NON-TARGET LEPIDOPTERAN SPECIES IN PHEROMONE TRAPS BAITED WITH ATTRACTANTS FOR SEVERAL TORTRICID MOTHS

NICOLAI OLENICI[1], IOSIF CĂPUŞE, VALENTINA OLENICI[1], IOAN OPREAN[2], VASILE MIHALCIUC[3]

[1]Institutul de Cercetări şi Amenajări Silvice, Staţiunea Câmpulung Moldovenesc, România

[2]Institutul de Chimie „Raluca Ripan", Cluj-Napoca, România

[3] Institutul de Cercetări şi Amenajări Silvice, Staţiunea Braşov, România

Abstract

The aim of this paper is to present the non-target species caught in the traps baited with synthetic pheromones of the species *Cydia pomonella, Grapholita funebrana, Grapholita molesta, Archips podana, Adoxophyes orana, Tortrix viridana* and *Gravitarmata margarotana*, in the frame of some experiments conducted during the years 1989-1990 in order to identify sexual attractants for the main conophagous Lepidoptera in Romania. At the same time we assessed the selectivity of these products and identified the compounds which could be used as sexual attractants for different tortricid species.

Deploying pheromone traps in coniferous mature tree stands or seed orchards having in their neighbourhood fruit trees or deciduous forests, only 5 reference species and 30 non-target species have been caught , 23 of them being tortricid moths.

The selectivity (specificity) of the used synthetic pheromones was rather low. However, this should not be a problem in the current works accomplished with atraPOM, atraPOD, atraRET and atraVIR products, because the species attracted are quite easily distinguished using morphological characteristics. On the other hand, the people using atraFUN and atraMOL pheromones could have insurmountable difficulties to establish the abundance of target species and other aspects, because these pheromones attract moths of *G. funebrana, G. molesta* and *Grapholita tenebrosana* which have a very similar appearance. Consequently, the possibilities of pheromone specificity improvement are analyzed.

The mixture of Z9-12Ac + E11-14Ac + Z11-14Ac + n-12Ac + n-14Ac (5:2:3:3:1) attracted the species *Cnephasia alticolana, Pammene suspectana, Retinia perangustana, Retinia resinella* and *Enarmonia formosana*, while Z8-12Ac + E8-12Ac + 12OH (0.970:0.030:3 and 0.930:0.070:3 respectively) attracted moths belonging to *R. perangustana, Hedya dimidiana, Grapholita tenebrosana* and *Epiblema scutulana*. The males of *Eucosma campoliliana* and *Hedya salicella* responded to E8,E10-12OH and those of *C. alticolana* responded also to the blends Z11-14Ac + E11-14Ac (1:1) and Z9-14Ac + Z11-14Ac (6:4), but *Cnephasia stephensiana* was attracted by Z11-14Ac, like *Dichelia histrionana*. However, the last mentioned species is stronger attracted by the mixture of Z11-14Ac + Z9-12Ac (relative ratio 4:6).

Keywords: Lepidoptera, non-target species, sexual attractants, synthetic pheromones, pheromone selectivity, tortricids

Rezumat
SPECII DE LEPIDOPTERE "NON-ȚINTĂ" CAPTURATE ÎN CURSELE FEROMONALE AMORSATE CU ATRACTANȚI AI CÂTORVA TORTRICIDE

Scopul acestei lucări este de a prezenta care au fost speciile „non-țintă" capturate în cadrul unor experimente desfăşurate în perioada 1989-1990, experimente în care s-au folosit feromonii sintetici ai tortricidelor *Cydia pomonella, Grapholita funebrana, Grapholita molesta, Archips podana, Adoxophyes orana, Tortrix viridana* şi *Gravitarmata margarotana*, şi care au avut ca obiectiv identificarea unor atractanți sexuali pentru lepidopterele conofage importante din punct de vedere economic în Romania. Totodată s-a urmărit să se evalueze selectivitatea (specificitatea) feromonilor testați şi să se stabilească compuşii chimici sau amestecurile de compuşi care manifestă atractivitate față de diferite specii de tortricide. Dat fiind obiectivul principal al experimentelor, capcanele feromonale au fost instalate în arborete sau plantaje de răşinoase, care însă au avut în apropiere pomi fructiferi sau păduri de foioase. În aceste condiții, la cursele feromonale s-au capturat doar 5 din cele 7 specii ale căror feromoni sintetici s-au utilizat (consi-derate „specii țintă"), şi 30 de alte specii („non-țintă"), dintre care 23 specii de tortricide.

Selectivitatea feromonilor sintetici testați a fost, în cele mai multe situații, redusă. Totuşi, se consideră că aceasta nu este un impediment pentru utilizarea produselor atraPOM, atraPOD, atraRET şi atraVIR în lucrările curente din producție, deoarece speciile ce sunt atrase de aceste momeli pot fi diferențiate destul de uşor după caracteristicile morfologice. Probleme deosebite pot să apară însă în cazul utilizării produselor atraFUN şi atraMOL, care atrag trei specii diferite de *Grapholita* (*G. funebrana, G. molesta* şi *G. tenebrosana*) ce nu pot fi deosebite decât după armătura genitală. În consecință sunt analizate posibilitățile de sporire a specificității acestor feromoni sintetici.

Feromonul sintetic de *Gravitarmata margarotana*, conținând Z9-12Ac + E11-14Ac + Z11-14Ac + n-12Ac + n-14Ac (5:2:3:3:1) a funcționat ca atractant față de speciile: *Cnephasia alticolana, Pammene suspectana, Retinia perangustana, Retinia resinella* şi *Enarmonia formosana*, în timp ce amestecul Z8-12Ac + E8-12Ac + 12OH (0.970:0.030:3 şi respectiv 0.930:0.070:3) a atras masculii de *R. perangustana, Hedya dimidiana, G. tenebrosana* şi *Epiblema scutulana*. Speciile *Eucosma campoliliana* şi *Hedya salicella* sunt atrase de E8,E10-12OH, iar *Cnephasia alticolana* a răspuns şi la amestecurile Z11-14Ac + E11-14Ac (1:1) şi Z9-14Ac + Z11-14Ac (6:4). Compusul Z11-14Ac a atras şi masculii speciilor *Cnephasia stephensiana* şi *Dichelia histrionana*, dar această ultimă specie a fost mai puternic atrasă de combinația Z11-14Ac + Z9-12Ac (4:6).

Cuvinte cheie: atractanți sexuali, feromoni sintetici, lepidoptere, tortricide, selectivitate, specii non-țintă

1. INTRODUCTION

By the mid-1980s, some of the coniferous seed orchards established in Romania about 20 years earlier, especially those of European larch (*Larix decidua* Miller, 1768), had begun to produce cones. Although the seed orchards are located at long distances from the tree stands of the same species, gradually they were colonised by several cone and seed pests that built-up large populations. This situation requested undertaking of protective measures. Therefore, it was necessary - first of all - to identify which are the pests. In order to facilitate the detection of conophagous Lepidoptera, in 1988 we started the study of sexual attractants for the economical important species, mainly *Retinia perangustana* (Snellen, 1883) and *Cydia strobilella* (Linnaeus, 1758).

Because there was no information about sexual pheromone or attractants for *Retinia perangustana* at that time, and no possibility to identify the compounds of the

natural pheromone in our country, we have begun the research testing by screening the synthetic pheromones of several tortricid species, that were produced by the Chemistry Institute of Cluj-Napoca, Romania, and which are used by horticulturists for detection, forecasting and control warning of the main tortricid pests in the fruit tree orchards (Iacob, 1977a, b; Trandafirescu et al., 2004). At the same time we used a pheromone synthesized going-off from the information occurring in the literature (Löfstedt et al., 1986) concerning the compounds of *Gravitarmata margarotana* (Heinemann, 1863) pheromone.

Some of the species were caught predominantly at the traps having certain lures and we could infer which chemical compounds or blends are attractant for non-target species. Thus we established the directions for research development and finally identified a sexual attractant for *R. perangustana* (Olenici et al., 2002), but the data concerning the other species remained so far unpublished and not valorised in this sense, as well as regarding the selectivity of the synthetic pheromones employed by us, an aspect which is very important for the works that are currently conducted using these products, because not all moths are easily identifiable, especially when covered with glue. Consequently, the aim of this paper is to present the species caught in the traps baited with different synthetic pheromones, to assess the selectivity of such products and to identify the compounds which could be used as sexual attractants for different tortricid species.

2. MATERIALS AND METHODS

Because the objective of our experiments conducted during the years 1989-1990 was to identify sexual attractants for lepidopteran pests of cones, the experimental plots for pheromone traps setting up have been selected in coniferous mature tree stands or seed orchards of Norway spruce [*Picea abies* (L.) Karst, 1881], silver fir (*Abies alba* Miller, 1768), European larch (*L. decidua*), Scots pine (*Pinus sylvestris* Linnaeus, 1753) and black pine (Pinus nigra J.F. Arnold, 1785). For the designation of experimental plots we use the data valid at the time of experiment carrying out, because the present situation concerning the ownership is unclear for some of them.

For tests we used commercial dispensers containing synthetic pheromones of the following species: *Cydia pomonella* (Linnaeus, 1758) (atraPOM), *Grapholita funebrana* (Treitschke, 1835) (atraFUN), *Grapholita molesta* (Busck, 1916) (atraMOL), *Archips podana* (Scopoli, 1763) (atraPOD), *Adoxophyes orana* (Fischer v. Röslerstamm, 1834) = *reticulana* Hübner, 1818-19 (atraRET) and *Tortrix viridana* Linnaeus, 1758 (atraVIR), as well as an experimental blend for *G. margarotana*.

The compositions of synthetic pheromones, with the relative ratios of components, were as follows: atraPOM - E8,E10-12OH, atraFUN - Z8-12Ac + E8-12Ac + 12OH (0.970:0.030:3), atraMOL - Z8-12Ac + E8-12Ac + 12OH (0.930:0.070:3), atraPOD - Z11-14Ac + E11-14Ac (1:1), atraRET - Z9-14Ac + Z11-

14Ac (6:4), atraVIR - Z11-14Ac. The synthetic pheromone for *G. margarotana* contained Z9-12Ac + E11-14Ac + Z11-14Ac + n-12Ac + n-14Ac (5:2:3:3:1).

Montedison traps, with sticky inserts were used in the most cases. However, 1989 at Hemeiusi-Bacau and Paltinoasa „cylinder" traps, without glue, have been employed too. Other details concerning the experiment organization are given in the tables 1 and 2.

During 1989 season, the biological material was collected from traps twice a week in all experimental plots. In 1990 we applied the same program at Hemeiusi-Bacău, but in the other plots the insect collecting was less frequently, weekly at Braşov and every three weeks at Tomnatic.

The identification of species was done by Dr. Iosif Capuse, who worked in that time at the Museum of Natural History „Grigore Antipa" in Bucharest. In the presentation of species we have adopted the nomenclature of Fauna Europaea (Karsholt & Nieukerken, 2004), some names used in 1989-1991 being today only synonyms.

In assessing the selectivity of pheromone products that we used in the experiments, we took into account only the tortricid species, because those belonging to other families, represented by low numbers of insects, arrived very probably only by

Table 1. Details concerning the experiments conducted in 1989
Detalii referitoare la experimentele efectuate în 1989

No.	Experimental plot[1]	Pheromone dispensers	Number of replications	Type of trap	Height of trap from the ground (m)	Experimentation period
1.	I.C.A.S., Tomnatic, VI Tomnatic, 43E (mature stands of spruce European larch and Scots pine)	atraFUN	3	Montedison	1.5-2.0	18 May - 29 August
		atraPOD	3			
		atraPOM	3			
		atraRET	3			
		atraVIR	3			
		control	3			
2.	Suceava, Gura Humorului V Paltinoasa, seed orchards of European larch, Norway spruce and black pine	atraFUN	3	cylinder	1.5-2.0	24 May - 27 July
		atraPOD	3			
		atraPOM	3			
		atraRET	3			
		atraVIR	3			
		Grav[2]	6	Montedison	1.5-2.0	5 June - 27 July
		control	3			
3.	Suceava, Gura Humorului, V Paltinoasa, 8A[3]	Grav[2]	12	Montedison	1.5-2.0	24 May - 29 August
		control	3			
4.	I.C.A.S. Hemeiuşi-Bacau, European larch seed orchard	Grav[2]	10	Montedison	1.5-2.0	5 May
			5	cylinder		26 May
5.	Brasov, Brasov, III Piatra Mare, 156 A (mature stands of spruce and silver-fir)	Grav[2]	4	Montedison	8-18	1 June – 16 August
		atraFUN	3		1.5-2.0	
		atraPOD	3			
		atraPOM	3			
		atraRET	3			
		atraVIR	3			

Notes: 1) Data refers to: forest direction (at county level), forest district, production unit and tree stand number; 2) Pheromone of *Gravitarmata margarotana;* 3) Mature stands of spruce and silver-fir.

Table 2. Details concerning the experiments conducted in 1990
Detalii referitoare la experimentele efectuate în 1990

No.	Experimental plot[1]	Pheromone dispensers	Number of replications	Type of trap	Height of trap from the ground (m)	Experimentation period
1.	I.C.A.S., Tomnatic, Tomnatic, 44B, 57A (mature stands of spruce and silver-fir)	Grav[2]	3	Montedison	15-25	12.04-24.05
		atraFUN	3			
		atraPOD	3			
		atraMOL	3			
		atraVIR	3			
		martor	3			
2.	I.C.A.S. Hemeiusi-Bacau, European larch seed orchard	Grav[2]	3	Montedison	4-6	15.05-5.07
		atraFUN	3			
		atraPOD	3			
		atraMOL	3			
		atraVIR	3			
		martor	3			
3.	Brasov, Brasov, III Piatra Mare, 156 A (mature stands of spruce and silver-fir)	atraFUN	3	Montedison	10-15	17.05-01.08
		atraPOD	3			
		atraMOL	3			
		atraVIR	3			
		martor	3			

Notes: 1) Data refers to: forest direction (at county level), forest district, production unit and tree stand number.
2) Pheromone of *Gravitarmata margarotana.*

chance in the traps. In addition, we analysed only the cases with at least 5 moths caught per pheromone treatment.

The appraisal of insect's response to different pheromones was conducted only for the species represented by at least 20 individuals.

3. RESULTS

3.1. Non-target lepidopteran species caught in pheromone traps

In 1989, using 91 traps, we collected a total of 802 lepidopteran individuals, from which 730 have been identified at the species level. There were 18 species from 5 families (Table 3), most of them (98.8 %) being tortricids. Only two tortricid species were „target species", *A. podana* and *C. pomonella* respectively. Together they were represented only by 35 individuals, namely 4.9 % of the total number of identified tortricids.

Non-target tortricid species were present in very different proportions. The most identified individuals (472, namely 65.5 %) belonged to the species *Cnephasia alticolana* (Herrich-Schäffer, 1851), which was collected within all the 5 experimental plots, but which was caught regularily only at Hemeiuşi-Bacău and Braşov. The following three species in decreasing order of their abundances were: *Dichelia histrionana* (Frölich, 1828) = *Parasyndemis histrionana* (Frölich, 1828) – 79 individuals (11.0 %) and *Epiblema scutulana* (Denis & Schiffermüller, 1775) – 48 individuals (6.7 %), both

caught at Tomnatic, as well as *Eucosma campoliliana* (Denis & Schiffermüller, 1775) - 44 individuals (6.1 %), exclusively caught at Braşov.

The other tortricid species were: *Cnephasia asseclana* (Denis & Schiffermüller, 1775) (= *interjectana* Havorth [1811] = *virgaureana* Treitschke, 1835), *Cydia coniferana* (Saxesen, 1840), *Cydia pactolana* (Zeller, 1840), *Dichrorampha incursana* (Herrich-Schäffer, 1851), *Enarmonia formosana* (Scopoli, 1763), *Grapholita tenebrosana* Duponchel, 1843, *Hedya salicella* (Linnaeus, 1758) and *Rhyacionia pinivorana* (Lienig & Zeller, 1846), all of them represented by a very low number of individuals.

In 1990 there were caught 2998 lepidopteran specimens from 11 families (Table 4), and the most captures (2925 individuals, 97.6 %) were tortricids belonging to 21 species, 7 more species than in 1989. During 1990 season, 4 of 5 target species were collected, namely *A. podana, G. funebrana, G. molesta* and *T. viridana.* The first of these species was present only by 3 individuals, and the last one by 29, all of them from Hemeiuşi-Bacău, where the experimental plot was in the neighbourhood of some European oak trees. The other two species were represented by 129 and 128 individuals respectively, *G. funebrana* being detected in mature tree stands of spruce and silver fir at Tomnatic and Braşov experimental plots, while *G. molesta* was collected in the European larch seed orchard at Hemeiuşi-Bacău. The individuals belonging to the 4 target species totalized only 9.9 % of the caught tortricids, while the most abundant 5 non-target species cumulated 83.9 %. Those non-target species were: *D. histrionana* – with 656 individuals (22.4 %), *C. alticolana* – with 606 individuals (20.7 %), *G. tenebrosana* – with 561 individuals (19.2 %), *Retinia perangustana* – with 358 individuals (12.2 %) and *Pammene suspectana* (Lienig & Zeller, 1846) – with 273 individuals (9.3 %). Moderate numbers of individuals (21-47) were registered for five of non-target species, as follows: *E. scutulana, Hedya dimidiana* (Clerck, 1759), *C. pactolana, Retinia resinella* (Linnaeus, 1758) and *Cnephasia stephensiana* (Doubleday, 1849).

Totally sporadic (1-13 insects) appeared 7 tortricid species, most of them unnoticed in 1989. These were: *Archips betulana* (Hübner, 1787), *Cydia illutana* (Herrich-Schäffer, 1851), *Hedya pruniana* (Hübner, 1799), *Olindia schumacherana* (Fabricius, 1787), *Pammene aurita* Razowski, 1991 (= *aurantiana* Staudinger, 1871) and *Pammene gallicolana* (Lienig & Zeller, 1846).

3.2. Selectivity of pheromone products

In 1989, atraPOD pheromone was the variant with the best selectivity. *A. podana* moths represented 87 % and 100 % from the total captures registered at that pheromone variant within the experimental plots Tomnatic and Hemeiuşi-Bacău respectively. However, the situation was totally different at Braşov, where the traps baited with the same pheromone caught only *C. alticolana* insects. AtraPOM, which had a much lower selectivity, achieved the best results (35.3 %) also in the Tomnatic experimental plot, while atraFUN at Braşov, where *Grapholita* individuals represented

Table 3. Lepidoptera caught in pheromone traps during the season 1989
Lepidoptere capturate la cursele feromonale în cursul anului 1989

No	Taxon	Number of insects caught at the variant[1]:							Total
		V_1	V_2	V_3	V_4	V_5	V_6	V_7	
	Experimental plot Tomnatic, VI, 43 E								
	Tortricidae								
1.	*Archips podana*		-	20	-	-	-	-	20
2.	*Cnephasia alticolana*		1	-	-	-	-	2	3
3.	*Cydia coniferana*		-	-	1	-	-	-	1
4.	*Cydia pomonella*		-	-	6	-	-	-	6
5.	*Dichelia histrionana*		-	1	-	52	23	1	77
6.	*Epiblema scutulana*		45	-	3	-	-	-	48
7.	*Grapholita tenebrosana*		1	-	-	-	-	-	1
8.	*Hedya salicella*		1	-	7	-	-	-	8
9.	*Rhyacionia pinivorana*		-	2	-	-	-	-	2
	Total		**48**	**23**	**17**	**52**	**23**	**3**	**166**
	Gelechiidae								
10.	*Acompsia cinerella*		-	1	-	-	-	-	2
	Lasiocampidae								
11.	*Selenophora lunigera*		1	-	-	-	-	-	2
	Noctuidae								
12.	*Mamestra pisi*		-	-	-	4	-	-	4
	Experimental plot Gura Humorului, V, seed orchards								
	Tortricidae								
1.	*Archips podana*	-	-	7	-	1	-	-	8
2.	*Cnephasia alticolana*	7	2	-	-	-	-	1	10
3.	*Cnephasia asseclana*	-	-	-	-	-	-	2	2
4.	*Cydia pactolana*	2	-	-	-	-	-	3	5
4.	*Cydia pomonella*	-	-	-	1	-	-	-	1
5.	*Dichrorampha incursana*	1	-	-	-	-	-	-	1
6.	*Dichelia histrionana*	-	-	-	-	-	-	2	2
7.	*Enarmonia formosana*	7	-	-	-	-	-	-	7
	Total	**17**	**2**	**7**	**1**	**1**	**-**	**8**	**36**
	Cymotophoridae								
8.	*Thyatira batis*	1	-	-	-	-	-	-	1
	Experimental plot Gura Humorului, V, 8A								
	Tortricidae								
1.	*Cnephasia alticolana*	1						-	1
2.	*Dichrorampha incursana*	2						-	2
3.	*Enarmonia formosana*	11						-	11
	Total	**14**						**-**	**14**
	Experimental plot Hemeiusi-Bacau – European larch seed orchard								
	Tortricidae								
1.	*Cnephasia alticolana*	131							131
	Experimental plot Brasov, III, 156A								
	Tortricidae								
1.	*Cnephasia alticolana*	98	7	129	-	96	-		330
2.	*Cydia* sp.	31	1	-	2	1	-		35
3.	*Grapholita* sp.	-	37	-	-	-	-		37
4.	*Eucosma campoliliana*	-	-	-	44	-	-		44
	Total	**129**	**45**	**129**	**46**	**97**	**-**		**446**

Note: 1) V_1 - pheromone of *G. margarotana,* V_2 - atraFUN, V_3 - atraPOD, V_4 - atraPOM, V_5 - atraRET, V_6- atra, VIR, V_7 - control.

Table 4. Lepidoptera caught in pheromone traps during the season 1990
Lepidoptere capturate la cursele feromonale în cursul anului 1990

Taxon	Number of insects caught at the variant[1]:						Total
	V_1	V_2	V_3	V_4	V_5	V_6	
Experimental plot Tomnatic, VI, 44B, 57A							
Tortricidae							
Archips podana	-	-	2	-	-	-	2
Cnephasia alticolana	576	8	-	-	-	-	584
Cydia illutana	-	3	-	-	-	-	3
Cydia pactolana	16	-	-	-	1	11	28
Dichelia histrionana	-	7	-	-	291	-	298
Epiblema scutulana	5	14	-	-	-	-	19
Grapholita funebrana	1	21	-	53	-	-	75
Grapholita tenebrosana	-	5	3	62	-	-	70
Hedya dimidiana	-	-	-	-	-	4	4
Retinia resinella	22	-	-	-	-	-	22
Total	**620**	**58**	**5**	**115**	**292**	**15**	**1105**
Arctiidae							
Atolmis rubricolliso	-	-	1	-	19	-	20
Ethmiidae							
Ethmia funerella	-	-	3	5	-	-	8
Geometridae							
Unidentified species	-	2	-	-	1	1	4
Experimental plot Hemeiusi-Bacau – European larch seed orchard							
Tortricidae							
Cnephasia alticolana	10	-	4	6	-	-	20
Cnephasia asseclana	2	10	-	-	1	-	13
Epiblema scutulana	3	21	-	4	-	-	28
Grapholita molestao	20	63	-	41	-	4	128
Grapholita tenebrosana	37	223	2	138	-	-	400
Hedya dimidiana	-	16	-	13	-	-	29
Hedya pruniana	-	1	-	-	-	-	1
Pammene aurita	-	-	-	-	2	-	2
Pammene gallicolana	-	1	1	3	-	-	5
Pammene suspectana	144	58	2	21	15	33	273
Retinia perangustana	89	93	30	121	16	9	358
Tortrix viridana	-	1	-	-	28	-	29
Total	**305**	**487**	**39**	**347**	**62**	**46**	**1286**
Gelechiidae							
Acompsia cinerella	-	-	4	-	-	-	4
Unidentified species	-	-	1	-	-	1	2
Experimental plot Brasov, III, 156A							
Familia Tortricidae							
Archips betulana		-	1	-	-	-	1
Archips podana		-	1	-	-	-	1
Cnephasia alticolana		-	1	1	-	-	2
Cnephasia stephensiana		-	-	3	18	-	21
Dichelia histrionana		5	2	11	339	1	358
Grapholita funebrana		24	1	29	-	-	54
Grapholita tenebrosana		47	3	37	4	-	91
Olindia schumacherana		-	-	1	-	-	1
Pammene aurita		-	1	2	2	-	5
Total		**76**	**10**	**84**	**363**	**1**	**534**

Table 4. (continue)

Taxon	Number of insects caught at the variant[1]:						Total
	V_1	V_2	V_3	V_4	V_5	V_6	
Gelechiidae		-	-	10	-	-	10
Geometridae		1	2	3	2	-	8
Noctuidae		1	-	-	-	-	1
Oecophoridae		-	-	1	-	-	1
Cymotophoridae							
Thyatira batis		-	-	-	1	-	1
Zygaenidae		-	4	-	-	-	4
Yponomeutidae							
Yponomeuta padellus		-	-	-	1	-	1
Unidentified species		2	4	-	1	-	7

Note: V_1 - pheromone of *G. margarotana*, V_2 - atraFUN, V_3 - atraPOD, V_4 - atraMOL, V_5 - atraVIR, V_6- control

82.2 % of total captures, but it was not possible to identify how many insect were of *G. funebrana*.

In 1990, the best selectivity had the pheromone atraVIR in the experimental plot Hemeiuşi-Bacău (45.2 %), atraPOD at Tomnatic (40.0 %) and atraFUN at Braşov (31.6 %) and Tomnatic (36.2 %).

3.3. Response of not-target species to synthetic attractants

The adults of *C. alticolana* were caught in 1989 in traps baited with pheromone of *G. margarotana*, with atraPOD and with atraRET in the proportion of 50.2 %, 27.3 % and 20.3 % respectively, but not all pheromone variants were present in each - experimental plot, at Hemeiuşi-Bacău (where 131 individuals have been caught) being used only the pheromone of *G. margarotana*. At Braşov, out of 330 specimens, 129 (39.1 %) were collected in traps with atraPOD, 98 (29.7 %) in those with *G. margarotana* pheromone and 96 (29.1 %) in those with atraRET. All these synthetic pheromones have a common chemical compound: Z11-14Ac, which seems to be -attractant for this species, while admixture of Z9-12Ac or Z9-14Ac seems to diminish the attractiveness. However, 1990 when atraRET variant wasn't used, the situation appeared totally different, 93.4 % of captures being in traps with pheromone of *G. margarotana* and only 0.8 % in those with atraPOD. That means the males of this species are attracted much stronger by the pheromone of *G. margarotana* than by the other two pheromones, and the results obtained in 1989 at Braşov could be influenced by the different height of the traps, as noted for example in *G. molesta* (Rothschild & Minks, 1977), *C. pomonella* (Ahmad & Al-Gharbawi, 1986; Weissling & Knight, 1995), *Endopiza viteana* (Botero-Garcés & Isaacs, 2003), T*haumetopoea processionea* (Breuer et al., 2003).

In 1989, *D. histrionana* was caught mainly in pheromone traps baited with atraRET (65.8 % of captures) and atraVIR (29.1 %). In 1990, the atraRET pheromone

was not tested and 96.0 % of captures were recorded in the traps baited with atraVIR, an indication that the males of *D. histrionana* are attracted by Z11-14Ac, the only compound of atraVIR pheromone.

E. scutulana was found, during the both research years, predominantly in the traps baited with atraFUN (93.8 % in 1989 and 74.5 % in 1990).

The males of *E. campoliliana* were collected only in 1989 and exclusively in pheromone traps with atraPOM baits, which contain the compound E8E10-12OH. *G. tenebrosana* moths were attracted almost equally of both synthetic pheromones of congeneric species (49 % of captures at atraFUN and 42.2 % at atraMOL). These products have a very similar composition, namely Z8-12Ac, E8-12Ac and 12OH in slightly different proportions.

A proportion of 52.7 % of all *P. suspectana* specimens was collected with traps having as lure the pheromone of *G. margarotana*, while 21.2 % of captures were in the traps baited with atraFUN, implying that males of this species respond to compounds from those products.

Out of 33 *H. dimidiana* specimens, 16 (48.5 %) were captured in traps baited with atraFUN and 13 (39.4 %) in those with atraMOL, denoting that the mixture of Z8-12Ac, E8-12Ac and 12OH attracts the males of this species.

A less abundant species, *R. resinella,* represented by only 22 captures, was attracted exclusively by the *G. margarotana* pheromone. *C. stephensiana* was also a less abundant species, with only 21 specimens, out of which 85.7 % in pheromone traps baited with atraVIR, containing Z11–14Ac and only 14.3 % in the traps with atraMOL (Z8-12Ac, E8-12Ac and 12OH).

4. DISCUSSION

4.1. Not-target lepidopteran species in pheromone traps

The reference (or target) species, whose pheromones we used, occur especially in fruit orchards or in other places where their cultivated or wild host-plants are growing (Sciarretta et al., 2001; Trematerra & Sciarretta, 2005; Sciarretta & Trematerra, 2006), excepting *G. margarotana* and *T. viridana*, which live in woodland with pine and oak trees respectively. Using their synthetic pheromones in coniferous forest ecosystems, having in the neighbourhood fruit trees or deciduous forests, there have been caught only 5 reference species and 30 non-target species. No specimen of *G. margarotana* and *A. orana* was caught, although these species were previously collected in Moldavia, Transylvania and other historical provinces of Romania (Rakosy et al., 2003).

According to expectation, the most non-target species (23, 76.7 %) were tortricid moths, 17 of the Olethreutinae subfamily and 6 of the Tortricinae subfamily, 10 of them being only sporadically caught, so we can not consider that they were attracted by pheromones. These species are: *C. coniferana, C. illutana, D. incursana,*

Table 5. Overview concerning the attractiveness of pheromone products on different moth species
Situația generală privind atractivitatea produselor feromonale testate față de diferite specii

Taxon	Presence of the species in the traps baited with:						
	Gravitar-mata	atra FUN	atra MOL	atra POM	Atra POD	atra RET	atra VIR
Family Tortricidae							
Subfamily Olethreutinae							
Archipsoohdani oi p				x			
Archiph(Celi oi		x					
Archipt i sloC oi	**x**						x
Archipt oy ooaCC p				**X**			
u hsDnoni y t Di hosenEi oi p	x						
boi ny ooh i dony oEi oi p	**X**						
b t hm(dy i Es eleC oi p	x	**X**	x	x			
b esoEy i psi y t o(Ki oi				**X**			
Gni t Do(li pteoamni oi	x	**X**	**X**		x		
Gni t Do(li py o(aEli	x	**X**	**X**				
Gni t Do(li plaoamnoEi oi pp	x	**X**	**X**		x		x
f acri pc hy hchi oi p		**X**	**X**				
f acri pt neoh i oi		x					
f acri Ei (lsaCC p		x		**X**			
Hi y y aoa i enhli			x		x		x
Hi y y aoapRi (Clso C oi		x	x		x		
Hi y y aoapEeEi as li oi	**X**	x	x		x		x
Palhoh i pt ani oReEli oi	**X**	**X**	**X**		x		x
Palhoh i pnaEhoaCC	**X**						
PDri shoo h i pt hohgoni oi					x		
Subfamily Tortricinae							
TnsDht Epmale C oi					x		
TnsDht Epi oci oi p					**X**	x	
Aoat Di Ehi pi (hso C oi	**X**	x	x		**X**	**X**	
Aoat Di Ehi pi EEas C oi	x	x					x
Aoat Di Ehi pElat DuoEhi oi			x				**X**
u hsDu(i DhElnhooi oi		x	x		x	**X**	**X**
x (oochi pEs Dey i s Dani oi p			x				
pyonlnh(pghnhci oi		x					**X**
Total species	12	15	13	5	11	3	9

Note: x – simple presence of some individuals; X – presumed attractiveness.

H. pruniana, P. aurita, P. gallicolana, R. pinivorana, A. betulana, C. asseclana, O. schumacherana. The other non-target tortricid species were attracted by one or more synthetic pheromones, and as a general rule, by attractants of target species belonging to the same subfamily. The only exception was *C. alticolana*, which was also attracted by the pheromone of *G. margarotana*.

The specimens belonging to the other families were also in very low number, so it is nothing showing a pheromone attraction for these species, although the 19 out of 20 specimens of *Atolmis rubricollis*, which were exclusively caught in the traps baited with atraVIR, could suggest the reverse.

4.2. Selectivity of synthetic pheromones

There was no specimen of *G. margarotana* and A. orana, and consequently we can not speak of any selectivity regarding these synthetic pheromones. The others had a very variable selectivity, and mostly a scanty one, depending on the abundance of target species populations in different experimental areas, but also by the abundance of other species which were attracted by tested chemical compounds.

Because the species attracted in traps baited with atraPOM, atraPOD, atraRET and atraVIR can be quite easily distinguished using morphological characteristics, the low selectivity (specificity) of these pheromones should not be a problem in the current works accomplished with such products, but the situation is quite different in the case of atraFUN and atraMOL pheromones, which have a very similar composition and both attract not only moths of *G. molesta* and *G. funebrana*, but also those of *G. tenebrosana*. All these three species have a very similar appearance (Meijerman & Ulenberg, 2004), and it is practically impossible to distinguish them without analyzing the genitalia (Hrdý et al., 1996; Rauleder, 2002), a requisite that is not feasible in the current works done by practitioners. Consequently, the simultaneous presence of the three species could result in unreliable data concerning the abundance of plum fruit moth or oriental fruit moth in the orchards when using the above mentioned products.

Testing the synthetic pheromone Atramol in different habitats in Hungary, Sziráki (1978a) found that target species represented over 60 % of the captures only after mid-September and the most frequent non-target species was *G. funebrana*. The reciprocal attractiveness of the pheromone for *G. funebrana* and *G. molesta* was mentioned also by Ostrauskas (1999, 2001) and Hrudová (2003), although the blend compositions were different of those used by us, namely Z8-12Ac + E8-12Ac + Z8-14Ac + 14Ac for the first species and Z8-12Ac + E8-12Ac + Z8-12OH for the second one.

The selectivity of atraFUN and atraMOL pheromones could be improved taking into account the compositions of the natural pheromones of *G. funebrana* and *G. molesta*, which are quite different. According to Guerin et al. (1986), the natural pheromone of *G. funebrana* contains Z8-12Ac, E8-12Ac, Z8-14Ac, Z10-14Ac, Z8-12OH in the proportions 100:1:30:5:2. In the field test, a mixture of Z8-12Ac and E8-12Ac (100:4) had the best attractiveness for *G. funebrana* and slightly attracted *G. molesta* too. The addition of the three tetradecenyl acetates, in the same proportions as found in the natural pheromone, induced no increase of G. funebrana captures, but inhibited the response of *G. molesta* and improved the selectivity of the pheromone, while the addition of Z8-12OH reduced by two thirds the attraction for *G. funebrana* and enhanced that for *G. molesta*, the two species being equally caught. This result is understandable if we take into account that the natural pheromone of the oriental fruit moth contains Z8-12Ac, E8-12Ac, Z8-12OH and 12OH in the proportions 100:7:30:6 (Cardé et al., 1979). Because both pheromones, atraFUN and atraMOL, contain three

of these compounds (Z8-12Ac, E8-12Ac and 12OH), it seems that they are rather optimized for attracting of oriental moth, but Baker & Carde (1979) and Linn et al. (1986) suggest that 12OH has a synergistic effect only when the blends contain reduced amounts of Z8-12OH, which is lacking in the above mentioned products. Moreover, according to Han et al. (2001), dodecanol showed in the field experiments no significant behavioural activities, and the most effective blend for male attraction in *G. molesta* was Z8-12Ac + E8-12Ac + Z8-12OH in the proportions 95:5:1. Similar results concerning the optimum blend for this species were reported by Lee et al. (2002), Yang et al. (2002) and Boo & Park (2005). The high specificity of this blend seems to be emphasized by the absence of other *Grapholita* species (known in Korea) in the pheromone-baited traps (Han et al., 2001), although Z8-12Ac and E8-12Ac are major pheromone components of many other *Grapholita* species (Roelofs & Brown, 1982; El-Sayed, 2006). However, it should be tested in Europe to prove the specificity of the blend for *G. molesta,* because in pheromone traps baited with a quite similar blend (Z8-12Ac + E8-12Ac + Z8-12OH in the proportions 100:8:3) *G. funebrana* moths represented up to 37 % of *Grapholita captures* (T?th et al., 1991). This proportion decreased to 8 % when the above mentioned blend contained Z6-12Ac (relative ration between Z8-12Ac and Z6-12Ac 100:1) too (T?th et al., 1991). In any case, Rauleder (2002) using plum fruit pheromone traps, reported a proportion of *G. funebrana* moths between 89.2 % and 100 % of total captures, which means a very high selectivity of the synthetic pheromone (of unstated composition).

4.3. Response of not-target species to synthetic attractants

For many species that were attracted by the synthetic pheromones used in our experiments, there had been already identified one or more compounds acting as attractants and details can be found in the Database of Insect Pheromones and Semiochemicals (El-Sayed, 2006). Our results confirm those of Priesner et al. (1980), who reported that *D. histrionana* males are attracted by Z11-14Ac, but not those of Frérot et al. (1979), who found that the mixture of Z11-14Ac and E11-14Ac is an attractant for this species, while in our experiments only a few individuals have been caught in the traps baited with atraPOD. Instead, the males were stronger attracted by the mixture of Z11-14Ac and Z9-12Ac (relative ration 4:6), that was not mentioned as an attractant of this species so far.

The males of *E. scutulana* were attracted by the mixture of Z8-12Ac, E8-12Ac and 12OH. The first chemical compound was mentioned as attractant for this species by Chambon & d'Aguilar (1974), Sziráki (1978a), Rotundo & Giacometti (1985) and Tóth et al. (1992), while Hrdý et al. (1979) mentioned a mixture of Z8-12Ac, E8-12Ac and 12Ac.

E. campoliliana males responded only to the compound E8E10-12OH, mentioned as attractant for this species by Chambon & d'Aguilar (1974) and Fassotte (in Arn et al., 1992).

Rose-hip tortricid moths were attracted by synthetic pheromones having in

their composition Z8-12Ac, E8-12Ac and 12OH. The first compound is mentioned as attractant for *G. tenebrosana* by Chambon & d'Aguilar (1974), Sziráki (1978a) and Witzgall et al. (1996), while Alford (1978) and Hrdý et al. (1979) reported that the mixture of Z8-12Ac and E8-12Ac acted as attractant for this species.

The captures of *P. suspectana* from the traps baited with atraFUN and atraMOL confirm that males of this species are also attracted by Z8-12Ac (Sziráki, 1978b) and by the mixture of Z8-12Ac, E8-12Ac and 12OH (Hrdý et al., 1979). However, our results sugest that the species responds stronger to the pheromone of *G. margarotana*, that was not mentioned so far as attractant for it.

The blends containing Z8-12Ac, E8-12Ac and 12OH attracted also males of *H. dimidiana,* although the literature indicates other compounds as attractants for this species, namely E8E10-12Ac (Ando et al., 1987) and the mixture of E8E10-12Ac and Z8Z10-12Ac (Witzgall et al., 1996).

Because *R. resinella* was exclusively attracted by the *G. margarotana* pheromone, we suppose that Z9-12Ac acted as attractant, this compound being present also in the mixture mentioned by Booij & Voerman (1984) as an attractant for this species (Z9-12Ac and delta9-12Ac, ratio 1:1).

C. stephensiana was attracted especially to Z11–14Ac, although the most bibliographical references (Beauvais et al, 1977; Alford, 1978; Hrdý et al., 1979; Witzgall et al., 1996) indicate Z8-12Ac, alone or together with E8-12Ac, as an attractant of this moth.

Similarly, *C. alticolana* seems to be attracted to Z11-14Ac, a chemical compound common for all synthetic pheromones in traps that caught this species (pheromone of *G. margarotana,* atraPOD and atraRET). The database of insect pheromones and semiochemicals (El-Sayed, 2006) contains no information concerning this species.

5. CONCLUSIONS

Deploying pheromone traps, baited with specific attractants for *C. pomonella, G. funebrana, G. molesta, A. podana, T. viridana, A. orana* and *G. margarotana*, in coniferous mature tree stands or seed orchards having in their neighbourhood fruit trees or deciduous forests, there have been caught only first 5 reference species and 30 non-target species, 23 of them being tortricid moths. The most species were caught in the traps baited with pheromone blends for *Grapholita* (15 and 13 respectively), *G. margarotana* (12), *A. podana* (11) and *Totrix viridana* (9), while the traps with atraPOM and atraRET caught only 5 and 3 species respectively.

The selectivity (specificity) of synthetic pheromones used was ruther low, but this situation should not be a problem in the current works accomplished with atraPOM, atraPOD, atraRET and atraVIR products, because the species attracted by these pheromones are quite easily distinguished using morphological characteristics. On the other hand, the people using atraFUN and atraMOL pheromones could have

insurmountable difficulties to establish the abundance of target species (*G. funebrana* and *G. molesta*, respectively), when the two species coexist or *G. tenebrosana* occurs in the same habitat, because of low pheromone specificity and of very similar appearance of these species.

The synthetic pheromone of pine twig moth containing Z9-12Ac + E11-14Ac + Z11-14Ac + n-12Ac + n-14Ac (5:2:3:3:1) displayed an obvious attractiveness for the following tortricid species: *C. alticolana, P. suspectana, R. perangustana, R. resinella and E. formosana.*

The mixtures of Z8-12Ac, E8-12Ac and 12OH (0.970:0.030:3 and 0.930:0.070:3 respectively) attracted moths belonging to: *R. perangustana, H.-dimidiana, G. tenebrosana and E. scutulana*, while E8E10-12OH attracted *E. -campoliliana* and *H. salicella*.

C. alticolana responded also to the blends Z11-14Ac + E11-14Ac (1:1) and Z9-14Ac + Z11-14Ac (6:4), but *C. stephensiana* is attracted by Z11-14Ac, which seems to be attractant for *D. histrionana* too. However, the last mentioned species is stronger attracted by the mixture of Z11-14Ac and Z9-12Ac (relative ration 4:6).

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Corespondence to/Corespondenţă: Nicolai Olenici: olenici.nicolae@icassv.ro