions.

KEYWORDS

Agrotis bigramma, *Allophyes oxyacanthae*, *Cucullia umbratica*, Lepidoptera, Noctuidae, pheromone lure, selectivity, fall armyworm

INTRODUCTION

The fall armyworm (FAW), *Spodoptera frugiperda* (JE Smith) (Lepidoptera: Noctuidae), ranks among the economically most damaging polyphagous noctuid pests in the Americas (Luttrell & Mink, 1999; Braman et al., 2000; Souza et al., 2013). Recently, the pest has been discovered in West Africa (Goergen et al., 2016; Abrahams et al., 2017; Cokola et al., 2020) and from there it has invaded India (Ganiger et al., 2018) and Central Asia (Baloch et al., 2020). After causing serious damage in Africa, the FAW is now affecting large areas all over China (Wang et al., 2020), and has also been reported from Australia (Cook et al., 2021; Nguyen et al., 2021; Piggott et al., 2021). In China, the FAW was at first recorded in Yunnan (Wang et al., 2020) and it has rapidly spread across 19 provinces. Based on a large set of recent distributional data and bioclimatic variables, a potential species distribution model was developed. It predicts that with global warming, a considerable expansion of this species can be expected. Mainland Europe is so far not infested, but introduction of *S. frugiperda* in the coming years is highly probable. The species is on the A2 list of EPPO (https://gd.eppo.int/taxon/LAPHFR).

Pheromone traps have proved to be very suitable tools for sensitive detection of pest moths new to a geographical area. The female-produced pheromone of *S. frugiperda* has been identified as a blend of (*Z*)-7-dodecenyl acetate (Z7-12Ac) and (*Z*)-9-tetradecenyl acetate (Z9-14Ac) (Tumlinson et al., 1986; Andrade et al., 2000; Meagher, 2001; Meagher et al., 2013), and synthetic pheromone lures are commercially available.

If pheromone trapping is performed in a recently invaded geographical area, it is not uncommon that non-target relatives of the target pest are captured. One explanation could be that in such areas, no evolution of species-specific communication channels based on pheromone composition could be developed as the newcomer species was previously missing from the area. Such non-target catches can be mixed up with the new pest by inexperienced farmers, which can lead to false alerts and irrelevant detection and monitoring data. In the case of the *S. frugiperda* pheromone lure, side catches of the noctuids *Leucania loreyi* (Duponchel) and *Spodoptera triturata* (Walker) have been reported from African sites (Meagher et al., 2019). In Asia (Turkey, Adana region) catches of *Chrysodeixis chalcites* (Esper) were observed, with no catches of the target *S. frugiperda* in the trapping (A Kurtulus, pers. comm.). In the present study, we aimed at checking non-target noctuids that were attracted by traps with the *S. frugiperda* pheromone in the Carpathian Basin (East-Central Europe), in a region where *S. frugiperda* has not been detected but its eventual appearance can be expected. Such data could be useful and assist later detection and monitoring programs in Europe.

MATERIALS AND METHODS

Field trapping tests were conducted at 10 sites in Hungary and Transcarpathia (West Ukraine), as shown in Table 1. Two pheromone traps were operated at each test site. Traps were visited at several-days intervals (preferably weekly), when captured moths were removed and recorded.

In the tests, funnel traps CSALOMON VARL were used (Plant Protection Institute, CAR ELKH, Budapest, Hungary). These traps have routinely been used for trapping various noctuids (Tóth et al., 2010, 2020; Szanyi et al., 2020; photos of the trap can be viewed at www.csalomontraps.com). For killing captured insects, a small piece (1 × 1 cm) of a household anti-moth insecticide strip (Chemotox; SaraLee Temana, Slouth, UK; active ingredient 15% dichlorvos) was placed into the catch container of traps.

Spodoptera frugiperda pheromone lures were obtained commercially (CSALOMON Trap Family; Plant Protection Institute, CAR ELKH, Budapest, Hungary) and contained Z7-12Ac and Z9-14Ac as active ingredients, as stated by the supplier (Tumlinson et al., 1986). Pheromone lures in the traps were replaced at monthly intervals.

RESULTS AND DISCUSSION

No *S. frugiperda* specimens were captured at any of the sites of this study. Altogether, Noctuidae specimens of 19 species were caught. Most of them were represented in <5 specimens and were seen as accidental catch, but three of them were recorded in sizeable numbers: *Cucullia umbratica* (L.), *Agrotis bigramma* (Esper), and *Allophyes oxyacanthae* (L.) (Table 2).

Cucullia umbratica was recorded in the largest number. This species is widely distributed in Europe, with the exception of the southern part of the Iberian Peninsula, and occurs more sporadically in West and Central Asia, predominantly in the steppe zone. The larvae are polyphagous on several herbaceous plants, mostly Asteraceae (e.g., species of *Aster*, *Chondrilla*, *Galatella*, *Sonchus*, *Taraxacum*; Ronkay & Ronkay, 1994; Zoltán Varga, pers. obs.). It was often recorded as a common species, but never as a pest. The species occurred in all sampling areas, but in varying numbers of individuals, and was present in the traps from April to September, depending on the area. The species has two generations in the Carpathian Basin, but the generations may converge, so their continued presence is not uncommon. These moths have elongated anterior and rounded hind wings. They look like hawk moths, and they cannot be confused with the target species based either on morphology or patterns (Figure 1).

Cucullia umbratica has been reported to respond to traps baited with synthetic Z-9-14Ac and Z7-12Ac (the same compounds as in the *S. frugiperda* lure) (Szőcs et al., 1983), and the large catches observed in the present study can most probably be explained by this. The results of the present study confirm earlier data from Lithuania, which reported the capture of *C. umbratica* in traps with the FAW sex-pheromone lure (Ostrauskas, 2003).

Agrotis bigramma was second as far as numbers caught. This species is widely distributed mainly in southern and eastern Europe, Asia Minor, Western Asia to Afghanistan, and southern Siberia (Fibiger, 1990). It is mostly common in steppic areas, e.g., in Pannonian steppic grasslands

TABLE 1 Details of field tests (two traps were operated at each site)

Locality	GPS	Period	Biotope
Beregszász - Ardó	48°13.7, 22°38.9	21 April – 30 October 2021	Bushy hillside with *Crataegus*, *Rosa*, etc. bushes
Beregszász	48°11.2, 22°39.5	21 April – 30 October 2021	Bushy hillside along an edge of a vineyard
Darvas	47°7.6, 21°19.0	17 April – 20 October 2021	Margin of a mixed arboreal forest and maize field
Debrecen	47°31.6, 21°40.9	13 April – 15 October 2021	Mixed orchard on sandy soil in a suburban area
Halásztelek	47°21.4, 19°0.5	11 April – 26 October 2021	Mixed orchard on sandy soil
Jánkmajtis	47°55.7, 21°41.6	11 April – 15 October 2021	Margin of a young walnut plantation
Kápolnásnyék	47°10.9, 18°42.4	11 April – 26 October 2021	Hedge along maize field
Nyíregyháza	47°56.1, 21°49.0	11 April – 15 October 2021	Hedge along maize field
Pusztaszabolcs	47°8.8, 18°46.6	11 April – 26 October 2021	Hedge along rape field
Sóskút	47°25.4, 18°49.9	11 April – 26 October 2021	Bushy hillside with *Crataegus*, *Rosa*, etc. bushes

TABLE 2 Total numbers caught of three non-target noctuids sampled by traps lured with sex-pheromone of *Spodoptera frugiperda* by sampling sites

Test sites	*Cucullia umbratica*	*Agrotis bigramma*	*Allophyes oxyacanthae*
Beregszász	133	20	2
Beregszász - Ardó	129	25	28
Darvas	63	10	0
Debrecen	22	10	0
Halásztelek	201	9	0
Jánkmajtis	41	169	0
Kápolnásnyék	84	0	0
Nyíregyháza	156	0	0
Pusztaszabolcs	73	0	0
Sóskút	35	0	6
Total	937	243	36

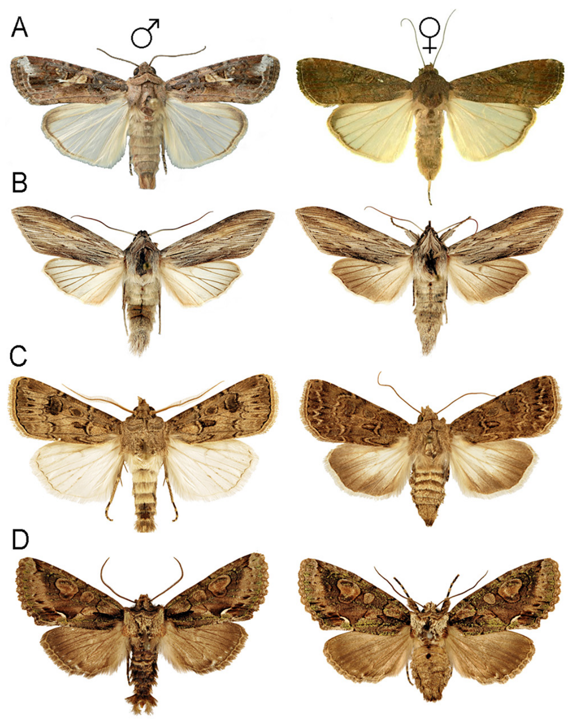

FIGURE 1 Males (left) and females (right) of (A) *Spodoptera frugiperda* and three non-target species attracted to traps baited with *S. frugiperda* sex-pheromone lures in the Carpathian Basin: (B) *Cucullia umbratica*; (C) *Agrotes bigramma*, and (D) *Allophyes oxyacanthae*. Photos by JL Capinera (*S. frugiperda* male: Lyle Buss, University of Florida, Bugwood.org; female: Robert J. Bauernfield, Kansas State University, Bugwood.org) and G Ronkay (other species)

characteristic for hillsides and lowland of the Carpathian Basin; however, it has not been considered as a pest species until now. *Agrotis bigramma* was found in six areas, from which it occurred with the highest abundancy on the border of Jánkmajtis, where traps were placed on the margin of a young walnut plantation with meadows with diverse herbaceous plants both in the orchard and its surroundings. The species swarms during August and September. Its adults differ from individuals of the target species by its more robust appearance and pectinated antennae. It should be noted, however, that more shabby males may be confused with females of the target species in some cases. However, as females of the target species do not respond to the pheromone trap, it should not cause false detection (Figure 1).

Agrotis bigramma has been reported to respond to traps baited with synthetic (*Z*)-9-dodecenyl acetate and Z7-12Ac (Szőcs et al., 1981, 1983), which is very similar to the composition of the FAW sex-pheromone lure.

Allophyes oxyacanthae was captured at only three of the sites, and in autumn only. It is known as a typical autumnal species, widely distributed in Europe with the exception of the Iberian Peninsula and southern Italy. In Asia Minor and the Caucasus it is replaced by a related species (Ronkay et al., 2001). *Allophyes oxyacanthae* is connected with shrubby vegetation, the larvae are feeding on Rosaceae species, such as *Cotoneaster*, *Crataegus*, *Prunus*, and *Pyrus* spp. The species was caught by traps placed especially on bushy hillsides. Farmers can easily distinguish both sexes from the target species by the presence of metallically shining scales and the complex forewing pattern, which FAW does not have (Figure 1).

Allophyes oxyacanthae has been reported to respond to traps baited with synthetic Z9-14Ac (Anonymous 1985, cited in El-Sayed 2022), which could explain its attraction to the *S. frugiperda* sex-pheromone lure.

The Carpathian Basin is out of the actual spreading routes of the invasive FAW, which matches the zero catches of our traps. However, the climatic models of various regions (Africa: Cokola et al., 2020; Central Asia: Baloch et al., 2020; China: Wang et al., 2020) predict rapid spread of the species into South and Central Europe as well, mainly through warmer lowland areas with intensive agriculture.

Among the three non-target noctuids caught in substantial numbers, only *A. bigramma* females can be confused with the target species, thus they are not likely to cause difficulties in the practical use of sex pheromone traps in the detection, monitoring, and following of the spread of FAW in Central Europe. Of course, for farmers inexperienced in moth taxonomy, identifying noctuid species may pose problems – especially of specimens that have spent days in the trap and whose morphology is damaged by bad weather conditions – so it is strongly suggested that a farmer who finds noctuid catches in his trap, should contact a plant protection expert or moth taxonomist for confirmation of the moth identity.

AUTHOR CONTRIBUTIONS

Szabolcs Szanyi: Conceptualization (equal); data curation (equal); investigation (lead); writing – original draft (equal); writing – review and editing (equal). **Antal Nagy:** Data curation (equal); investigation (equal); methodology

(equal); writing – original draft (equal); writing – review and editing (equal). **Zoltán Varga:** Writing – original draft (equal); writing – review and editing (equal). **Miklos Toth:** Conceptualization (equal); formal analysis (equal); methodology (equal).

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

Data available on request from the authors.

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