Union Internationale des Sciences Biologiques

ORGANISATION INTERNATIONALE DE LUTTE BIOLOGIQUE ET INTEGREE CONTRE LES ANIMAUX ET LES PLANTES NUISIBLES

SECTION REGIONALE OUEST PALEARCTIQUE

ISBN 92 9067 020 7

WORKING GROUP "USE OF PHEROMONES AND OTHER SEMIOCHEMICALS IN INTEGRATED CONTROL"

GROUPE DE TRAVAIL "UTILISATION DES PHEROMONES ET AUTRES MEDIATEURS CHIMIQUES EN LUTTE INTEGREE"

PROCEEDINGS / COMPTE-RENDU

AVIGNON (FRANCE) 20 - 22.09.88

EDITED BY
EDITE PAR
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WPRS BULLETIN
BULLETIN SROP

1989 / XII / 2

International Union of Biological Sciences

INTERNATIONAL ORGANIZATION FOR BIOLOGICAL AND INTEGRATED CONTROL OF NOXIOUS ANIMALS AND PLANTS

WEST PALAEARCTIC REGIONAL SECTION

IOBC WPRS OILB SROP

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INTRODUCTION

ARABLE AND VEGETABLE CROPS

ORCHARDS AND VINEYARDS

INTRODUCTION

Use of attractant chemicals for insect monitoring and detection: An exercise in intraspecific communication

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Insects may have it easier than people: their language seems complex, but it is precise and understood by all concerned. Furthermore, insects possibly produce and also utilize less information than we do, so it may be simpler for them to tell the signal from the noise. At earlier meetings of the "Working Group: Use of Pheromones and Other Semiochemicals in Integrated Control" of IOBC-WPRS, we heard about interesting applications of pheromones for monitoring, but it seemed that the right people were not always there to listen. We felt, for example, that the orchard entomologists who are using traps extensively should all have been informed about the English forecasting system for the pea moth based on pheromone traps. At a joint meeting with the EPRS Working Group in Balatonalmádi, we therefore decided to devote one meeting in the future to the detection and monitoring with attractant chemicals across all agricultural crops.

We could not begin to organize such a symposium without a prior knowledge of the existing activities around Europe, and in order to collect more information we carried out a survey. A panel under the chairmanship of Clive Wall and composed of Hermann Bogenschütz, Pierre Charmillot, Jost Freuler, Albert Minks, Augustin Schmid, Theo Wildbolz and myself met at the Changins Federal Research Station in 1986 to work out the questionnaires. Roland Bues joined a year later to help evaluate the answers. During these meetings it became increasingly clear how difficult it can be, for people in a multilingual society, to make sure they talk about the same thing.

The Avignon meeting gave us another opportunity to talk about terminology, first in English and French, later in German. English turned out to provide the most concise and precise definitions; the other languages sometimes didn't have a one word term or descriptions with combinations of words were not always satisfactory: see e.g. the French version for "survey". Participants of the *ad hoc* discussion group which gathered after Wednesday's papers felt that even though it was difficult to find the perfect equivalent in each case, terms such as "monitoring" in English and "surveillance" in French were flexible enough to be mutually accepted as synonyms. An agreement could not always be reached: The two different french versions for "timing" were proposed and vigorously defended by scientists from the same town! It was interesting to note that in different languages, terms with the same roots can have different meanings like in "survey" and "surveillance"; For the same reason we dropped "contrôle" in French (in the sense of "inspection") to avoid confusion with the meaning of the English word "control".

The purpose of scientific meetings is to establish contacts between people with common interests. Let's hope that the dictionary given below facilitates communication; most likely it will give also rise to further debates.

Dictionary of terms used in insect monitoring and detection

Detection	Détection	Nachweis
Survey	Répartition géographique	Erhebung
Monitoring	Surveillance	Überwachung
Forecasting	Prévision	Prognose
Timing - of sampling - of treatments	Positionnement - des échantillonnages - des traitements ou bien: Calendrier prévisionnel Calendrier d'intervention	Bestimmung des Zeitpunkts für - Stichprobenahmen / Probesuchen - Behandlungen
Risk assessment	Estimation des risques	Beurteilung des Risikos
⇨ **Early warning**	⇨ **Avertissement**	⇨ **Frühwarnung**

Survey on the Use of Attractant Chemicals for Insect Monitoring and Detection, 1986/87

Species	**Crop**	**Respondent, Country**		❶ Trapping	❷ Interpretation	❸ Detection	❹ Timing	❺ Risk	❻ Operational?	❼ Satisfied?
		Arable crops								
Coleoptera										
Sitona lineatus	Vicia faba	Horák	CSSR			SF			E	
Diptera										
Dasineura brassicae	Rape	Williams	UK				T	R	E	
Hymenoptera										
Aphidius rhopalosiphi	Wheat	Decker	UK	R	R	F			E	I
Aphidius rhopalosiphi	Cereal	Powell	UK	R	R	S			E	J
Praon volucre	Wheat	Decker	UK	R	R	F			E	I
Lepidoptera										
Agrotis exclamationis	Sugar beet	Zolotov	USSR			SF	S		E	SJ
Agrotis ipsilon	Cereal	Bues	F	GA	A	SFO	ST		O	SJI
Agrotis segetum	Cereal	Bues	F	A	AR	SFO	S			
Agrotis segetum	Sugar beet	Zolotov	USSR			SF	S		E	SJI
Amathes c-nigrum	Sugar beet	Zolotov	USSR			SF	S		E	
Autographa gamma	Sugar beet	Zolotov	USSR			SF	S		E	I
Chilo suppressalis	Rice	Galichet	F	A	A	FQ			O	SJ
Cnephasia pumicana	Cereal	Cate	A			SF				
Cnephasia pumicana	Cereal	Tolbukhin	BG	A	A	SFQ	T	R	O	J
Coleophora deauratella	Clover, alfalfa	Chmyr	USSR			SF			E	
Cucullia tanaceti	Sugar beet	Zolotov	USSR			SF	S		E	
Cydia medicaginis	Alfalfa	Tolbukhin	BG	A	A	SF	T	R	E	J
Cydia medicaginis	Alfalfa	JZD	CSSR	O	O	SF			E	I
Cydia medicaginis	Clover, alfalfa	Chmyr	USSR			SF			E	
Diachrysia chrysitis	Sugar beet	Zolotov	USSR			SF	S		E	I
Discestra trifolii	Sugar beet	Zolotov	USSR			SF	S		E	I
Emmelia trabealis	Sugar beet	Zolotov	USSR			SF	S		E	
Grapholita compositella	Clover	Chmyr	USSR			SF			E	
Heliophobus reticulata	Sugar beet	Zolotov	USSR			SF	S		E	I
Mamestra brassicae	Sugar beet	Subchev	BG			S				I
Mamestra brassicae	Sugar beet	Zolotov	USSR	GA	A	SF	ST	F	O	I
Ostrinia nubilalis	Maize	Berger	A	G	A	S	T	F	E	I
Ostrinia nubilalis	Maize	Langenbruch	D	AR	AR	SF			E	
Ostrinia nubilalis	Maize	Galichet	F			F			O	SJI
Ostrinia nubilalis	Maize	Gatellet	F	GA	A	SF	S		O	JI
Ostrinia nubilalis	Maize	SPV Du Mans	F	G	A	SF	ST		O	JI
Ostrinia nubilalis	Maize	Stockel	F	R	R	SF	S	F	O	SJ

❶/❷ Trapping/Interpretation done by grower (G), advisor (A), researcher (R), other (O). ❸ Use for detection: survey (S), flight observation (F), quarantine (Q), other (O). ❹ Use for timing of other sampling methods (S), treatments (T), other (O). ❺ Use for risk assessment: Relation between catch and population density or damage (R), use of a threshold (T), future use (F). ❻ System operational (O), experimental (E). ❼ User satisfied (S), effort justified (J), improvements needed (I).

Species	Crop	Respondent,	Country	1 Trapping	2 Interpretation	3 Detection	4 Timing	5 Risk	6 Operational?	7 Satisfied?
Ostrinia nubilalis	Maize	Pasqualini	I				T			
Ostrinia nubilalis	Maize	Melamed-Madjar	IL		R	SF	T		E	SJ
Pectinophora gossypiella	Cotton	Hosny	Egypt			SF	ST	RT		SJ
Peridroma saucia	Sugar beet	Zolotov	USSR			SF	S		E	I
Pseudaletia unipuncta	Gramineae	Bues	F	A	A	F	T		E	I
Pyrrhia umbra	Sugar beet	Zolotov	USSR			SF	S		E	
Sesamia nonagrioides	Maize	Galichet	F	A		F	T		O	I
Sesamia nonagrioides	Cereal	Mazomenos	GR	G	A	SFO	ST		O	J
Sesamia nonagrioides	Maize	Rotundo	I	A	A	SF	T		E	J
Spodoptera exempta	Gramineae	Rose	Kenya	A	A	SF	ST	RT	O	SJI
Spodoptera exempta	Gramineae	Luhanga	Malawi	A					E	J
		Vegetable crops								
Coleoptera										
Sitona lineatus	Peas, bean, alfalfa	Jensen	DK	A	A	SF			E	
Diptera										
Contarinia pisi	Peas (vining)	Wall	UK			F	S	R	E	I
Delia radicum	Cabbage	Hommes	D			F				S
Delia radicum	Brassica	Finch	UK	GAR	R	S	T	RT	OE	SJI
Psila rosae	Umbelliferae	Städler	CH	G	A	SF	T	RT	E	JI
Suillia lurida	Garlic	Kahrer	A	A	A	F			E	I
Hemiptera										
Aphids	Potato	Cruz-de-Bollpaepe	P	A	R	SF	T	RT	E	I
Lepidoptera										
Acrolepiopsis assectella	Leek	Hommes	D			F				I
Acrolepiopsis assectella	Leek	Monnet	F	GA		F				I
Acrolepiopsis assectella	Leek	Rahn	F	GAR	A	SFO	T	R	O	SJ
Acrolepiopsis assectella	Leek	Villevieille	F	A	A	F	T		O	I
Agrotis ipsilon	Vegetables	Bues	F	GA	A	SFO	ST		O	SJI
Agrotis segetum	Vegetables	Hommes	D			F				SJI
Agrotis segetum	Carrot, red beet, onion, leek, potato	Esbjerg	DK	GAR		SF	T	T	OE	J
Agrotis segetum	Vegetables	Bues	F	A	AR	SFO	S		E	
Agrotis segetum	Root crops	Kobro	N	GA	A		T		E	J
Agrotis segetum	Carrots	Jönsson	S	A	A		T	F	E	I
Ascotis selenaria	Avocado	Wysoki	IL	GA	R	S	T		O	S
Cnephasia sp.	Vegetables	Jensen	DK			S			E	
Cydia nigricana	Peas	Horák	CSSR	GAR	AR	SF	T		O	SJI
Cydia nigricana	Peas	Uksúp	CSSR	A	A	F	T		E	
Cydia nigricana	Peas	Kälberer	D	A	A	SF	ST		E	JI

Species	Crop	Respondent	Country	❶ Trapping	❷ Interpretation	❸ Detection	❹ Timing	❺ Risk	❻ Operational?	❼ Satisfied?
Cydia nigricana	Peas	Minks	NL	GA	AR	SF	T	RT	O	SJI
Cydia nigricana	Peas	Jönsson	S	A	A	SF			OE	SI
Cydia nigricana	Peas	Jönsson	S	A	A	F		FT	O	SI
Cydia nigricana	Peas	Tuovinen	SF	G	R	SF	T	RT	E	SJ
Cydia nigricana	Peas	Biddle	UK	GA	GA	S	T	T	O	SJ
Cydia nigricana	Peas	Harris	UK	G	A	S	T	T	O	SJ
Cydia nigricana	Peas (combining)	Wall	UK	GA	GA		T	T	O	SJI
Cydia nigricana	Peas (vining)	Wall	UK					RT	OE	J
Cydia nigricana	Peas	Chmyr	USSR	A	A	S	T	T	O	SI
Evergestis forficalis	Cabbage	Hommes	D			F				J
Evergestis forficalis	Cabbage	Rahn	F	GO	AO	F			O	SJ
Gortyna xanthenes	Artichoke	Rotundo	I	A	A	SF	T		E	J
Heliothis armigera	Tomato	Bues	F	A	A	SF	S	F	O	JI
Heliothis armigera	Tomato	Villevieille	F	A	A	F	T		O	SJ
Mamestra brassicae	Cauliflower	Freuler	CH	A		SF	ST			SJ
Mamestra brassicae	Cabbage	Hommes	D			F				I
Mamestra brassicae	Cauliflower	Bues	F	A	A	SF	S	F	O	JI
Mamestra brassicae	Cabbage	Zolotov	USSR	GA	A	SF	ST	F	O	I
Mamestra oleracea	Tomato	SPV Cenon	F	A		F			E	
Phthorimaea operculella	Tomato, potato	Berlinger	IL	G	R	S	ST		E	
Phthorimaea operculella	Potato, tomato (processing)	Yathom	IL	GA	R	SF	ST			SJ
Plutella xylostella	Cabbage	Hommes	D			F				
Plutella xylostella	Cabbage	Rahn	F	GAO	AO	F			O	SJ
Plutella xylostella	Cabbage vegetables	Minks	NL	AR	A	SF	T			

Orchards

Species	Crop	Respondent	Country	❶	❷	❸	❹	❺	❻	❼
Diptera										
Ceratitis capitata	Citrus	Prota	I	A	A	SF	T	T	E	SJ
Dacus oleae	Olives	Haniotakis	GR	A	A		T	T	E	JI
Dacus oleae	Olives	Delrio	I	A		F	T	RT	E	J
Dacus oleae	Olives	Filipe	P	GA	A	SF			E	J
Dasyneura tetensi	Black currant	Wall	UK			SF	T		E	
Rhagoletis cerasi	Cherry	Kneifl	CSSR	G	G	F	T		O	SJ
Hemiptera										
Aonidiella aurantii	Citrus	Bar-Zakay	IL	G	A	S	T	RT	O	SJ
Planococcus citri	Citrus	Prota	I			F	T		E	J
Quadraspidiotus perniciosus	Peach	Rice	USA	A	A	SF			O	SJ
Lepidoptera										
Adoxophyes orana	Apple	Fassotte	B	R	R	SF	ST	R	E	SJI
Adoxophyes orana	Pear, cherry, plum	Paternotte	B	GA	A		T	T	O	SJ
Adoxophyes orana	Apple	Baumgärtner	CH	A	A	FO	T		E	I
Adoxophyes orana	Apple	Charmillot	CH	G	G	SF	T	T	O	SJ

Species	Crop	Respondent,	Country	❶ Trapping	❷ Interpretation	❸ Detection	❹ Timing	❺ Risk	❻ Operational?	❼ Satisfied?
Adoxophyes orana	Apple	Mani	CH	GA	GA		ST	T	O	SJ
Adoxophyes orana	Orchards	Schmid	CH	G	A	SF	T		O	SJ
Adoxophyes orana	Orchards	UOCHB-ICEU	CSSR			SF				
Adoxophyes orana	Apple	Neuffer	D	GA	GA	F	ST		O	SJ
Adoxophyes orana	Apple	Übergebietliche Spezialberatung	D	GA	A	SF	T	RT	O	SI
Adoxophyes orana	Apple	INRA-SRIV	F			F	T	T	OE	
Adoxophyes orana	Apple, pear	Monnet	F	G	A	SF	ST	T	E	JI
Adoxophyes orana	Pear, apple, plum	SPV Cenon	F			F	T			
Adoxophyes orana	Apple	SPV Du Mans	F	G	A	SF				
Adoxophyes orana	Apple	Waldner	I	GA	A	SF	T			SJ
Adoxophyes orana	Apple, pear	Minks	NL	GA	A	SF	ST		O	SJ
Anarsia lineatella	Peach	Uksúp	CSSR	A	A	F	T		E	
Anarsia lineatella	Peach	Audemard	F	R	R	F			E	
Anarsia lineatella	Peach	INRA-SRIV	F	A	A	F	T		O	SJ
Anarsia lineatella	Peach	Rice	USA	GA	GA	SF	T		O	SJ
Archips crataegana	Apple	Fassotte	B	R	R	SF			E	SJI
Archips crataegana	Apple	Kolesova	USSR			SF			E	
Archips podana	Apple	Fassotte	B	R	R	SF	ST		E	SJI
Archips podana	Orchards	UOCHB-ICEU	CSSR			SF			E	
Archips podana	Apple	Neuffer	D	A	A	SF			E	
Archips podana	Apple	Boscheri	I	R	R	F	T		E	SJI
Archips podana	Apple, pear	Pasqualini	I	GA	A	SF	T	RT	O	SJ
Archips podana	Apple	Waldner	I	GA	A	SF	T			SJ
Archips podana	Apple, pear	Minks	NL	AR		SF				
Archips podana	Apple	Kolesova	USSR			SF			E	
Archips rosana	Apple	Fassotte	B	R	R	SF	ST		E	SJI
Archips rosana	Orchards	Mani	CH			S		T	E	
Archips rosana	Orchards	UOCHB-ICEU	CSSR			SF				
Archips rosana	Apple	Neuffer	D	A	A	SF			E	
Archips rosana	Apple, pear	Minks	NL	AR		SF				
Archips rosana	Apple	Kolesova	USSR			SF			E	
Archips sorbiana	Apple	Kolesova	USSR			SF			E	
Archips xylosteana	Apple	Fassotte	B	R	R	SF	ST		E	SJ
Archips xylosteana	Orchards	UOCHB-ICEU	CSSR			SF			E	
Archips xylosteana	Apple	Kolesova	USSR			SF			E	
Argyresthia conjugella	Apple, rowan	Kobro	N	GA	A	O	T	RT	E	JI
Argyrotaenia pulchellana	Apple	Fassotte	B	R	R	SF	ST		E	SJ
Argyrotaenia pulchellana	Apple	G.D.A. Durance	F	G	GA	F	T	T	E	SJ
Argyrotaenia pulchellana	Apple, pear	Pasqualini	I	A	A	SF	ST		O	J
Argyrotaenia pulchellana	Apple	Kolesova	USSR			SF			E	
Choristoneura diversana	Apple	Kolesova	USSR			SF			E	
Choristoneura hebenstreitella	Apple	Fassotte	B	R	R	SF			E	SJ

Species	Crop	Respondent,	Country	❶ Trap-ping	❷ Inter-preta-tion	❸ Detec-tion	❹ Timing	❺ Risk	❻ Opera-tional?	❼ Satis-fied?
Choristoneura sorbiana	Apple	Neuffer	D	A	A	SF			E	
Clepsis neglectana	Apple	Kolesova	USSR			SF			E	
Clepsis spectrana	Apple	Fassotte	B	R	R	SF			E	SJI
Clepsis spectrana	Apple, pear, varia	Minks	NL	AR		SF				
Cossus cossus	Orchards	Pasqualini	I	A		O				SJ
Croesia holmiana	Apple	Kolesova	USSR			SF			E	
Cydia fagiglandana	Chestnut	Rotundo	I	A	A	SF	T		E	J
Cydia pomonella	Orchards	Fischer-Colbrie	A	GA	GA	F	T		O	SJI
Cydia pomonella	Apple	Plam	A	G	A	F			O	SJ
Cydia pomonella	Apple	Fassotte	B	R	R	SF	ST		E	SJI
Cydia pomonella	Pear, apple	Paternotte	B	GA	A		T	T	O	SJ
Cydia pomonella	Apple	Charmillot	CH	G	G	F	ST	RT	O	SJ
Cydia pomonella	Apple	Mani	CH	GA	GA		ST	T	O	SJI
Cydia pomonella	Apple	ACHP-VLKOS	CSSR	GA	A	F	T	T	E	SJ
Cydia pomonella	Apple	Benko	CSSR	G		F	T		E	
Cydia pomonella	Apple	Berankova	CSSR	GA	GA	SF	ST		O	SJI
Cydia pomonella	Apple	JZD	CSSR	G	G	F	T	RT	O	SJ
Cydia pomonella	Apple	JZD	CSSR	G	GR	SF	T	F	OE	JI
Cydia pomonella	Apple	JZD	CSSR	G	G	F	TO		O	J
Cydia pomonella	Apple	JZD	CSSR	G	G	F	ST	T	O	SJ
Cydia pomonella	Apple	Kneifl	CSSR	G	G	F	T	F	O	SJ
Cydia pomonella	Apple	Uksúp	CSSR	A	A	F	T		O	
Cydia pomonella	Apple	ZLONICE	CSSR	G	G	SF	T		O	SJI
Cydia pomonella	Apple	Zyngas	CY	A	A	F	T		O	S
Cydia pomonella	Apple	Neuffer	D	GA	GA	F	T		O	SJ
Cydia pomonella	Apple, pear	Übergebietliche Spezialberatung	D	GA	A	SF	ST			SI
Cydia pomonella	Apple	Esbjerg	DK	G	AR	SF	T	FT	OE	I
Cydia pomonella	Apple	Franco	E	A	A	SF	ST		O	SJ
Cydia pomonella	Apple	Audemard	F	GAR	GAR	F	T	RT	OE	SJ
Cydia pomonella	Apple	Blanc	F	G	A	F	T	RT	E	
Cydia pomonella	Apple	G.D.A. Durance	F	G	GA	F	T	T	O	SJ
Cydia pomonella	Apple	G.R.C.E.T.A	F	GA	A	SF	T	RT	O	SJ
Cydia pomonella	Apple	INRA-SRIV	F	A	A	F	T	RT	O	SJ
Cydia pomonella	Apple, pear	Monnet	F	G	A	F	T	RT	O	SJ
Cydia pomonella	Apple, pear	SPV Cenon	F	GA	A	F	T	T	O	J
Cydia pomonella	Apple, pear	SPV Du Mans	F	G	A	F	T		O	SJ
Cydia pomonella	Apple, pear	Tarbouriech	F	G	G	F		T	O	SJ
Cydia pomonella	Apple	Boscheri	I	A	A	F	ST		E	
Cydia pomonella	Apple	Boscheri	I	G	R	F	T		E	I
Cydia pomonella	Apple, pear	Pasqualini	I	GA	A	SF	T	RT	O	SJ
Cydia pomonella	Apple	Waldner	I	G	A	S	T			S
Cydia pomonella	Apple	Minks	NL	GA	A	SF	ST	T	O	SJ
Cydia pomonella	Apple	Cruz	P	A	A	SF	ST			
Cydia pomonella	Orchards	Filipe	P	GA	A	SF	ST		E	SJ
Cydia pomonella	Apple	Gonçalves	P	A	A	SF	S	R	E	
Cydia pomonella	Apple	Graca	P	A	A	SF	S	R	E	
Cydia pomonella	Apple	Tuovinen	SF	G	GAR	SF	T	RT	O	SJ

Species	Crop	Respondent,	Country	❶ Trapping	❷ Interpretation	❸ Detection	❹ Timing	❺ Risk	❻ Operational?	❼ Satisfied?
Cydia pomonella	Apple	Ballard	UK	R	R		T	T	O	SJI
Cydia pomonella	Apple	Kolesova	USSR	GA	A		T	FT	O	SJI
Enarmonia formosana	Apple	Fassotte	B	R	R	SF			E	SJI
Enarmonia formosana	Apricots	ZLONICE	CSSR	G	G	SF	T	R	OE	SJI
Enarmonia formosana	Apple	Neuffer	D	A	A	SF			E	
Enarmonia formosana	Orchards	Sziráki	H			F	T		O	
Enarmonia formosana	Apple, plum	Minks	NL	AR		SF				
Enarmonia formosana	Apple	Kolesova	USSR			SF			E	
Euzophera bigella	Apple, pear	Pasqualini	I			S				
Exapate congelatella	Apple	Kolesova	USSR			SF			E	
Grapholita funebrana	Orchards	Fischer-Colbrie	A	GA	GA	F	T		O	SJI
Grapholita funebrana	Plum	Charmillot	CH	G	G	F	T	F	O	I
Grapholita funebrana	Plum	Hauri	CH	A	A	F	T		O	SJ
Grapholita funebrana	Plum	Mani	CH	A	A		S			
Grapholita funebrana	Plum	Neuffer	D	GA	GA	F	T		E	SJ
Grapholita funebrana	Plum	SPV Cenon	F	G	A	F	T	F	E	J
Grapholita funebrana	Apple, pear, plum	Minks	NL	A		SF				
Grapholita funebrana	Apple	Kolesova	USSR			SF			E	
Grapholita molesta	Peach	Uksúp	CSSR	A	A	SFQ	T		E	
Grapholita molesta	Peach	Audemard	F	GAR	AR	F	S	RF	E	J
Grapholita molesta	Peach	G.R.C.E.T.A	F	GA	A	SF	ST	R	O	SJ
Grapholita molesta	Peach	INRA-SRIV	F	A	A	F	T		O	SJ
Grapholita molesta	Peach	Nicolas	F	A	A	F				SJ
Grapholita molesta	Peach	SPV Cenon	F	G	A	F	T		E	
Grapholita molesta	Peach	Vaschalde	F	G	GA			RT	O	SJI
Grapholita molesta	Peach	Rice	USA	GA	GA	SFQ	T		O	SJ
Hedya nubiferana	Apple	Fassotte	B	R	R	SF			E	SJI
Hedya nubiferana	Apple	JZD	CSSR	G	GR	SF	ST		OE	I
Hedya nubiferana	Orchards	UOCHB-ICEU	CSSR	R		SF			E	
Hedya nubiferana	Apple	Neuffer	D	A	A	SF			E	
Hedya nubiferana	Apple	Minks	NL	R		SF				
Hedya nubiferana	Apple	Kolesova	USSR			SF			E	
Monima gothica	Apple	Neuffer	D	A	A	SF			E	
Monima incerta	Apple	Neuffer	D	A	A	SF			E	
Operoptera brumata	Apple	Albert	D	A	GA	FO			E	S
Pammene rhediella	Orchards	Mani	CH	R	R	S		T	E	
Pammene rhediella	Apple	Minks	NL	A		SF				
Pandemis cerasana	Apple, pear	Pasqualini	I	GA	A	SF	T	RT	O	SJ
Pandemis cerasana	Apple	Kolesova	USSR			SF			E	
Pandemis chondrillana	Apple	Kolesova	USSR			SF			E	
Pandemis heparana	Apple	Fassotte	B	R	R	SF	ST	F	E	SJI
Pandemis heparana	Orchards	Mani	CH			S		T	E	
Pandemis heparana	Apple	Neuffer	D	A	A	SF			E	
Pandemis heparana	Apple	Audemard	F	GAR	AR		T	T	OE	
Pandemis heparana	Apple	Blanc	F	G	A	F	T	T	E	
Pandemis heparana	Apple	G.D.A. Durance	F	G	GA	F	T	T	O	SJ
Pandemis heparana	Apple	G.R.C.E.T.A	F	GA	A	SF	T	T	O	SJI
Pandemis heparana	Apple, pear	SPV Du Mans	F	G	A	SF	T	R	O	

Species	Crop	Respondent,	Country	❶ Trapping	❷ Interpretation	❸ Detection	❹ Timing	❺ Risk	❻ Operational?	❼ Satisfied?
Pandemis heparana	Apple	Waldner	I	GA	A	SF	T			SJ
Pandemis heparana	Apple	Kolesova	USSR			SF			E	
Phyllonorycter blancardella	Apple	Fassotte	B	R	R	SF	ST		E	SJI
Phyllonorycter blancardella	Apple	Paternotte	B	GA	GA		T		O	SJ
Phyllonorycter blancardella	Apple	JZD	CSSR	G	GR	SF	ST		E	I
Phyllonorycter blancardella	Apple	Neuffer	D	A	A	SF			E	
Phyllonorycter blancardella	Apple, pear	Monnet	F	GA	A	F	T			I
Phyllonorycter blancardella	Pear, apple	SPV Cenon	F							
Phyllonorycter blancardella	Apple	Minks	NL	R		SF				
Phyllonorycter blancardella	Apple	Minks	NL	R		SF				
Prays oleae	Olives	Delrio	I	G		F	ST		O	J
Prays oleae	Olives	Filipe	P	GA	A	F	T		E	J
Ptycholoma lecheana	Apple	Fassotte	B	R	R	SF			E	SJI
Ptycholoma lecheana	Apple, pear	Minks	NL	R		SF				
Ptycholoma lecheana	Apple	Kolesova	USSR			SF			E	
Spilonota ocellana	Apple	Fassotte	B	R	R	SF			E	SJI
Spilonota ocellana	Orchards	UOCHB-ICEU	CSSR							
Spilonota ocellana	Apple	Neuffer	D	A	A	SF			E	
Spilonota ocellana	Apple	Minks	NL	R		SF				
Synanthedon myopaeformis	Apple	Fassotte	B	R	R	SF	T		E	SJI
Synanthedon myopaeformis	Apple	Charmillot	CH	A				FT	E	
Synanthedon myopaeformis	Orchards	Mani	CH	A	A	S		T	E	J
Synanthedon myopaeformis	Apple	JZD	CSSR	G		SF	T		E	
Synanthedon myopaeformis	Apple	Audemard	F	AR	R	F	S		E	
Synanthedon myopaeformis	Apple	Blanc	F	G	A	F			E	I
Synanthedon myopaeformis	Apple	G.D.A. Durance	F	G	GA	F	T		O	JI
Synanthedon myopaeformis	Apple	Monnet	F	GA	A	F	T		E	I
Synanthedon myopaeformis	Orchards	Pasqualini	I	A		SF				
Synanthedon myopaeformis	Apple	Waldner	I	G	A	F	T			SJ
Synanthedon myopaeformis	Apple	Minks	NL	AR		SF				
Synanthedon tipuliformis	Red currant	Minks	NL	A		SF				
Syndemis musculana	Apple	Minks	NL	R		SF				

Species	Crop	Respondent,	Country	❶ Trapping	❷ Interpretation	❸ Detection	❹ Timing	❺ Risk	❻ Operational?	❼ Satisfied?
		Vineyards								
Lepidoptera										
Eupoecilia ambiguella		Höbaus	A	G	A	F	T		O	SJI
Eupoecilia ambiguella		Boller	CH	G	A	F	T	RT	O	S
Eupoecilia ambiguella		Neukomm	CH	G	A	SF	T	RT	E	JI
Eupoecilia ambiguella		Jednotne	CSSR	G	G	SF	T	R	O	SJI
Eupoecilia ambiguella		JZD	CSSR	G	G		T		O	SJ
Eupoecilia ambiguella		JZD	CSSR	G	G	F	T	T	O	SJ
Eupoecilia ambiguella		SAV	CSSR	GR	GR	SF			O	I
Eupoecilia ambiguella		UKSUP	CSSR	A	A	F	T		O	
Eupoecilia ambiguella		Bourquin	D	AR	AR	SFO	S	T	O	J
Eupoecilia ambiguella		Haub	D	A	A	SF	ST	T	O	S
Eupoecilia ambiguella		Schruft	D	G	A	F	T		O	SJ
Eupoecilia ambiguella		G.D.A. Durance	F	G	GA	F	T		O	JI
Eupoecilia ambiguella		Magnien	F	GA	A	SF	S		O	S
Eupoecilia ambiguella		Maurin	F	A	A	SF			E	
Eupoecilia ambiguella		SPV Cenon	F	G	A	SF	S			
Eupoecilia ambiguella		Delrio	I	GA	GA	SF	ST	RT	O	J
Lobesia botrana		Höbaus	A	G	A	F	T		O	SJI
Lobesia botrana		Provincial Tuinbowcentrum	B	A	A	F			E	SJ
Lobesia botrana		Boller	CH	G	A	SF	T		O	S
Lobesia botrana		Schmid	CH	G	A	SF	S	T	O	JI
Lobesia botrana		ACHP-VLKOS	CSSR	A	A	SF	T		E	SJ
Lobesia botrana		Jednotne	CSSR	G	G	SF	T	R	O	SJI
Lobesia botrana		JZD	CSSR	G	G	F	T	T	O	SJ
Lobesia botrana		SAV	CSSR	GR	GR	SF			O	
Lobesia botrana		Zyngas	CY	A	A	F	T	F	O	J
Lobesia botrana		Bourquin	D	A	A	S			O	S
Lobesia botrana		Haub	D	A	A	SF	ST	T	O	S
Lobesia botrana		Coscolla	E			F	ST			
Lobesia botrana		Blanc	F	A	A	F	T		E	I
Lobesia botrana		Carles	F		R	SF	T	T	E	SJI
Lobesia botrana		G.D.A. Durance	F	G	GA	F	T		O	JI
Lobesia botrana		ITV Colmar	F	A	A	F		R	O	J
Lobesia botrana		ITV Nîmes	F	G	A	F	T		O	SJ
Lobesia botrana		Laurent	F	G	A	F	T		O	SJ
Lobesia botrana		Magnien	F	GA	A	SF	S		O	S
Lobesia botrana		Marcelin	F	A	A	F	T		O	SJ
Lobesia botrana		Maurin	F	A	A	SF			E	
Lobesia botrana		Roehrich	F	G	A	F	ST	RF	OE	J
Lobesia botrana		SPV Cenon	F	G	A	SF	S		E	I
Lobesia botrana		Stockel	F	R	R	F		R	O	S
Lobesia botrana		Stockel	F	R	R	F			O	SI
Lobesia botrana		Delrio	I	GA	GA	SF	ST	RT	O	J
Lobesia botrana		Menke	I	GA	A	F	T	T	E	SJ
Lobesia botrana		Vita	I	A	A	F	TO	RT	O	SJI
Lobesia botrana		Gonçalves	P	A	A	SF	S	R	E	

Species	Crop	Respondent,	Country	❶ Trapping	❷ Interpretation	❸ Detection	❹ Timing	❺ Risk	❻ Operational?	❼ Satisfied?
Peribatodes rhomboidaria		Schmid	CH	G	A	SF				J
Sparganothis pilleriana		Schmid	CH	G	A	SF			E	J
Forestry										
Coleoptera										
Ips sexdentatus	Pinus sp.	Paiva	P	R	R			F	E	JI
Ips typographus	Picea abies	Inst. Forstentom. Wien	A	GA	GA	FO		R		I
Ips typographus	Picea abies	Holtmann	D	G	A	SF			O	SJ
Ips typographus	Picea abies	König	D	G	A	F		T	O	
Ips typographus	Picea abies	Lösekrug	D	R	R			R	O	SJI
Ips typographus	Picea abies	Niemeyer	D	G	G			RT	O	
Ips typographus	Picea abies	Ravn	DK	G	R			FF	E	
Ips typographus	Picea abies	Bakke	N	R	R			R	O	
Ips typographus	Picea abies	Grijpma	NL			SF		F	E	
Ips typographus	Picea abies	Annila	SF	A	A	O		F	E	
Ips typographus	Picea abies	Nuorteva	SF		R				E	
Orthotomicus erosus	Pinus sp.	Paiva	P	R	R	SF	ST	F	E	JI
Pityogenes chalcographus	Picea abies	Holtmann	D	G	A	SF			O	SJ
Pityogenes chalcographus	Picea abies	Lösekrug	D	R	R			R	E	
Trypodendron lineatum	Conifers	Inst. Forstentom. Wien	A	GA	GA	F		R	O	I
Trypodendron lineatum	Picea abies	Holtmann	D	G	A				O	SJ
Trypodendron lineatum	Conifers	König	D	G	A	F		T	E	
Trypodendron lineatum	Picea abies	Lösekrug	D	R	R			R	O	I
Trypodendron lineatum	Picea abies	Niemeyer	D	G	G			RT	O	I
Lepidoptera										
Choristoneura fumiferana	Conifers	Sanders	CDN	A	A	S		R	O	SJI
Choristoneura murinana	Abies alba	Du Merle	F	AR	R	SF	S		O	SJ
Cossus cossus	Poplar	Gianni	I	R	R	SF			E	
Cossus cossus	Willow	Minks	NL	A		SF				
Gypsonoma aceriana	Poplar	Gianni	I	R	R	SF	T		E	
Laspeyresia pactolana	Pinus sp.	Minks	NL	AR		SF				
Lymantria dispar	Oak	Prota	I	R	R	SF	S		E	J
Lymantria monacha	Picea abies	MLVH-CSR	CSSR	G	A	S	S	FT	O	
Lymantria monacha	Pine	Altenkirch	D	G	A			FT	E	
Lymantria monacha	Picea abies	Bogenschütz	D	G	A			T	E	I
Lymantria monacha	Pinus silvestris	FVFA München	D	G	A	F		RT	O	SJI
Lymantria monacha	Conifers	Bejer-Peterson	DK			S	O	F		

Species	Crop	Respondent,	Country	❶ Trapping	❷ Interpretation	❸ Detection	❹ Timing	❺ Risk	❻ Operational?	❼ Satisfied?
Lymantria monacha	Picea abies, pine	Jensen	DK	G	A			T	E	
Orgyia antiqua	Picea abies	Jensen	DK			S			E	
Panolis flammea	Pine	Altenkirch	D	G	A			FT	E	
Panolis flammea	Pine	Lösekrug	D	A	A	SF	ST	F	E	I
Panolis flammea	Pine	Jensen	DK			S			E	
Paranthrene tabaniformis	Poplar	Dehorter	F	G	A	F	T		O	SJ
Paranthrene tabaniformis	Poplar	Gianni	I	GR	GR	SF	T		E	
Paranthrene tabaniformis	Poplar	Halperin	IL	G	GA		T	F	E	SJ
Paranthrene tabaniformis	Poplar	Grijpma	NL			SF			E	
Paranthrene tabaniformis	Poplar	Minks	NL	A		SF				
Rhyacionia buoliana	Pine	UOCHB-ICEU	CSSR							
Rhyacionia buoliana	Pine	Robredo	E	A	A					J
Thaumetopoea pityocampa	Pine	Perez	E	R	R	S	T		O	SJI
Thaumetopoea pityocampa	Pinus nigra	Battisti	I	R	R	SF	S		E	SJ
Thaumetopoea pityocampa	Pine	Halperin	IL	GA	A	S	T	R	O	SJ
Tortrix viridana	Oak	Du Merle	F	R	R	F		R	E	SJ
Tortrix viridana	Oak	Malphettes	F	A	R	SF	ST		E	
Zeiraphera diniana	Larix decidua Picea	Baltensweiler	CH			SF		R		
Zeiraphera diniana	Picea abies	Jiloviste-Strady	CSSR	G	A	S	S	RT	O	I
Stored products										
Lepidoptera										
Ephestia spp.		Fleurat-Lessard	F	A	A	SF	T	RT	O	SJI
Phycitids		Nawrot	PL	A	A	FQ	T		E	J
Plodia spp.		Fleurat-Lessard	F	A	A	SF	T	RT	O	SJI
Other										
Coleoptera										
Popillia japonica		Martins	P	A	A	SFQ	T	R	E	
Hymenoptera										
Apis mellifera		Ferguson	UK	G	G	O			O	J

COMPTE RENDU DE L'ENQUETE SUR L'UTILISATION DE PHEROMONES ET AUTRES MEDIATEURS CHIMIQUES EN LUTTE INTEGREE

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Depuis 1959, année au cours de laquelle BUTENANDT & al isola la première phéromone, au récent récapitulatif de l'OILB (ARN & al, 1987) qui recense 1520 formulations d'attractifs sexuels concernant 463 genres d'arthropodes, plusieurs symposiums ont permis de suivre l'évolution des travaux sur les synthèses des phéromones et les progrès dans leurs applications. La généralisation de leur emploi pour la surveillance et l'avertissement, parallèlement aux méthodes de "lutte éthologique", a entraîné une diversité des techniques et méthodes utilisées. L'enquête réalisée en 1986 par le groupe de travail OILB/SROP sur "l'utilisation des phéromones et autres médiateurs chimiques en lutte intégrée" avait pour objectif un inventaire des domaines et des objectifs d'applications tant en agriculture, sylviculture que pour les denrées stockées.

Les tableaux qui sont présentés ci-après, résument l'essentiel des 364 réponses reçues de 1986 à 1987. Il est impossible d'évaluer quel pourcentage de réponses cela représente. Sur ce point, nous nous écartons de la méthodologie employée par les enquêteurs professionnels. D'autres difficultées sont apparues à l'analyse: questions trop générales ou au contraire trop précises..., qui ont montré les limites de nos compétences en la matière. Toutefois, c'est peut être sur le plan "linguistique" que sont apparues les difficultées majeures d'interprétation des réponses. Dans le souci de permettre la plus large diffusion du questionnaire, des traductions ont été effectuées dans plusieurs langues, l'examen de certaines des réponses montre que des différences d'interprétation des questions ont vraisemblablement eu lieu.

Ces limites étant précisées, il est possible de faire apparaître des tendances et de dégager les orientations générales qui se dessinent principalement au niveau des domaines et des objectifs d'application en agriculture et en sylviculture. Pour les denrées stockées, comme cela apparaîtra dans les tableaux, le trop faible nombre de réponses (3) ne permet pas une interprétation. Cela pose plutôt une première question: l'utilisation des phéromones dans ce domaine est-elle réduite ou la diffusion du questionnaire ne s'est-elle pas faite? Dans ce dernier cas qu'en est-il pour les autres cultures?

L'analyse des résultats peut se faire par rapport à plusieurs critères, nous avons privilégié celui des types de cultures. Bien qu'il soit critiquable, il présente entre autres l'avantage de s'ordonner avec les sessions du symposium.

A) REPARTITION DES REPONSES

Des réponses nous sont parvenues de 27 pays différents, 17 d'entre eux ont, au total, envoyé entre 1 et 10 réponses, 5 pays entre 11 et 30, 5 autres entre 30 et 80 réponses.

Le tableau 1 résume la répartition en fonction des types de cultures.

(*)Cette enquête a été réalisée par un groupe de travail: Mrs , H. ARN, H. BOGENCHUTZ, R. BUES, P.J. CHARMILLOT, J. FREULER, A.K. MINKS, A. SCHMIT, C. WALL & T. WILDBOLZ. Nous remercions les nombreuses personnes qui à des titres divers ont participé à la distribution, la rédaction et la collecte des informations. L'essentiel des données regroupées dans les tableaux ci-après, sont extraites du fascicule remis aux participants au symposium.

Tableau 1: Répartition des réponses par pays, en fonction des types de cultures

Pays:	Types de cultures: fruit.	légum.	annuel.	Vigne	Forêt	Denrées stockées
Angleterre	2	6	4	/	/	/
Belgique	19	/	/	1	/	/
France	34	11	9	17	4	2
Hollande	16	2	/	/	5	/
Italie	20	1	2	4	5	/
Portugal	6	1	/	1	2	/
R.F.A.	16	7	1	5	14	/
Suisse	10	2	/	4	1	/
Tchécoslov.	23	2	2	9	3	/
U.R.S.S.	18	2	15	/	/	/
Divers<10 réponses	13	11	8	4	15	1
Total (+4divers types)	177	45	41	45	49	3

Il apparaît nettement que ce sont les cultures fruitières qui ont fait l'objet du plus grand nombre de réponses (177), les autres types de cultures concernent entre 40 et 50 réponses. Peut-on déduire de cette répartition une plus grande généralisation de l'emploi des phéromones en cultures fruitières? C'est vraisemblable. Toutefois, la répartition entre cultures varie selon les pays, ce qui permet de distinguer, pour ceux qui nous ont adressé un nombre suffisant de réponses, d'autres secteurs importants d'utilisation: par exemple, la forêt en RFA, la vigne en France, les cultures annuelles en URSS.

B) ESPECES CONCERNEES

Le tableau 2 montre sans ambiguïté, l'importance de l'ordre des Lépidoptères dans l'utilisation des phéromones. Si l'on dresse la liste des espèces ayant fait l'objet, pour chaque type de culture, de plus de 5 réponses (tableau 3), quelques espèces apparaissent prépondérantes, notamment sur cultures fruitières et vignobles.

Tableau 2 : Répartition des réponses en fonction des différents ordres d'insectes

Types de cultures	Lépidoptères	Coléoptères	Diptères	Divers
C. fruitières	168	/	6	3*
C. légumières	39	/	5	1*
C. annuelles	36	1	1	2*1**
Vigne	45	/	/	/
Forêt	30	19	/	/
Diverses	2	1	/	1**
D. stockées	3	/	/	/

(*)Homoptères (**)Hyménoptères

Tableau 3 : Répartition des espèces principales par types de cultures et nombre de réponses (Divers= <5 réponses)

Cultures fruitières:
Adoxophyes orana (15)
Archips podana (8)
Archips rosana (5)
Cydia pomonella (50)
Enarmonia formosa (6)
Cydia funebrana (8)
Hedya nubiferana (6)
Pandemis heparana (9)
Phyllonorycter blancardella (5)
Synanthedon myopaeformis (10)
Divers (55)

Cultures légumières:
Cydia nigricana (12)
Divers (33)
(dont 13 Noctuidae)

Cultures annuelles:
Ostrinia nubilalis (8)
Divers (33)
(dont 15 Noctuidae)

Vigne:
Eupoecilia ambiguella (15)
Lobesia botrana (28)
Divers (2)

Forêt:
Ips typographus (9)
Trypodendron lineatum (5)
Lymantria monacha (5)
Divers (30)

Denrées stockées
plus divers (7)

C) PIEGEAGE ET INTERPRETATION

Le niveau d'utilisation des phéromones peut être apprécié par le degré de vulgarisation des méthodes, c'est à dire leur mise en oeuvre par l'agriculteur lui même. Le tableau 4 indique, en fonction du type de culture, les pourcentages de participation de chacun des utilisateurs. Malgré des fluctuations on peut cependant considérer, excepté pour les cultures annuelles où la moitié des personnes ne se prononcent pas, qu'un tiers environ du travail de piégeage est effectué par les agriculteurs, de 20 à 50 % par les techniciens et finalement relativement peu par les chercheurs, excepté en forêt (27,3 %). Notons que pour les denrées stockées les 3 réponses reçues indiquent que le piégeage est effectué par les techniciens.

Tableau 4: Répartition des responsabilités du piégeage (en pourcentages)

Types de cultures	Qui piège?: Agriculteur	Technicien	Chercheur	pas de réponses
C.fruitières	34,5	36,8	15,7	13,0
C.légumières	28,6	49,2	7,9	14,3
C.annuelles	13,6	25,0	11,4	50,0
Vigne	38,8	50,7	9,0	1,5
Forêt	36,4	21,8	27,3	14,5

Note: Certaines des réponses concernent 2 responsables

On pourrait donc penser que la vulgarisation du piégeage sexuel est relativement avancée. Toutefois cette impression est relativisée lorsque l'on considère, tableau 5, la répartition en pourcentages des responsables de l'interprétation des résultats des captures.

Tableau 5: Répartition des responsabilités de l'interprétation des résultats du piégeage (en pourcentages)

Types de cultures	qui interprète?: Agriculteur	Technicien	Chercheur	pas de réponses
C.fruitières	16,5	43,5	14,5	25,5
C.légumières	4,0	52,0	18,0	26,0
C.annuelles	0	31,0	16,6	52,4
Vigne	21,2	65,4	11,5	1,9
Forêt	11,3	37,7	32,1	18,9

Note: Certaines des réponses concernent 2 responsables

La majorité du travail d'interprétation est effectuée par les techniciens, bien qu'en vignobles et dans une moindre proportion en cultures fruitières et en forêt un pourcentage significatif d'agriculteurs ou de sylviculteurs réalisent eux mêmes ce travail. L'accroissement des pourcentages de personnes qui ne se prononcent pas semble révéler des difficultés face à cette question.

Il est possible de présenter un autre aspect du niveau de vulgarisation de la méthode de piégeage, selon que celle-ci est considérée comme encore expérimentale ou déjà opérationnelle (tableau 6).

Sur vigne le piégeage est considéré comme opérationnel par 2/3 des personnes, cette proportion décroît aux environs de 1/3 pour les autres types de cultures, ce qui correspond sensiblement aux pourcentages d'agriculteurs qui réalisent le piégeage, les cultures annuelles mises à part. La méthode de piégeage est cependant considérée comme encore expérimentale par un pourcentage élevé de personnes: 61% en cultures annuelles et 49% en forêt.

Tableau 6: Niveau d'utilisation de la méthode de piégeage en fonction du type de culture (en pourcentages)

Types de cultures	La méthode est-elle expérimentale?: Expérimentale	Opérationnelle	pas de réponses
C.fruitières	47,5	33,3	19,2
C.légumières	31,1	37,8	31,1
C.annuelles	61,0	24,4	14,6
Vigne	24,4	66,7	8,9
Forêt	49,0	34,7	16,3

D) OBJECTIFS DU PIEGEAGE

En fonction des questions posées il est possible, dans un premier temps, de regrouper les réponses dans trois rubriques: a) surveillance des vols, b) avertissements, c) dans quelques cas, pour la mise en quarantaine de certains végétaux ou denrées importées. Le tableau 7 indique, par types de cultures, les pourcentages respectifs de réponses pour chacun des objectifs: La surveillance des vols avec 92 à 97% des réponses est bien l'objectif principal contre 60 à 75% pour les avertissements. Notons que pour la forêt les pourcentages de réponses, par rapport aux autres types de cultures, sont relativement plus bas

Tableau 7: Objectifs du piégeage en fonction du type de culture

Types de cultures	Surveillance des vols		Avertissements		Quarantaine
C.fruitières	162*	92,6**	108*	61,7**	2*
C.légumières	42	93,3	29	64,4	/
C.annuelles	39	95,1	28	68,3	2
Vigne	44	97,8	34	75,6	/
Forêt	31	63,3	14	28,6	/
D.stockées	3	/	0	/	1
Divers	2	/	2	/	1

Note: Quelques réponses concernent 2 objectifs.
(*) Nb de réponses (**) P.cent par rapport au nombre de réponses par type de culture

Dans le questionnaire, chacun de ces objectifs principaux recouvrait deux orientations. Pour la surveillance des vols on distinguait aire de distribution et période de vol, dans le cas des avertissements on distinguait le piégeage comme signal pour le déclenchement d'autres méthodes d'échantillonnages et le piégeage comme facteur unique de décision pour traiter. Les données détaillées, en pourcentages du nombre de réponses pour chacun des deux objectifs principaux, sont résumées dans le tableau 8.

Tableau 8: Objectifs détaillés en fonction du type de culture (en pourcentages)

types de cultures	Surveillance des vols		Avertissements	
	Aire de distribution	Période de vol	Pour autres échantil.	Décision de traiter
C.fruitières	68,9	98,8	29,6	95,4
C.légumières	61,9	83,3	31,0	86,2
C.annuelles	84,6	92,3	67,9	50,0
Vigne	54,5	100	38,2	79,4
Forêt	80,6	74,2	57,1	64,5

Note: Pour chacun des 2 objectifs principaux, plusieurs réponses concernent les 2 orientations.

Pour la surveillance des vols, l'orientation majeure semble concerner la période de vol, excepté pour la forêt. Pour les avertissements le piégeage est considéré comme facteur de décision par 95,4% des réponses en cultures fruitères contre 86,2 et 79,4% respectivement, en cultures légumières et en vignobles. En définitive, un très fort pourcentage de personnes considère le piégeage comme un moyen de déterminer les périodes de vols et comme un facteur de décision pour les traitements.

Toutefois, ces résultats de l'enquête doivent être considérés avec précaution, c'est essentiellement sur ces questions qu'ont joué conjointement l'ambiguïté des traductions et l'imprécision des questions et des réponses.

En ce qui concerne, l'état actuel des résultats obtenus et les objectifs présents et futurs du piégeage, deux autres questions relatives soit à la relation entre le nombre de captures et le niveau de population ou de dégâts, soit à l'emploi d'un seuil de captures, devaient permettre de préciser le niveau d'utilisation des phéromones. Les résultats sont donnés en pourcentages dans le tableau 9.

Tableau 9: Relation entre le nombre de captures et le niveau des populations dans les cultures (en pourcentages)

Types de cultures	Nb captures /niv.popul.*	Utilisez-vous un seuil de captures?: Actuellement	Dans le futur	Pas de réponses
C.fruitières	12,6	22,3	3,4	74,3
C.légumières	17,8	31,1	4,4	64,5
C.annuelles	9,8	2,4	7,3	90,2
Vigne	22,2	26,7	4,4	68,9
Forêt	26,5	22,4	14,3	63,3

(*)P.cent calculés par rapport au nombre total de réponses par type de culture.

C'est en forêts et en vignobles que la corrélation, entre le nombre de captures et le niveau de la population, est le plus élevé, deux fois plus qu'en cultures fruitières. Il est étonnant de constater qu'un seuil de captures est utilisé en cultures légumières pour 31% des réponses contre 26,7% en vignobles et 22,4% en forêt. Mais il est possible qu'il s'agisse alors d'un seuil de prévision négative. De même que le taux de 22,3% de réponses, pour lesquelles un seuil de captures est utilisé en cultures fruitières, apparaît en contradiction avec les 95,4% de réponses indiquées dans le tableau 8, qui considèrent le piégeage comme un critère de décision. Il est probable qu'une interprétation différente des questions a eu lieu. Dans tous les cas, peu de personnes envisagent dans l'avenir l'utilisation d'un seuil de captures, ce qui pourrait indiquer une certaine hésitation.

Il restait enfin à demander quel était le sentiment des utilisateurs des phéromones: étaient-ils satisfaits, les dépenses et le travail engagés étaient-ils justifiés et des améliorations étaient-elles nécessaires? Les réponses sont indiquées dans le tableau 10.

Tableau 10: Evaluation des résultats obtenus avec le piégeage sexuel (en pourcentages)

Types de cultures	Satisfaits	Dépenses et travail justifiés	Des améliorations nécessaires	P.cent de réponses
C.fruitières	38,1	43,3	18,6	60,0
C.légumières	32,2	33,9	33,9	73,3
C.annuelles	16,7	44,4	38,9	34,1
Vigne	37,3	41,8	20,9	84,4
Forêt	30,0	40,0	30,0	47,0

Note: Plusieurs réponses concernent 2 appréciations.

Elles montrent que 1/3 seulement est satisfait (16,7% pour les cultures annuelles), une fraction légèrement plus élevée (40% en moyenne) estime que les dépenses et le travail sont justifiés, mais paradoxalement un pourcentage moindre estime que des améliorations sont nécessaires.

CONCLUSIONS

L'examen relativement succinct des réponses aux principales questions de l'enquête ne permet pas de conclusions précises. Notons qu'un certain nombre de questions n'ont pu être analysées à cause de la diversité des réponses. Si le nombre de réponses avait été suffisant et l'interprétation des questions plus homogène, des analyses plus détaillées par exemple par pays et surtout par espèce, auraient pu permettre des recoupements intéressants. Des indications peuvent cependant être soulignées qui pourront, éventuellement, faire l'objet de discussions au cours de ce symposium:

a) C'est en cultures fruitières que le piégeage sexuel semble être le plus utilisé, quel que soit le type de cultures, c'est parmi l'ordre des Lépidoptères que se trouve la presque totalité des espèces piégées, excepté en forêt où l'ordre des Coléoptères est proportionnellement important.

b) Si le piégeage est pratiqué à presque égalité par les agriculteurs et les techniciens, ce sont surtout ces derniers qui interprètent les résultats, avec une participation des chercheurs. Ceci, même si la méthode est considérée comme opérationnelle par 1/3 des personnes pour les différents types de cultures, excepté en vignobles (2/3).

c) Les objectifs du piégeage sont premièrement la surveillance des vols, principalement le suivi de la dynamique des populations adultes. Pour 60 à 75% des personnes (excepté en forêt 28,6%), les résultats du piégeage sont, pris en compte et intégrés dans la gestion de la lutte.

d) La relation quantitative entre le nombre de captures et le niveau des populations n'est reconnue que par une relativement faible proportion, de 10% pour les cultures annuelles à 26,5% en forêt. Parallèlement, l'utilisation d'un seuil de captures est peu répandue, notamment en cultures annuelles, ce que semble étayer le fait que, pour cette culture, les résultats du piégeage ne soient généralement considérés que comme une composante des paramètres pris en compte dans la gestion de la lutte.

Enfin, excepté en cultures annuelles, 30 à 38% des personnes qui ont répondu sont satisfaites et 40% environ pensent que les dépenses et le travail investis dans le piégeage sont justifiés.

Depuis la réalisation de l'enquête les recherches se sont poursuivies, les nombreux exposés qui vont suivre le démontre. Chaque espèce pose des problèmes spécifiques d'emploi possible des phéromones ou d'autres médiateurs chimiques. De nombreux travaux sont encore nécessaires afin d'accroître leur fiabilité et permettre une plus grande généralisation de leur utilisation.

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ARABLE AND VEGETABLE CROPS

TWO MONITORING SYSTEMS FOR THE PEA MOTH, *Cydia nigricana*, IN COMBINING AND VINING PEAS.

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Summary

Two sex-attractant monitoring systems are currently available for the pea moth, *Cydia nigricana* (F.) in the United Kingdom; one for use in combining (dry-harvested) peas for human consumption or seed, and the other for use in vining peas for freezing or canning. The former is well established, widely used, and enables farmers to decide the need to spray and time the sprays correctly with the aid of a central temperature-driven computer model run by the advisory services. The latter can be used to predict damage levels in vining peas, but is not being taken up by the farming community.

Introduction

The pea moth, *Cydia nigricana* (F.) is a potentially serious pest of peas, the larvae boring into the pods and damaging one or more of the developing seeds. The economic effect of this damage and the presence of the larvae and frass depends on the type of pea crop. In combining crops damage to peas can be removed after harvest, but the farmer will incur penalties. In vining peas hardly any damage can be tolerated, because the peas cannot be 'cleaned' mechanically after harvest. *C. nigricana* rarely has much effect on yield in the United Kingdom, so it is considered unnecessary to attempt control in crops grown for animal feed.

The Problem

The erratic appearance of this univoltine pest means that there is a need for a local monitoring technique, which preferably can be used by the individual farmer. The only real alternative to this is to use prophalactic insecticide sprays. However, the questions to be answered by the monitoring system differ for combining peas and vining peas.

Combining pea varieties produce pods sequentially for several weeks, and therefore are at risk from the start of flowering to shortly before harvest. Also, it is usually possible for the larvae to complete their development before harvest, thus causing maximum damage and ensuring completion of the life cycle. A monitoring system for this crop is therefore required to provide information on (1) arrival of moths, (2) need to spray, (3) optimum timing of the spray(s).

Vining pea varieties produce pods over a very short period of time. These are harvested ca. three weeks after flowering. Timing of the insecticide spray is not, therefore, important because only one spray can be applied at full flower. A monitoring system for this crop is therefore required to provide information on the need to spray. Since infesting larvae are often killed at harvest, the density of C. nigricana in vining pea areas is generally very low. However, very low damage tolerances are set by the processors, resulting in the need for a particularly sensitive monitoring technique.

The Combining Pea System

This system has been available commercially since 1978. A pair of traps is placed 100 m apart and 5 m into each field on adjacent headlands on the side of the prevailing wind (Wall et al., 1987). The traps are set at right angles to each other so that on any one day one trap will be optimally orientated to the wind, since wind direction greatly affects the catch (Lewis & Macaulay, 1976). Each trap contains 3 mg of E-10-dodecen -1-yl acetate on rubber, which will remain constantly attractive for at least three months (Greenway et al., 1981; Wall & Greenway, 1981). In fields larger than 50 ha a second pair of traps is placed in the opposite corner (Perry & Wall, 1984). The traps are installed in mid-May, before the flight season, and examined every other day.

Spraying is necessary only if a 'threshold' catch is achieved - this is 10 or more moths in either trap during two consecutive 2-day periods (Macaulay et al., 1985). The date of the 'threshold' is taken to indicate the start of substantial oviposition in the crop, and a developmental model using max./min. daily temperatures (Lewis & Sturgeon, 1978), is used to calculate the rate of egg development and thus predict the date of the first spray with ca. 80% accuracy. This can be done using a simple calculator (Macaulay et al.,1985), but it is much more efficient for the advisory services to provide an interpretation service based on a computer model and temperature records from local meteorological stations. As a result of this service a very high proportion of farmers run their own traps and control the pest effectively, whilst applying pesticides only when needed.

There have been remarkably few difficulties. One of the most persistent, however, is the tendancy for farmers not to put traps out early enough in the season. This can lead to false 'threshold' catches as the traps catch a backlog of immigrant males. In years when the moths emerge very late, farmers may have to examine traps regularly for several weeks before catches are obtained and some may decide to stop trapping too early.

The Vining Pea System

This system was launched commercially in 1987 on a trial basis to assess interest amongst farmers.Single traps containing 200 ug of the stabilised pheromone E,E8,10-dodecadien-l-yl acetate (Greenway, 1984) on rubber are placed at least 100 m into the crop (Wall et al., 1986) and at least 600 m from the nearest trap to avoid interactions (Wall & Perry, 1987). They are installed in mid-May, before the flight season, examined daily and re-orientated to the wind. The cumulative catch at full flower is used to predict the maximum likely damage if the crop is not sprayed, based on the confidence limits of the regression of damage on trap catch.

Despite the findings of Graham (1984) that moths migrate into combining peas at or after flowering, no such relationship could be found between the catches in traps and crop phenology in vining peas. Males were caught up to 40 days before full flower (Wall et al., 1986). This led to the conclusion that the traps are sampling males from outside the sowing in which they are placed, and that they may be indicating the presence of the moths in the area rather than the crop.

It is very difficult to obtain information on the levels of damage by C. nigricana at which vining pea crops are rejected by processors. During the three-year trial by Wall et al., (1986) damage was extremely low, averaging 0.05% in unsprayed plots in 50 crops. Only 12% of the crops had damage in excess of 1%, which would probably represent an economic loss, and yet 54% of the crops were sprayed. Thus C. nigricana seems to have been of minor importance on vining peas in the United Kingdom during recent years. Despite this many farmers spray prophylactically, whilst others hardly ever spray. The problem is to encourage both 'schools' to use the traps which are now available. The 'no-spray' school do not think the moth is a problem, the 'spray' school regard it as pointless to trap when insecticide application is so cheap and timing is not a problem.The area of protein peas in the United Kingdom has increased considerably over the last few years. Since there is little need to control C. nigricana in protein peas, this increase could lead to a build-up of moth populations and increasing problems in both the combining-pea and vining-pea crops. The question is - do we really have to wait until that problem hits the vining pea industry in the United Kingdom before farmers will start to use monitoring traps extensively?

A second problem is the specificity of the attractant. It must be acknowledged that E,E8,10-dodecadien-l-yl acetate is an attractant for males of several closely related species of Cydia (Arn et al., 1986). Of these C. servillana has already turned up as a contaminant in vining- pea monitoring traps. The scale of the problem will only become apparent with time.

Acknowledgements

This paper would not have been possible without the efforts of several colleagues who have contributed as authors of the papers cited and others who helped in a support capacity.

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CATCHES OF PEA MOTH, CYDIA NIGRICANA, IN SEX-ATTRACTANT TRAPS, EXTENT OF MALE POPULATION DENSITIES IN AGRICULTURAL ECOSYSTEMS

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Summary

Within the period 1979 - 1984 the distribution of pea moth, Cydia nigricana (F.)(Lepidoptera, Tortricidae), was investigated in Czechoslovakia. The monitoring of males was carried out by means of traps with (E)-10-dodecen-1-yl acetate, sex--attractant. The variability of catches was considerable, from 0 to 1 662 males in two traps within entire season. Out of 13 679 moths C. nigricana represented 80.4 % and Phyllonorycter spp. 19.0 %. It was found, on the basis of similarity dendrogramme that the set of objects (pea fields) consisted of three marked clusters (A, B, C) and one separate object. High catches ($\bar{y}$ = 736.6 males) were characteristic for cluster A where, within crop rotation system, pea was grown in short distances ($\bar{x}_1$ = 0.11 km) from the previous year pea field, acreage of the pea field was small ($\bar{x}_2$ = 8.5 ha) and pea has been grown there for many years ($\bar{x}_3$ = 20.2 years). Vice versa situation was represented by cluster C ($\bar{y}$ = 38.5 males, $\bar{x}_1$ = 6.2 km, $\bar{x}_2$ = 75.5 ha, $\bar{x}_3$ = 7.8 years). In spite of the fact that the pea field is reached by greater number of females than males the relationship between catches of males and percentages of damaged peas is significant. The pea producers may control the pea moth by agricultural ecosystem management without sprays. Thus the traps are to verify the reliability of the measures taken.

1.1 Introduction

Within the period 1979 - 1984 we mapped distribution of pea moth in five regions of Czechoslovakia. In the traps with (E)-10-dodecen-1-yl acetate the total number of 13 679 moths was caught, pea moth represented 80.4 %, Phyllonorycter spp. 19.0 %. The variability of pea moth catches was considerable ($0 \leqq \bar{y} \leqq 1662$ males in two traps over one season). Catches were mostly surprisingly low, but some localities showed strikingly high catches repeatedly found year by year. This concerned the localities where pea was grown in the crop rotation system covering short distances from the previous year pea fields ($\bar{x}_1$, km) and from which moths disperse after wintering; where pea was grown upon small acreages ($\bar{x}_2$, ha) for many years ($\bar{x}_3$, number of years). We presumed that relationship between male catches and male population density was positive and significant. Can the rate of male catches be regulated through system of pea growing, i.e. by modification of x_1, x_2, x_3?

1.2 Results

The cluster analysis confirmed the selected set of 27 pea fields (objects) to fall into three expressive clusters (A, B, C) and one individual object (table 1).

Table 1. Monitoring of pea moth, Cydia nigricana, in sex-attractant traps. Classification of pea fields - cluster analysis results.

Cluster	Number of objects (pea fields)	Traits males $\bar{y}$	km $\bar{x}_1$	ha $\bar{x}_2$	years $\bar{x}_3$
A	11	736.6	0.11	8.5	20.2
B	11	99.5	0.56	35.4	5.9
C	4	38.5	6.20	75.5	7.8
-	1	42	0.05	188.0	6

Regression and correlation analysis of data (n = 52) showed that relationship between catches (y) and distance (x_1) and acreage (x_2) may be expressed by two-factor power function ($r_{y.x_1x_2}$ = 0.6259, p = 0.0005).

As the relationship between male catches (y) and % damaged seeds is significant the losses in pea crops may be reduced by agricultural ecosystem management. The longer distance from emergence site decreases the number of males which reach the pea field. The larger the acreage the scarcer the population distribution and also the percentage of damaged seeds thus decreases. In regression estimate we must count with longer distances x_1 altering sexual index in behalf of females.

Two potential purposes of pea moth sex-attractant traps:

- timing of sprays,
- check of non-chemical measure reliability (pea moth control by ecosystem management).

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EXPERIENCES WHEN MONITORING THE PEA MOTH, *Cydia nigricana (F.)* IN DENMARK BY MEANS OF PHEROMONE TRAPS

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Background

In recent years, there has been an enormous increase in the area in Denmark used for growing peas. In 1987 peas were grown on about 200,000 ha whereas the area was less than one tenth of this in 1983. In the long run, this increase may lead to more problems with certain kinds of pests in peas. (One reason may be the higher risk of immigration of pests from neighbouring fields.)

The total annual gross value of the present pea production is estimated at about 1.2 billion D.kr. (approx. 1.5 billion ECU).

The estimated average frequency of insecticide applications in peas is about 1.5 times a year (Nøddegaard 1986). In 1987, insecticides were used in about one third of the pea area, in spite of the fact that the control required must have been considerably below that.

This stresses the importance of developing methods which may with more certainty establish the need for control measures.

Previous registrations of pea moths in Denmark

Since 1985, pheromone traps with synthetic pea moth sex pheromone have been used in Danish pea fields (with two traps per field and two weekly inspections). This has enabled the growers to catch some of the migrating males and gather information on the time and extent of their flight activity. The number of moths caught in these traps have been reported to the Plant Protection Centre.

In general, the traps have been useful for finding out when the flight takes place at the various locations. The time of the flight culmination varies considerably (± 14 days) from year to year and from region to region within the same year. Moreover, the flight intensity may differ very much within short distances, and the catch level will only apply to the field in question. These experiences are in line with results from England, where the pheromone trap system was developed and has been used in dry-harvested peas for human consumption (Wall et al. 1987) as an efficient means of establishing the need and optimum time for control.

The damage threshold used in England (min. 10 months per trap in either of the two traps in two successive catch periods) was not passed in 1985, and only on very few occasions in recent years.

Problems with pheromone traps for pea moths

In 1985, information was received from 271 fields, in 1986 from 70, and in 1987 from only 33 pea fields.

The methods for estimating attacks of pests in practical farming has to be simple and reliable, and the pest in question must be of some relevance to the growers. Pheromone traps are simple enough to use, but Danish pea growers do not feel that the problems in connection with pea moths are of any great importance. Pea moths are a problem only where quality demands are particularly high (seed peas or peas for human consumption).

According to Swedish calculations (Mörner 1987), the economic damage threshold for pea moths in fodder peas is at about 50% pods with attacks. Almost 80% of the Danish area is used for fodder peas, and since pea moths have until now only occurred in very small numbers, it has been difficult to maintain the growers' interest in pheromone traps - in spite of the fact that the traps should only be inspected twice per week instead of every other day, as in the English system.

The outlook for the monitoring system under Danish conditions

If peas continue to be grown on the present large area, keeping track of the pea moth level will become increasingly important. There is a clear tendency for the catches to be highest in the regions of the country where peas have been grown for the longest time.

In order to keep the growers' interest in pest monitoring, also in an endemic situation, the work involved must be kept at a minimum. This may be done by developing warning models for the probable time of flight activity and restricting ourselves to monitoring the flight activity around the time of the maximum activity.

From 1988, registration of pea moth flight activity has been part of a system for monitoring all important pests and diseases (five insect pests and three fungal diseases) in Danish pea fields. About 100 pea growers have once a week sent in the results of two weekly evaluations of pest and disease densities in their field. A reply giving a computer-based survey of the region and the country as well as recommendations for the field in question was sent to the grower every week.

When this system has been fully developed, it will contain an estimate of the damage threshold for each field as well as recommendations about the time of insectide application, if any. The system will be developed for use on Personal Computers.

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LES TORDEUSES DU POIS ET DE LA LUZERNE : UTILISATION DU PIEGEAGE SEXUEL POUR LA PREVISION DES RISQUES ET L'ORGANISATION DE LA LUTTE EN FRANCE

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Deux tordeuses à larve séminivore occasionnent des dégâts aux productions de légumineuses en France : la tordeuse du pois Cydia nigricana F. et la tordeuse de la luzerne Cydia medicaginis Kuzn. Le premier insecte a fait l'objet d'études en relation avec la progression récente de pois protéagineux ; quant à la tordeuse de la luzerne, il s'agit d'un insecte de description assez récente en France dont les dégâts ne concernent que les surfaces consacrées à la production de semences. Le cycle de ces insectes est comparable, puisqu'il s'agit d'espèces monovoltines, hivernant dans le sol, dont les oeufs sont déposés sur les feuilles d'où la jeune larve gagne les gousses dans lesquelles elle se développe. Les dégâts moyens de la tordeuse de la luzerne, définis par le pourcentage de grains dévorés, varient en l'absence de traitement de 1 à 10 p.100 selon les années et les zones de production. Quant à la tordeuse du pois, 10 à 20 p.100 des champs, en zone non traitée, présentent des dégâts supérieurs à 4 p.100 de grains dévorés (BADENHAUSSER et al., 1988). Les difficultés d'orienter la lutte par le comptage des adultes ou des oeufs ont entraîné depuis une dizaine d'années des recherches sur l'utilisation pratique du piégeage sexuel de ces deux tordeuses.

Modalités de piégeage

Pour les 2 espèces, on place un piège (modèle INRA breveté) par champ pourvu d'une capsule de caoutchouc imprégnée de l'attractif spécifique, la capsule étant posée sur le fond englué. Ce type de diffuseur s'est révélé aussi bon que des fibres creuses pour le piégeage de C. medicaginis. Des études successives (BOURNOVILLE, 1979 ; WALL et al., 1987) ont montré que l'acétoxy-1-dodécène 10 E (E-10 DDA) est le composé pratiquement utilisable pour la tordeuse du pois, tandis que l'acétoxy-1-dodécadiène 8 E (E-8, E-10 DDA), malgré son instabilité est un attractif puissant de C. medicaginis. La dose d'attractif est de 1 mg par capsule suite aux études conduites sur les deux espèces (WALL et al., 1987). Le piège est installé dans la bordure du champ où arrivent les vents dominants, au niveau supérieur de la végétation. En raison des cycles biologiques des insectes et de l'évolution phénologique des cultures, on adopte les dates suivantes de piégeage :

- 15 mai-15 juillet pour C. nigricana dans les cultures de pois protéagineux de printemps (5 mai-5 juillet pour le pois protéagineux d'hiver),
- 10 juin-10 août pour C. medicaginis (1er juin-1er août en Languedoc Roussillon).

La capsule attractive n'est pas changée durant la période de piégeage.

Prévision des risques et organisation de la lutte

Dès les premiers résultats, nous avons signalé la corrélation positive liant les captures de C. nigricana aux dégâts larvaires estimés par l'ouverture de 300 gousses ayant atteint leur maturité (BOURNOVILLE, 1980). L'analyse de résultats de plusieurs années (BADENHAUSSER et al., 1988) a permis d'établir une relation linéaire entre le risque (exprimé en données transformées) et les captures cumulées au 15/7. On montre ainsi que 10 p.100 de gousses attaquées (ce qui équivaut à 4 % de graines dévorées) correspondent à 700 captures cumulées. Pour intéressante qu'elle soit, cette relation ne peut pas être utilisée pour orienter la lutte. On a établi une autre régression linéaire entre le pourcentage de gousses attaquées (=p) et les captures au début du stade "gousse verte pleine". Des essais de lutte insecticide ont prouvé que ce stade est optimum pour situer des traitements insecticides contre la tordeuse du pois. La relation : arc sin $\sqrt{p} = 0,089 + 0,59.10^{-3}$ (captures Stade g.v. pleine), (r = + 0,72 pour 63 ddl) permet d'établir une estimation des risques en fonction des attaques à une période compatible avec une intervention.

On n'a pas observé une relation équivalente entre les dégâts et les captures dans le cas de C. medicaginis. Une certaine instabilité du composé attractif, qui ne peut pas être compensée par l'adjonction d'anti-oxydant, est peut être à mettre en cause. En revanche, le suivi de la courbe de vol obtenu par le piégeage sexuel de la tordeuse de la luzerne et notamment de son maximum qui précède d'environ une semaine l'éclosion de 50 p.100 des oeufs, a permis d'orienter la protection, dans les zones à risque, sous réserve que la culture présente le stade sensible à la pénétration de la jeune chenille (stade gousse verte lâche). Des essais de traitement insecticides ont confirmé ces résultats: on situe l'intervention une semaine après le pic de vol.

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THE PROBLEM OF CONVERTING SEX TRAP CATCHES INTO RISK LEVELS - AGROTIS SEGETUM AS AN EXAMPLE.

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SUMMARY

Agrotis segetum sex trap catches during 7 years in Denmark and damage registrations have been used to examine possible relationships. No direct relation could be established, but larval mortality due to low temperature and soil moisture could explain the disturbing variations. Forecasting has been gradually improved by including these factors. The conclusion is that it may not always be realistic to request direct catch-damage relationships. The ecological strategy applying to each species has to be considered. Useful risk levels may be expressed via sex trap catches together with several other parameters.

INTRODUCTION

Economic damage thresholds and the derived control thresholds are basic elements of IPM. For practical use of thresholds monitoring of pest populations and establishment of pop.density-yield relations are essential. The crucial step is development of simple, robust monitoring methods and expressing farmer-relevant risk levels based on monitoring results. In this respect sex traps are of particular interest and mostly risk levels are expressed directly by catch per time unit. It is, however, questionable how reasonable this procedure is in general, as:

1) Sex trap catches may not picture more than mating success
2) There are several life stages between the one caught and the one causing damage. As each life stage may be vulnerable to varying mortality effects, a considerable variation in the number of damaging individuals produced by the same initial number is likely. This trouble has been anticipated in Danish A. segetum forecasting and it may now be elucidated by catch-damage experiences and results of selected experiments under controlled conditions.

MONITORING AND DAMAGE

A. segetum has been monitored in Denmark 1982-1988 by means of 3 sex traps per locality and with 3-component synthetic pheromone (Arn et al., 1983) as lure and a trap design selected by Esbjerg et al. (1982). Further details about the monitoring in Denmark have been reported by Esbjerg (in print). Considerable annual and geographical variation in the cathes has been reported, and as a main principle, forecastings have not been issued solely on the basis of the catch. Also statistically based knowledge of weather influence (Mikkelsen & Esbjerg, 1981) has been used. In order to compare with other monitoring systems, possible relations between total catch during the season, total catch above a certain level, number of days and weeks of catches above a certain level and the subsequent damage on redbeets and carrots at selected localities have been examined. It has not been possible to establish any direct conversion of A. segetum catch into a risk measure.

INCORPORATION OF OTHER RELEVANT DAMAGE FACTORS

The lack of direct catch-damage relation is not astonishing, as it has been shown for both Denmark (Mikkelsen & Esbjerg, 1981) and the UK (Bowden et al., 1983) that major attack fluctuations are caused mainly by temperature and precipitation conditions during the summer. Experiments have confirmed that temperature (Esbjerg, in preparation) and soil moisture (Esbjerg et al., 1986) are very important larval mortality factors, mortality for all larval instars being 75% at 15°C and dry conditions, but only 30% at 25°C, and mortality among L_1-L_2 at 20°C being approx. 90% if the soil surface is moist for more than two weeks. In view of this effect, soil type and crop structure are also important elements. Forecasting has been improved via increased incorporation of temperature and precipitation into a risk-level system based on crop and soil type as fixed parameters and with catch, temperature and precipitation as variables.

CONCLUSIONS

The experience with A. segetum in Denmark shows a clear lack of direct catch-damage relationship which may lead to the conclusion that 1) it may prove profitable to preconsider the likelyhood of catch-damage relationships according to ecological strategy (r versus k) of the species; 2) some established thresholds may in reality be very rough and may be improved, and 3) improved thresholds may be established via combinations of the traditional trial-and error field experiment and more detailed experiments under controlled conditions.

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POPULATION MONITORING OF AGROTIS SEGETUM AND PSEUDALETIA UNIPUNCTA BY PHEROMONE TRAPS AND INSECTICIDE APPLICATION TIMING. COMPARISON WITH LIGHT TRAP CAPTURES

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Summary

The turnip moth, Agrotis segetum Schiff and the armyworm, Pseudaletia unipuncta (Haw.) (Lepidoptera, Noctuidae) occasionally cause considerable damage to various crops in Greece. Modified International Pheromones type plastic traps, baited with a blend of 30μg from each of Z5-10:Ac, Z7-12:Ac and Z9-14:Ac for the turnip moth and 500μg Z-11-16:Ac and 1μg Z-11-16:Ol for the armyworm were used to monitor insect populations in NE Peloponnese, SE, SW, Central and Northern Greece. In Kopais (Central Greece), a Pennsylvania type light trap was also in operation. The turnip moth appeared the year round in South and Central Greece and April to November in Northern Greece. Four to five discrete flights were recorded. The armyworm was active from April to November. Only in Eleftheroupoli was there a high population density early in April-May. Since the damage reported by the two species concerns spring crops, their population density is of practical value in their first flight. A forecast is, therefore, possible, whenever high populations occur during winter-spring, considering the ensuing young larval generation. Comparison of pheromone- with light- trap captures showed that both types described more or less the general population trend in the two species.

Introduction

The turnip moth, Agrotis segetum, occasionally builds up high population numbers and causes serious damage to spring crops such as: maize, cotton, tobacco, sugar beets, vegetables, necessitating reimplantation. Occasional population outbreaks in Pseudaletia unipuncta have caused serious damage to maize in the areas of Eleftheroupoli, Serres and Drama in Northern Greece.

The present study aimed at studing seasonal appearance and adult population fluctuation of the two species by pheromone traps and comparing captures of pheromone with light traps.

Materials and Methods

Three modified International Pheromone traps (Phytophyl Co. Ltd., Athens, Greece) were used in each location placed 100m apart. Small Vapona plaquettes were used as killing agent. A blend of 30μg from each of Z-5-10:Ac, Z-7-12:Ac and Z-9-14:Ac (Arn et al. 1983) for A. segetum, and 500μg of Z-11-16:Ac and

1μg Z-11-16:01 (Arn, personal communication) for P.unipuncta were used in polypropylene dispensers exchanged every month. Traps were checked twice a week. Both species were monitored in the areas of Varda (W. Peloponnese), Agrinio (SW. Greece), Kopais (C. Greece), Istiaea (E. C. Greece), Eleftheroupoli, Chryssoupoli, Serres, Drama (N. Greece) during the years 1987-1988. In Kopais, pheromone with BL ligth trap (Pennsylvania type, 15 Watt) captures were compared in 1985-1988.

Results and Discussion

Adult activity of A. segetum occurs throughout the year in Central and South Greece, but it ceases from mid-December to March in Northern Greece. Population numbers diminish during October-February and there seem to appear 4-5 flights per year. The armyworm, P. unipuncta, does not show any activity from February to April except in Varda where it appears almost throughout the year. The population levels and the number of flights, presumably four, however, differ from place to place being more abundant in the North. In Eleftheroupoli, where it causes considerable damage occasionally, there exists an increased activity early in the season from April. It seems that there exist locally favorable conditions for the creation of high populations in certain years when problems are detected. Migrations of the insect have not been studied as assumed elsewhere (FIELDS and MCNIEL, 1984) and they are not likely to be the cause of attack. The species cause damage to spring crops. Later generations find the plants grown and not susceptible to damage. It is possible, therefore, to use pheromones for population monitoring and to supervise for taking control actions with insecticides, if necessitated. Since correlation between trap catches and infestation levels has not been studied in Greece, and experience in other countries has shown that such data have not been found reliable, trap capture data could be used for supervision of the larval populations of both species. Folliar treatment against the armyworm and soil treatment against the turnip moth. Treatment of the latter could take care of Agrotis ipsilon larval populations, monitored equally well with pheromones (unpublished data), the insect causing similar to the turnip moth damage. The trap comparison data showed a general population trend in both kinds, although the pheromone traps caught higher numbers in A. segetum. The results were more or less similar in P. unipuncta. The results support the use of pheromone traps for population monitoring.

Acknowledgements

Supply of part of the pheromone dispensers used and information from Drs. R. Bues and H. Arn are gratefully acknowledged.

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FIELD TESTING OF VARIOUS PARAMETERS FOR THE DEVELOPMENT OF A PHEROMONE BASED SYSTEM FOR THE CORN STALK BORER, SESAMIA NONAGRIODES (LEF.), (LEPIDOPTERA : NOCTUIDAE).

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Summary
Different sex pheromone trap designs were tested for trap ping the corn stalk borer Sesamia nonagrioides (Lef.) males. The funnel type moth trap was the more effective than the other pheromone trap designs tested. To determine an optimal sex pheromone blend for attracting males field studies were conducted using pheromone baited funnel type moth traps. Tests with various combinations of the four components found in sex pheromone glands indicated that a blend of Z-11 hexa decenyl acetate, dodecyl acetate, Z-11-hexadecenal and Z-11-hexadcenol dispensed to rubber septa at a ratio of 69:15:8 :8 was optimal. Dose-response relationship was also exami ned, traps baited with 40 µg of the pheromone blend attra cted more males than the other concentrations tested.

1.1 Introduction

Sreng et al., (1985) reported that, the, Sesamia nonagrioi des, utilizes a sex pheromone system composed of two components, Z-11-hexadecenyl acetate (Z-1116:Ac) and Z-11-16:OH. This identi fication was confirmed by Rottundo et al., (1985), they further indicated that the synthesized two component blend (95:5) attra cted also high numbers of, Pseudaletia unipuncta (Haworth), males Later, Mazomenos, (1985,1987), identified two additional compo-nents, from diethyl ether washes of virgin females and headspace volatiles, namely, Z-11-hexadecenal (Z-11-16 :Ald) and dodecyl acetate (12:OAc), which improve male captures in field tests. Although previous field tests have shown promising results (Mazomenos et al., 19 87), further information is required to maximized the use of pheromone traps in a control program. This paper present data from studies conducted to determine the rela tive efficiency of different pheromone trap designs, the most effective sex pheromone blend, and the relative attractiveness of various pheromone concentrations.

1.2 Methods and Materials

In 1985 one field test was carried out to compare the effi cacy of different trap designs. The type of traps tested were: (a) Delta trap (INRA), (b) Cylindrical trap, from PVC drainpipe

16 cm long, 10 cm (od). In both traps sticky material was used to kill or immobilize the attracted males. (c) 1.5 liter plastic cylindrical bottle, the bottle was filled with water with an oil-layer to reduce evaporation and hold the trapped males. (d) Pla stic funnel used for other noctuid species and (e) funnel type moth trap. A slow release formulation of DVP (Vapona) was used as killing agent for traps (d) and (e). The pheromone was dispensed from rubber septa loaded with 250 μg of the pheromone.

In 1987 two field tests were conducted. In the first test the funnel type moth traps were baited with rubber septa contai ning different concentrations of the pheromone blend. In the se cond the traps were baited with each pheromone component and blends containing the Z-11-16:0Ac and one, two or three secondary components.

1.3 Results and Discussion

The funnel type moth trap proved to be the most effective trap. Nighttime observations in the field revealed that the males which were attracted did not fly directly to the pheromone sour-ce, but they were landed on the trap and then they were walking to the pheromone source. This type of male behaviour was of favor to the funnel moth trap. Funnel moth trap was selected for fur-ther studies and insect monitoring.

A dose response relationship field test was design to deter mine the most effective lure and the upper and lower limit of ma le responsiveness. The concentration of pheromone in the lure had a significant effect on the number of males caught. It appears that there are limits for S. nonagrioides males, because traps baited with 10, 320,640 and 1280 μg lures caught significantly less than those with 40 μg. The 40 μg lure proved to be the most effective in 1987, however in earlier tests using a different ty-pe of rubber septa the 200 μg lure was the most effective. The difference may be the result of different evaporation rates or may be due to the chemicals added to manufacturing of the septa.

Results from the test designed to test the attractiveness of each pheromone component and the combinations of Z-11-16:0Ac with one, two or three of the secondary components indicated that Z-11 -16:0Ac attracted males. The secondary components when added indi vidually or two in ratio similar to that found in the female vola tiles slightly increased catches. The blend of the four component in a 69:15:8:8 ratio attracted signicantly more males.

In our field tests, traps baited with Z-11-16:0Ac and combi nations with the alcohol or the dodecyl acetate attracted also quite high number of Pseudaletia unipuncta males. The male cat ches were signicantly reduced in traps baited with the four compo nent blend.

Clearly traps baited with the four component blend may be used as a specific and effective monitor for adult S.nonagrioides However the relationship between number of males trapped and the number of egg masses or larvae found to feeding in the field need to be established.

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FIELD EVALUATION OF SOME BLENDS AS SEX ATTRACTANTS FOR **Sesamia nonagriodides** LEF MALES

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The noctuid moth Sesamia nonagrioides Lef is a major pest of maize in the mediterranean area. Some components of S. nonagrioides female pheromone were identified by Sreng et al. (1985) ((Z-11)-HDA; (Z-11)-HDol; 90:10) and Mazomenos et al. (1987) ((Z-11) HDA; (Z-11)-HDol; (Z-11)-HDal; DDA, 65:8:8:15).

In order to evaluate their specifity, some field trials have been carried out in 1986, 1987 and 1988 in Catalonia (NE of Iberian peninsula).

Both of two tested blends trapped significant numbers of noctuid males others than S. nonagrioides, particularly of Discestra trifolii (Rottenberg). Noticiable captures of noctuids Oria musculosa (Hübner); Xanthodes graellsi (Feisthamel); Mamestra oleracea (L.); Ochropleura plecta (L.) and Mythimna unipuncta (Haworth) were also recorded in 1988.

The statistical comparison (ANOVA and Duncan test) in 1988 did not show significant differences ($p \angle$ 0,005) between S. nonagrioides and D. trifolii trapped by the two tested blends.

Since D. trifolii had never been trapped when S. nonagrioides virgin females were used (1985 and 1985 unpublished results) more experimental works has to be done in order to identify the exact components of the mediterranean corn borer pheromone and their proportion.

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PROBLEMS IN MONITORING POPULATIONS OF CABBAGE ROOT FLY, DELIA RADICUM, WITH TRAPS BAITED WITH HOST-PLANT CHEMICALS

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Introduction

The water traps used at Wellesbourne for capturing cabbage root fly (*Delia radicum*) consist of plastic dishes sprayed fluorescent yellow. Earlier experiments indicated that such traps caught more flies when fitted with a dispenser releasing allylisothiocyanate (ANCS), one of the odorous chemicals that attracts cabbage root flies to their cruciferous host plants. Attempts to reduce root fly populations directly by adding synthetic and naturally-occurring isothiocyanates to traps were unsuccessful (Finch & Skinner, 1982). Nevertheless, host-plant attractants that improve the performance of monitoring traps may still be useful in pest control. Results on the effectiveness of water-traps (standard traps) and similar traps releasing ANCS (ANCS traps) are compared in this paper.

Experimental

During 1982, 1983 & 1985, three standard traps and three ANCS traps were spaced alternately through plots of cauliflowers, each containing 4900 plants. Cabbage root flies were collected from the traps each Monday, Wednesday and Friday. Fly eggs laid on the plots were sampled by scraping soil from around the base of 20 plants.

At the start of the first generation of flies in May, first flies were caught at the same time in both types of trap. Approximately 20 and 45 eggs/plant were recovered from the soil samples collected during the week of peak egg-laying by the first and second generation of flies, respectively. The numbers of flies caught in the standard traps in the week preceding maximum oviposition, the most appropriate time to decide whether an insecticide is warranted on established crops, varied between 25-30 and 55-65 for the two generations, respectively. Despite being smaller, the first generation infestation severely damaged the roots of the crop whereas the second generation infestation had no noticeable effect on the roots. In each year, peak egg-laying occurred before peak numbers of flies were caught.

The relationship between the numbers of flies caught in ANCS and standard traps was not constant. It changed throughout the year and varied considerably from one year to the next (Table 1).

Table 1. Monthly ratios of the numbers of flies caught in ANCS: standard traps

Year	May	June	July	August	September	Total females caught
1982	2.5:1	3.5:1	5:1	9.5:1	20:1	
1983	3.5:1	2:1	2:1	4:1	5:1	
1985	6:1	3:1	2.5:1	5:1	8.5:1	61000

In 1982 the ANCS traps became more effective as the season progressed, rising from about 2.5 times as effective as the standard traps in May to 20 times as effective by late September. Despite the large numbers of females caught during August and September in 1982 (43/trap/day), few eggs were collected during these months. Hence, the numbers of females caught in ANCS traps appeared to be a poor indicator of the period when insecticidal protection is needed. In the standard traps, most females (15/trap/day) were caught during late July, shortly after peak oviposition by the second generation of flies, and fewest (2/trap/day) in September when oviposition was low. Hence the standard traps gave the better indication of the period when crops were most at risk from cabbage root fly attack.

The relationship between the numbers of flies caught in ANCS traps and standard traps was highly variable throughout 1983. In 1986 a high response to ANCS traps occurred in late May, shortly after peak oviposition by the first generation of flies. In the remaining part of the exeriment, captures again increased markedly in late August and throughout September.

Discussion

To be useful in an insect monitoring system, the traps should not alter the probability of an insect being caught and the chance of insects being caught must be similar for all individuals (Moran, 1951). Neither condition was satisfied by the ANCS traps used in these experiments. As usual with traps releasing volatile chemicals to attract day-flying insects, the numbers of insects caught increased dramatically in periods of warm settled weather. Similarly, the chance of being caught did not remain equal for all individuals in these experiments, as captures in ANCS traps increased dramatically once the females had laid most of their eggs. It seems that when only the number of flies caught is considered, ANCS traps regularly overestimate the size of the fly population.

There seems little to be gained from including volatile host-plant chemicals in traps for catching cabbage root fly and closely-related dipterous pests of vegetable crops. Data for accurate cabbage root fly forecasting schemes (Finch & Collier, 1986) can be obtained readily from non-chemical traps painted an appropriate colour. Furthermore, if the numbers of females caught in standard traps is to be used in monitoring schemes to decide whether or not an insecticide treatment is warranted, then separate "threshold numbers" will be required for the two generations.

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MONITORING SPODOPTERA EXEMPTA IN EAST AFRICA.

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Summary

A wide network of pheromone and light traps is used in many countries of Eastern Africa to monitor moth populations of the African armyworm. *Spodoptera exempta* (Wlk). This paper presents an account of the biology of the African armyworm to highlight those aspects which are important to the understanding and application of trap results; in particular those which relate to moth migration, and the subsequent concentration of moths to oviposit and cause outbreaks of caterpillars in high densities. Brief mention is made of the composition of the pheromone lure used and of the practical results of recent studies made to improve lure and trap design. The history is then given of the development of the trap networks in ten member and neighbouring countries of the Desert Locust Control Organisation. The distinct requirements of networks for particular purposes are reviewed. These include the traps for the national and regional armyworm outbreak forecast services; for the investigation of moth source areas; for the early detection and control of primary outbreaks; for high risk crops; and for research.

1.1. Introduction

The African armyworm is the caterpillar of a noctuid moth, *Spodoptera exempta* (Wlk) which may migrate long distances, carried downwind, flying at night. Those which are carried to places of wind convergence and rainfall are concentrated in the air by storm outflows, and often settle in trees at night to mate. Many pairs may be seen in each tree between 0100-0300h in areas of concentration. The moths hide during the following day under tufts of grass, dung and tree bark before emerging at dusk. Female moths are then to be found sitting head upwards on grasses, whereas males are mostly flying, being caught in large numbers in pheromone and light-traps. The females turn to a head-down position about 2100h to deposit about 500 eggs in a mass on the grass. The eggs usually hatch in 3-5 days, and if grasses are favourable there is a high survival of the newly hatched caterpillars which feed by scraping the surface of leaves of host graminae until they reach IIIrd instar. The subsequent moult is accompanied by physical and physological changes which are crucial to their importance as crop pests. Their mandibles change from fine scraping teeth to powerful biting tools capable of chewing fully grown leaves of host plants (C.F. Dewhurst, pers.comm). and if the caterpillars are crowded there is a change to the gregaria phase, typical of armyworm outbreaks. The caterpillars become hyperactive, predominantly black, and may occur in densities as high as 100-1000 per square metre sometimes over many thousands of square kilometres. They are then the cause of serious losses to cereal crops and pastures. Uncrowded caterpillars remain passive, with cryptic colouration, in solitaria phase in low densities.

The caterpillar stage extends for 2-3 weeks, then pupation occurs in the ground. At an outbreak site there is a mass emergence of moths from the ground 7-10 days later during the early part of the night. Newly emerged moths fly into nearby trees, and the trees are spectacular with many resting before dispersal. The main migration flights occur about midnight on the night of emergence or at dusk the following evening. (Rose & Dewhurst 1979).

1.2 Biological considerations.

Points to stress are:

a) Pheromone traps do not attract freshly emerged males at the site of emergence. This has been noted on many occasions when large numbers of moths have stayed overnight before dispersal. They may be attracted after dispersal, less than a day later (Rose *et al* 1985). High numbers are found in traps only in places where moths have been concentrated after dispersal.

b) Catches in traps are generally associated with rainfall, where moths settle and are concentrated. Also female moths require water, generally provided by rainfall, to develop to maturity, and they may hold-up development in its absence for several days (Page, 1988). The relationship with rainfall may also be complex for males, and this is indicated by pheromone traps which catchafter a shower of rain during daylight during a long dry period.

c) Pheromone traps catch male moths throughout the night with peak numbers between 0100-0300h, and with only a low number caught during the day (Dewhurst, 1984). Even so, during the serious outbreak in 1984, moths came to pheromone capsules held in the hand during daylight wherever observers stopped in an area of 100,000 sq. kilometres. This proved a quick method for estimating the size of a potential outbreak.

d) Moths have been seen to fly upwind to traps for a distance of twenty metres. Observations have not been made for longer distances.

e) Light traps complement pheromone traps for monitoring populations because they attract both male and female moths of all ages. Oocytes can be measured and spermatophores counted to assess physiological age of populations, and the sex ratios of catches can be estimated to distinguish migrants with even ratios from settled populations which are predominantly male.

f) Light traps capture many more males than pheromone traps until the population is settled. Then the situation is reversed. Consequently the positive correlation found between numbers of male moths caught in light and pheromone traps (Campion *et al*, 1976) does not hold in these circumstances.

1.3 Chemical and Physical Considerations.

The lure used is a mixture of (Z)-9- tetradecenyl acetate (Z9-14AC) and (Z)9,(E)12- tetradecadienyl acetate (ZE9,12-14AC) in a ratio of 100:7.5. This mixture was synthesised following a preliminary analysis of the natural sex pheromone in 1975 (Beevor *et al* 1975). The mixture is loaded at the rate of 4mg in a rubber septa, with the addition of an anti-oxidant. Until 1986, vials and then septa, were prepared in London and sent to Nairobi. Since then septa have been loaded in Nairobi by technicians of DLCO-EA. The original pheromone lures have been highly satisfactory. Further analyses of the natural sex pheromone have detected four other components which have been investigated by the pheromone scientists at ODNRI (Cork *et al*, in press), and one of these, (Z)-11- hexadecenyl acetate added to the other two components has sometimes improved the lure and is still being investigated. Studies of trap design have shown that sticky and yellow funnel traps are more effective than the early traps used and these are being introduced into the national trap networks.

1.4 Field Application

Armyworm moth traps were introduced initially into Eastern Africa in order to monitor populations and understand their movements (Brown et al 1969). During the period 1961-69 a network of light traps was developed in Kenya, Tanzania and Uganda (Odiyo 1979), daily catches of S.exempta were recorded and analysis confirmed that there were seasonal movements of moths. In 1969 an armyworm forecast service was introduced and this used trap catch data, outbreak records and weather data to warn farmers of impending outbreaks. This service, centred on the East African Agriculture and Foresty Organisation, was expanded to all member countries of the Desert Locust Control Organisation in 1977 and since then to other neighbouring countries, as well as countries in southern and western Africa. Trap networks are now maintained in Djibout, Ethiopia, Kenya, Somalia, Tanzania and Uganda (DLCO-EA member countries) and the neighbouring countries of Burundi, Malawi and the Yemen.

Pheromone traps were introduced into the networks in 1977 and now there are more pheromone than light traps.

There are five main uses for pheromone traps in the DLCO-EA region:-

a) The Armyworm forecast service:

Each member country is responsible for its own moth traps, their supervision, maintenance, collection of daily records and preliminary analysis. In some countries especially Kenya and Tanzania, a full national armyworm forecast service is operated with forecasts being sent weekly to concerned agricultural personnel. All member countries have National Armyworm Programme Co-ordinators, and there is a weekly exchange of information between the national and the regional DLCO-EA forecast services. Kenya and Tanzania have the most traps with over fifty light and pheromone traps placed in selected areas in each country.

Forecasts are based on the analysis of the daily trap catches, wind streamline charts, positions of previous outbreaks, and rainfall (Odiyo 1979). From the size of caterpillars, particularly head capsule measurements, dates of arrival of parent moths and emergence of derived moths can be estimated, and this is valuable for improving accuracy of forecasts and understanding the seasonal movements of moths for development of control strategies. The time and place of rainfall, particularly at the beginning of the wet season after drought, marks areas where outbreaks are most likely to develop. The use of Meteosat infra-red images of high cumulus cloud cover has enabled these areas to be predicted with greater accurancy. The project is now at the stage of completing the data bank on micro computer and developing computer software for a forecast system. Software for comparing current and historical records for any place and time, for preparation of maps and for estimating moth development times from outbreak records, has been developed. (R. Day, pers.comm).

b) Investigation of moth source areas:

Networks of pheromone traps are maintained and visited monthly in areas where populations are suspected of persisting for all or most of the year. Presently these are placed in the coastal regions of Kenya and Tanzania and in Southern Ethiopia. Persistent populations have been recorded for three years in the coastal region of Kenya.

c) Detection of primary armyworm outbreaks:
Certain areas of Kenya and Tanzania are known as primary outbreak areas because the first outbreaks of the season often occur there. They are generally areas with low and erratic rainfall. Moths concentrated by early rain storms are able to start outbreaks which then lead to spread of secondary outbreaks in the region.

Pheromone traps are placed in high density within the areas during the vulnerable period of the year, under the supervision of local extension officers. When 20 moths or more are captured in one night the extension officer organises surveys for caterpillars and their control, and reports to district officers.

d) High risk area traps:
These are traps used on large farms to provide early warning during the period that susceptible crops are grown. The farmer is fully responsible for trap maintenance.

e) Research.
Pheromone lures placed on plastic sheets, coated with sticky materials and fixed to the ground with nails, have been found to be useful for mark and capture experiments to record distances migrated by moths from emergence sites (Rose et al, 1985). These traps are quickly made in large numbers for short term usage.

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UTILISATION DE PIEGES A ATTRACTIF SEXUEL POUR L'AVERTISSEMENT DES ATTAQUES DE CHENILLES DE SPODOPTERA FRUGIPERDA EN PRAIRIES GUYANAISES

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Résumé

Des expérimentations réalisées en Guyane française depuis 1979 ont montré que l'on pouvait utiliser des pièges à attractif sexuel pour l'avertissement des attaques de chenilles de Spodoptera frugiperda (J.E. Smith) en prairie. Sur la base de ces résultats, un réseau expérimental d'avertissement a été mis en place en 1983. Compte tenu des résultats positifs obtenus, ce réseau est devenu opérationnel en 1985; date à laquelle sa gestion a été confiée au Service de la Protection des Végétaux. La méthodologie de piégeage a été progressivement simplifiée et améliorée par l'utilisation de nouvelles formulations phéromonales et de pièges plus faciles d'emploi; alors que la précision de l'avertissement bénéficiait du développement des connaissances relatives à la dynamique des populations de S. frugiperda en prairies.

1. Le problème entomologique

Les prairies artificielles, établies à partir de 1976 en Guyane française, ont fait l'objet, dès leur implantation, d'attaques dévastatrices de chenilles de lépidoptères Noctuidae. L'utilisation tardive de produits insecticides ne permettait pas d'éviter la perte de quantités importantes d'herbe et la réapparition des chenilles quelques semaines plus tard. Deux espèces de noctuelles étaient responsables de cette situation : Spodoptera frugiperda (J.E. Smith), la plus importante d'un point de vue économique, et Mocis latipes (Guenée). Sur le plan appliqué, l'efficacité des produits insecticides utilisés ne paraissant pas être en cause, il apparaissait essentiel de pouvoir fournir aux agriculteurs une information précise sur les risques et les dates d'apparition des pullulations de chenilles. Nos travaux se sont donc orientés vers la mise au point d'un dispositif d'avertissement des attaques de chenilles, basé sur le suivi, au moyen de pièges à attractif sexuel, des populations de papillons.

2. Mise en évidence de l'efficacité du piégeage sexuel comme méthode de prévision de l'évolution des populations larvaires de S. frugiperda. Mise en place d'un dispositif expérimental d'avertissement. Amélioration du dispositif et de la validité des avertissements réalisés.

L'utilisation de pièges à glu et d'Acétoxy-1 dodécène-9Z (Z9-DDA) comme attractif, a permis de mettre en évidence une corrélation forte et significative (rs=0,70) entre les captures de papillons et le nombre de chenilles récoltées la semaine suivante dans les prairies. Parallèlement l'examen des courbes de vol des papillons et de récolte des chenilles a montré que l'insecte présente en Guyane une génération toutes les 4 à 5 semaines; il était donc possible de prévoir un mois à l'avance la date d'apparition de la génération suivante. Ces résultats ont été confirmés sur un second site, situé à 100 km du premier. La similitude temporelle des résultats obtenus sur ces deux sites permettait de penser que l'évolution saisonnière de S. frugiperda obéissait à un même schéma général tout au long de la bande côtière. Compte tenu du caractère très positif de ces observations, un réseau expérimental de stations d'avertissement, constitué de neuf stations, a été mis en place en 1983 avec l'aide du Service de la Protection des Végétaux. Une formulation phéromonale plus complexe était utilisée et des pièges en plastique à cône testés sur deux des stations. Les résultats fournis par ce réseau ont confirmé ceux obtenus précédemment et en particulier le fait que les populations de S. frugiperda évoluent au cours du temps de façon similaire tout au long de la bande côtière; ce qui conduit à penser que les phénomènes migratoires ne jouent pas un rôle important dans la dynamique des populations de cette espèce en Guyane. De nombreux messages d'avertissement ont pu être diffusés à l'attention des éleveurs. La gestion du réseau a été confiée en 1985 au SPV.

Entre 1985 et 1987, en liaison avec les chercheurs de l'INRA, de nouveaux types de pièges et de nouvelles phéromones ont été testés en vue de simplifier la méthodologie de piégeage et d'améliorer la précision des avertissements réalisés, tout en en diminuant le coût (entre février et août 1987, le coefficient de corrélation des rangs obtenu en comparant captures de papillons et récoltes de chenilles la semaine suivante a atteint une valeur maximale de 0,87). L'étude de la dynamique des populations de l'insecte permet de mettre en évidence l'importance de la corrélation existant entre l'évolution des populations de S. frugiperda et l'évolution temporelle de la pluviosité. Enfin, au niveau de l'exploitation agricole, l'étude des modalités d'infestation des prairies permet de prévoir, en cas de pâturage tournant, dans quelles parcelles les chenilles seront susceptibles de pulluler après un vol important de papillons.

3. L'avertissement des attaques de chenilles de S. frugiperda.

La prévision des risques de pullulations de chenilles se fait en deux temps : la période d'apparition de la génération mensuelle est d'abord estimée à partir de l'analyse des courbes de capture de papillons. Puis une prévision hebdomadaire de l'évolution des populations est entreprise à partir des résultats des derniers piégeages réalisés, en tenant compte de l'évolution de la pluviosité au cours des semaines précédentes. Un message d'avertissement sera diffusé lorsque plus de 5 papillons auront été capturés par piège et par nuit; l'éleveur étant alors incité à surveiller prioritairement certaines parcelles de son exploitation, en fonction de la nature de la graminée utilisée, de sa densité de recouvrement et de son âge-repousse.

4. Perspectives d'Avenir.

Alors que la méthodologie de piégeage mise au point dans le cadre de cette étude à déjà pu être utilisée pour le suivi des populations d'autres noctuelles déprédatrices des cultures en Guyane (Mocis latipes, Anticarsia gemmatalis), la mise en place dans un autre pays ou une autre région d'Amérique du Sud d'une telle structure d'avertissement est envisagée.

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UTILISATION DU PIEGEAGE SEXUEL POUR L'ETUDE DES MIGRATIONS DE *Agrotis ipsilon* Hufnagel (*Lepidoptera Noctuidae*) COMPARAISON AVEC LE PIEGEAGE LUMINEUX

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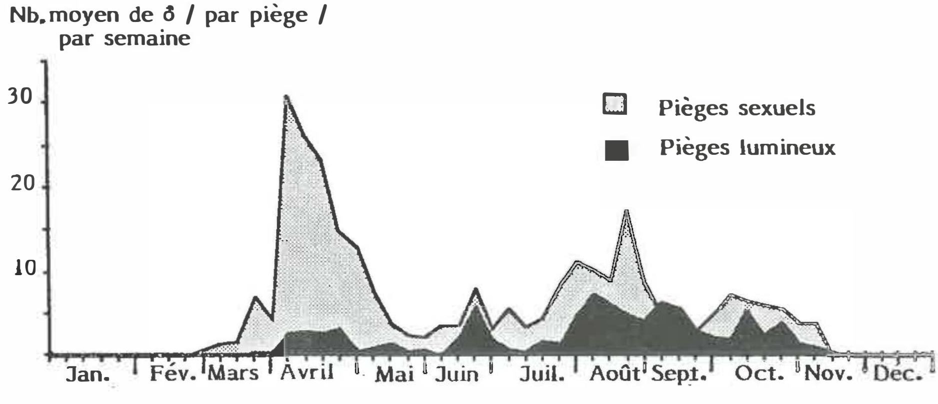
La mise en évidence en tunnel de vol du rôle synergique d'un troisième composé, le Z11-16:Ac chez *A. ipsilon* (**CAUSSE & al**, 1985; **WAKAMURA & al**, 1986), en complément du Z7-12:Ac et du Z9-14:Ac, déjà déterminé par **HILL & al** (1981) a permis, d'une part de mettre en place dès 1987 un réseau de piégeage de surveillance au niveau national et d'effectuer par ailleurs une étude comparative du piégeage sexuel et lumineux dans le sud de la France, à proximité du littoral méditerranéen.

Des pièges sexuels à eau et des pièges lumineux de type pensylvannien à lumière actinique ont été utilisés. Ils sont situés à 1,5m. du sol, distants de 50m. à 300m. et relevés deux fois par semaine. Le complexe phéromonal est donc constitué d'un mélange de 20 μg. de Z7-12:Ac; 5 μg. de Z9-14:Ac et de 20 μg. de Z11-16:Ac par capsule.

Chez cette espèce on décèle généralement par piégeage 3 périodes de vol (4 dans l'extrême sud de la France), plus ou moins bien séparées selon les années ou les lieux de capture. Pour un certain nombre de localités de piégeage caractéristique, allant de Colmar au littoral méditerranéen, nous constatons en ce qui concerne le 1er vol, que les captures diminuent proportionnellement du sud vers le nord, tandis que le phénomène inverse se produit pour le 2ème vol avec des taux de captures d'autant plus importants que la latitude est élevée.

Ces résultats confirment donc l'hypothèse selon laquelle ce 1er vol serait un vol d'immigration, se produisant au printemps par le sud de la France. La population est à ce moment bien représentée dans le sud (49 à 63% du total des captures annuelles) tandis que quelques individus arrivent à atteindre le nord (12% à Colmar). Le 2ème vol correspondrait à la descendance de cette population immigrante, dont une petite partie seulement se reproduit sur place (16% en Camargue) alors que l'autre partie, plus importante, continue son déplacement vers le nord pour atteindre 74% à Colmar. Au cours du 3ème vol les pourcentages tendent à s'uniformiser dans toutes les régions ce qui dénote, partout en France à ce moment, la présence d'un mélange de populations.

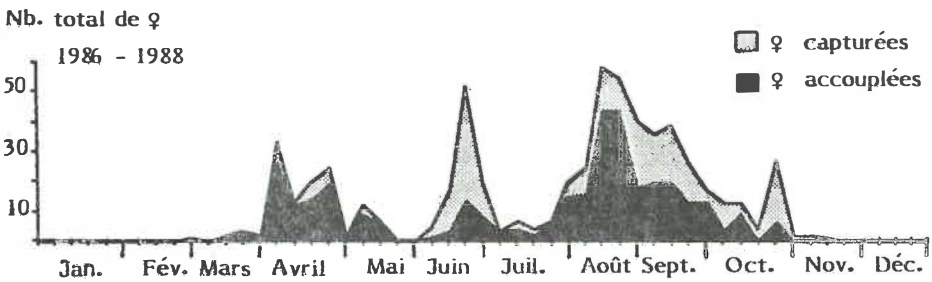
De 1984 à 1988 a été effectué par ailleurs une étude comparative du piégeage sexuel et lumineux, dont les résultats ont été regroupés sur le graphique suivant.



Tout d'abord du point de vue quantitatif, on peut dire que dans l'ensemble les pièges sexuels capturent plus que les pièges lumineux. Ces résultats ont déjà été observés pour d'autres espèces par CAMPION (1976), NASR & VISSA (1978) et ESBERG & al (1980).

Bien qu'il existe d'importantes variations, non seulement entre différents pièges au sein d'une même année, mais surtout entre pièges situés aux mêmes endroits selon les années, ces deux types de piégeage mettent en évidence des fluctuations de population identiques et permettent d'observer et de séparer plus ou moins bien les 4 vols. Mais la différence fondamentale qu'il faut noter, réside dans l'importance du 1er vol ou vol d'immigration, beaucoup mieux caractérisé par les pièges sexuels. En automne les 3ème et 4ème vols d'émigration quoique quantitativement plus faibles, paraissent mieux différenciés aux pièges lumineux. WILSON (1981), par des comparaisons similaires sur la même espèce, avait montré surtout l'importance du vol d'été au piège lumineux.

La présence des femelles aux pièges lumineux, permet de constater que les deux sexes de *A. ipsilon* sont capturés simultanément et que leur sex-ratio, dont la valeur moyenne se situe autour de 0,55, reste relativement constant dans le temps. Par contre la dissection de toutes ces femelles fait apparaître un taux d'accouplement plus fluctuant, avec des valeurs de 74,6%, 36,2% et 58,2% respectivement pour les trois premiers vols; le nombre de données concernant le 4ème vol étant trop faible pour prendre en compte le nombre de femelles accouplées. Ces résultats sont représentés sur le graphique suivant.



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MONITORING OF CABBAGE ARMYWORM BY MEANS OF PHEROMONE TRAPS

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ABSTRACT

Cabbage armyworm *Mamestra brassicae* L. is a very serious pest on field crops in some regions of Eurasia. In this conection estimation of the exact beginning of the flight, peaks of the flight, as well as the relative population density of it is quite important for an effective control.

Institute of Zoology, cooperated with Institute of Organic Chemistry, Bulgarian Academy of Sciences, has supplyed some Stations of Agrochemical Survice in Bulgaria with pheromone caps for the cabbage armyworm since 1984. The effective use of the pheromone traps for this pest however is limitted in some cases by either unadequate to the population level of the moth low catches or unadequate to the population state leaps of the catches.

Low catches (appart the situation when they reflect a low population level in nature) could be due to impropriate pheromone blend, impropriate rate of pheromone evaporation or impropriate design of the trap used. Among the related to the main pheromone component of the species, we failed to find any one, more effective than Z-11-hexadecenal in Bulgaria (Subchev et al., 1987). We beleive also that the sticky traps (Pherocon 1C) used in Bulgaria, are not the most appropriated one, because of the rapid contamination and hence increase of the catches. Preliminary investigations of ours with dry traps for cabbage armyworm have given encouraging results.

Leaps in catches can reflect adequate state of the pest population - mass flight in the frame of a generation, mass flight after faviorable meteorological conditions for mass imagination etc. As for overcoming unadequate leaps in the catches several ways or combination of them could be proposed. The first one is to increase the trap number, that will overcome the effect of the irregular distribution of the moths in the field. The second one is to use caps with more stable evaporation to overcome decrease in the attractiveness with aging of them, and to use traps that are not affected so much by a contamination and overloading - dry, water etc. Another way to avoid the effect of decrease of the catches in a time because of the aging of the caps and sticky layers is to refresh them not simultaneously but consecutively in such a manner that all the time the combination of different aged caps and sticky layers wuold be the same.

Preparing of the report was supported by a grant from the Ministry of Culture, Science and Education, Sofia.

APPLICABILITY OF PHEROMONE-BAITED TRAPS FOR MONITORING THE EUROPEAN CORN BORER (OSTRINIA NUBILALIS HBN.; LEPIDOPTERA: PYRALIDAE) IN SOUTH HESSE (Federal Republic of Germany)

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Summary

The suitability of pheromone-baited traps for monitoring the European corn borer (ECB) in South Hesse was the subject of our investigations. For our field trials during 1982-88 we used the "Biotrap" (Hoechst-AG), which is not yet commercially available with ECB baits. Furthermore the "Pherocon 1C Trap" (Zoëcon) was tested. A pheromone strain survey showed that the Z-strain of the ECB is predominant in our region. With the "Biotrap" dispensers (rubber tubes), lure concentrations of 20 and 60 µg per dispenser seem to catch better than those of 2, 7 or 100 µg of the attractant 97:3 / Z:E 11-tetradecenyl acetate (11-tda). The traps should preferably be located in a field where maize was cultivated the year before (emergence area of the insect), if possible in autumn-sown wheat, because of its late harvest. For a reliable monitoring we suggest placing 4 traps per survey area (2 × 60 µg and 2 × 20 µg) when the "Biotrap", and 3 traps when the "Pherocon 1C Trap" is used. By means of the tested traps it was not possible to appoint the male maxima, but the emergence of the first borers could be determined. The capture of non-target insects can be reduced by dark colour coating of the original "Biotrap".

1.1. Introduction

The current methods for monitoring the European corn borer, including the overwintering of larvae in outdoor cages, the use of lighttraps, and the control of egg-laying in the field, all require a lot of time. Due to this, we wanted to know if pheromone-baited traps (with their simplicity of construction and maintenance, their species-specifity and the little need of time for handling) were a suitable device for monitoring the ECB.

In the Federal Republic of Germany the use of pheromone-baited traps for ECB-monitoring has not yet been introduced in agricultural practice. The traps are not commercially available. Since 1982, when the first traps of a German producer ("Biotrap") became avaiable for testing, their suitability in South Hesse has been the subject of our investigations.

Within the ECB species two pheromone-strains are known which cannot be discriminated morphologically. These two strains respond optimally to specific proportions of the geometrical isomers of their species-specific sex pheromone (11 - tetradecenyl acetate). The so-called Z-strain uses a

* The authors acknowledge the support of the DFG (Deutsche Forschungsgemeinschaft)

blend of 97:3 / Z:E 11-tetradecenyl acetate (tda) and the E-strain one of 3:97 / Z:E 11-tda. Hybrid females produce an intermediate blend (35:65 / Z:E 11-tda). For this reason the first step was to find out which pheromone strain was the predominant one in our region.

A further question aimed at the optimal dosage of the pheromonal compound per dispenser ("Biotrap"). We tested lures at different concentrations (2, 7, 20, 60, 100 µg).

A loss in attraction of the traps ("Biotrap") may be caused by non-target insects being attracted. In 1987 and 1988 we compared the influence of the trap colour on the catches of the borer and the most frequent non-target insects in our region (Chrysopa carnea, Episyrphus balteatus, Syrphus spec., Sphaerophoria spec.).

Finally we looked for the most effective trap-site and compared pheromone-trap captures ("Biotrap") to those of the "Pherocon 1C Trap" (Zoëcon) and to other methods of flight control.

1.2. Results

In some cases we could find males in traps with an E-strain bait but their number was so small, that these catches can be regarded as an accidental event. From the results of this investigation we conclude that only the Z-strain of the ECB is of phytopathological importance in South Hesse. For a survey it is sufficient to use Z-strain baits .

The best results have been attained with 20 and 60 µg per dispenser. Eight out of eleven times these two concentrations were most effective when tested against lower or higher ones. The most efficient concentration differed from year to year, from site to site, as did the average amounts throughout the years. There were great differences among traps with the same baits, so that it is advisable to place 2 traps of each concentration respectively at each area of survey.

Because the larvae spend the winter in plant residues of maize plants, a field where maize was cultivated the year before (emergence area of the insect) with an ensuing gramineous crop should be a good place for trap-siting. Our results support this hypothesis. The actual crop should be a grain (micro-climatically preferred by the ECB). If the whole flight period of the moth is to be observed, the crop should be autumn-sown wheat, because of its late harvest.

By means of "Biotrap" it is not possible to determine the flight peak of the moth. This information is necessary to terminate the application of Bacillus thuringiensis or chemical agents to control the pest. But the emergence of the first borers can be determined. The beginning of the flight is the point of time for releasing Trichogramma-wasps.

The best results in trapping (most borers, few non-target insects) with the "Biotrap" was achieved when a dark colour was applied to the original trap. It is remarkable that, though the traps are delivered in white, they catch better when sprayed with a white varnish. The intensive white colour of the original trap seems to attract non-target insects over long distances.

The "Pherocon 1C Trap", which is commercially available in the U.S., was superior with respect to the amount of trapped males throughout the flight period. Nevertheless, the flight peak could not be determined. However, the beginning of flight can be detected.

For a reliable monitoring of the ECB we suggest the placement of 4 traps per area for the "Biotrap" (2 × 60 µg and 2 × 20 µg 11-tda), and 3 traps when the "Pherocon 1C Trap" is used.

LIMITATIONS OF PHEROMONE TRAPS FOR MONITORING POPULATIONS OF THE EUROPEAN CORN BORER, Ostrinia nubilalis Hb. (LEPIDOPTERA : PYRALIDAE)

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Summary

The author studied the correlation between the number of male Ostrinia nubilalis caught in pheromone traps and the number of larvae, at harvest, in stems of maize close to the traps. The correlation was positive at Marais Poitevin where the population remained below 0.75 larvae per plant, but negative in Beauce, where the population was above the threshold of 2.6 larvae per plant.
Practical uses of this data to predict when crops are most at risk to this pest are discussed.

1.1 Introduction

An extension of infestation aerias by European Corn Borer is observed year after year in France. As a result many farmers must use chemicals to control this insect in the risk aerias. Sex traps are generally used to determine for this pest the exact moment for an insecticide traitement : that is the QUALITATIVE MONITORING.

However it seems difficult to get by this technique a correct information about a QUANTITATIVE RISK of damage caused later by the larvae in the stems. In other words : what is the relationship between the male captures in summer and the larval population level in Autumn in the maize fields ?

2.1 Method and materials

We selected 2 maize cultivation aerias known since a long time for their different level of E.C.B. population
- the Beauce region where an insecticide traitement is always a necessity because an high level
- the Marais poitevin where it is'nt because a low level of population.

In a preliminary experiment, we confirmed in these 2 aerias the presence of the same pheromonal strain of O. nubilalis : the strain "Z", whose the males are attracted by a precise blend of the 2 stereoisomers of the 11-Tetradecenyl Acetate (11-TDA) Z/E : 97/3.

"INRA Sextraps" were put in different localities in the 2 above aerias (4 in Beauce region, and 5 in Marais Poitevin). Each trap was baited with 100 μg of the same pheromone blend in rubber septa dispensers. During the experiment the traps followed the growth of the plant because insects prefer tp stay at the upper level of the maize canopy. At the end of the sex trapping season, by dissecton of 100 Maīze stems, in each place, we evaluated the number of larvae present in each locality and for the two aerias.

3.1 Results and discussion

The comparison of male captures to the numbers of larvae locality by locality permitted us to draw 2 regression curves :
In Marais Poitevin : a positive and significant correlation (Y1) between cumulative male captures up to the end of the first flight and the larvae numbering at autumne

$$Y1 = -14,42 + 0,44\ X \quad (r = 0,95\ ;\ P\ 0.02)$$

In Beauce region : a negative and significant correlation (Y2) between male captures and larvae numbers

$$Y2 = 1095.66 - 2.38\ X \quad (r = 0.99\ ;\ P\ 0.01)$$

These 2 correlations were already significant at the whorl stage of the Maīze (22 july) which happened at the half of the flight.

According to these data it is easy to see that for a same number of male trapped (between 175-195) it is possible to observe later 2 different levels of damages caused either by 0.75 larvae per plant or 7,0 larvae per plant. If in the 1th case there is no risk of yield loss, on the contrary, above 1 larvae per plant the loss can reach 25 % at harvest.

Consequently, with such observations it is oviouoly impossible for the farmer, using sex traps, to monitor with precision the risks of damages caused by the ECB in his fields.

To explain such different results according to the population level of the pest we propose an hypothesis based on the competition : pheromone dispenser-wild female.

The most species of Lepidopterous females generally release between n nanogr. and n micro.gr. of pheromone during their dusk attractive period. To draw a parallel, a rubber septum loaded with 100 μg of synthetic pheromone can be assimilated to a SUPER FEMALE.

In these conditions, in a low level population aeria, it is a big competition between this super female and the wild females present in the maīze field.

Consequently the number of males is OVERESTIMATED. On the other hand in a high level population aeria, this competition is not so hard because the big number of wild females. Then, one male flying upwind toward a synthetic bait has many chances to meet a true female on its way. In this cases it stops and copulates ; of course this male is not trapped and it is clear as a result that the number of males is UNDERESTIMATED.

Conclusion

These observations proved that it is not possible every where to bound the insect captures is summer with the larval population level in autumn. From a point of view of application, excepted the case of NEGATIVE PREDICTION, it is possible to indicate to the farmer a valuable capture number for a decision traitement. The sex trapping is not an applicable method for a QUANTITATIVE MONITORING of the European corn borer.

Nota

More details of these observations are available in AGRONOMIE, 1984, n°4, 597-602.

FORESTRY

PRACTICAL EXPERIENCES IN MONITORING LEPIDOPTEROUS FOREST PESTS

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Integrated pest management systems were introduced into forestry early in this century, to achieve stable forests on an economic basis. It is evident, that forest entomologists quickly made use of insect pheromones to enable them to monitor the population dynamics of pests. A substantial amount of research has been carried out since the early enthusiastic studies, however the results were not always satisfying. Therefore, the importance to analyze the results obtained in the past became evident. For this purpose the working group "Use of pheromones and other semiochemicals in integrated control" of the International Organization for Biological and Integrated Control of Noxious Animals and Plants (IOBC)/West Palaearctic Regional Section (WPRS) sent out questionnaires entitled "Survey on the use of attractant chemicals for insect detection and monitorring" (BUES 1989). This paper evaluates the replies gathered from the survey with special attention drawn to the lepidopterous pests. The results on the use of bark beetle pheromones is delt with in the following paper by NIEMEYER (1989) and other contributions to this volume.

A total of 58 questionnaires were returned, 9 of which were received after the deadline for the general evaluation of BUES (1989). The replies came from 12 countries within the limits of the WPRS (including Israel), as well as Czechoslovakia (belonging to the EPRS) and Canada. The distribution of the replies does not correspond with the importance of forestry in the economy of each country. Some countries with vast forest areas, above all Sweden, but also Great Britain and Belgium failed to respond (see tab. 1 in BUES 1989). The number of replies from each country is a reflection of the promotion of the questionnaires by working group members or the activity of pheromone research in the countries. 89 % of the questionnaires were answered by researchers. The replies reported on 21 different species (tab. 1). The most important lepidopterous pests mentioned are: the nun moth, *Lymantria monacha*, the gypsy moth, *Lymantria dispar*, the larch bud moth, *Zeiraphera diniana*, and the nearctic spruce bud-worm, *Choristoneura fumiferana*. It is logical that *L. monacha*, one of the most dangerous pests in the Central and North European coniferous forests, leads the list. Monitoring its population dynamics is an important task of the agencies responsible for forest protection. It is easy to understand why we received only two replies about *L. dispar*. The gypsy moth is a very important pest in Eastern Europe, in the Mediterranean countries, and especially in North America. In Central and North European forests however, the gypsy moth is only of small importance. In accordance with this fact, it must be noted that the two questionnaires came from Sardinia and Slovakia. Furthermore, two replies mention *Z. diniana* which seem to be representative considering the geographic distribu-

Table 1: **Forest pests mentioned in the questionnaires arranged by the number of replies**

Species	Family	Number of replies
Coleoptera		
Ips typographus	Scolytidae	11
Trypodendron lineatum	Scolytidae	6
Pityogenes chalcographus	Scolytidae	2
Ips sexdentatus	Scolytidae	1
Orthotomicus erosus	Scolytidae	1
Lepidoptera		
Lymantria monacha	Lymantriidae	6
Paranthrene tabaniformis	Aegeriidae	5
Tortrix viridana	Tortricidae	4
Panolis flammea	Noctuidae	3
Thaumetopoea pityocampa	Thaumetopoeidae	3
Cossus cossus	Cossidae	2
Lymantria dispar	Lymantriidae	2
Operophthera brumata	Geometridae	2
Rhyacionia buoliana	Tortricidae	2
Zeiraphera diniana	Tortricidae	2
Coleophora laricella	Coleophoridae	1
Choristoneura fumiferana	Tortricidae	1
Choristoneura murinana	Tortricidae	1
Gypsonoma aceriana	Tortricidae	1
Laspeyresia pactolana	Tortricidae	1
Orgyia antiqua	Lymantriidae	1

tion of this species: The larch bud moth is a typical species of the alps, where European larch and Swiss stone pine are infested. Whereas in the Sudeten Mountains the main host is Norway spruce, on which outbreaks are not seldom. Accordingly, the two replies came from Switzerland and Czechoslovakia.

Less important species are represented frequently in the replies, whereas other very important pests are missing such as: Epinotia tedella (Tortricidae), Dendrolimus pini (Lasiocampidae), and Bupalus piniarius (Geometridae). Sex attractants are available for the first two mentioned species (ARN et al. 1986), and both have been tested in the field (PRIESNER et al. 1984, 1988). The search for an attractant for B. piniarius has not yet been successfull although a lot of analytical work has already been done (BOGENSCHÜTZ et al. 1985).

In interpreting the replies, it is important to know that no practical foresters answered the questionnaires. Therefore the question arises: Are the pheromone systems not yet introduced to forestry well enough, so that they can be handled by foresters in the field without the help of researchers? It was asked in the questionnaire: Is the system, which is to be reported on, operational or still experimental? The replies show that some of the Scolytid systems are well introduced in practice: 62 % of the replies confirm that the system is operational. On the contrary, only 22 % of the systems used for Lepidoptera are operational.

The essential contents of the questionnaire concentrated on three themes: the trapping systems used, the collected data, and the interpretation of the data.

1. The trapping systems

To catch bark beetles, commercial traps were applied almost exclusively such as: the drain pipe trap (Borregard), the slot trap (Theyson) and the flat funnel trap (Röchling). For Lepidoptera there was a large spectrum of commercial or self-made trap types available. They can be divided into traps with sticky boards and traps with a container (high capacity traps).

Commercial dispensers were used for *Ips typographus* (Ipslure from Borregard, and Pheroprax from Shell Agrar), *Pityogenes chalcographus* (Chalcoprax from Shell Agrar), and *Trypodendron lineatum* (Linoprax from Shell Agrar). For the remaining two pine bark beetle species and for all Lepidoptera, dispensers have been produced by chemical industries or by research institutes to correspond with each specific demand. Rubber plugs or tubes, polyethylen stoppers, polyvinyl chloride pellets, "Folienbeutel" (Shell Agrar) and "barrels" (Farmoplant) served as dispensers.

Bark beetle traps were deployed singly or in small groups (details will be given in the following papers on bark beetle monitoring). The operations for catching Lepidoptera were vary variable. Up to 12 traps were exposed per stand in line or in another geometrical figures. The number of traps and the position to each other in more or less homogeneous stands is a very important problem in the statistical evaluation of the catches. The employment of the traps in about eye level was a very convenient procedure and therefore most often used. Traps were usually read once a week. This schedule is appropriate for the normal procedure using high capacity traps. In applying sticky traps readings should be carried out more often to avoid trap saturation, especially when population densities increase.

It is not possible to go further into the details at this point. However, the large variety in the methods used, showed that in monitoring lepidopterous forest pests, the technological transfer to practical use in the field is less advanced than for bark beetle management.

In this context the difficulty of interpreting trapping data should be mentioned. It will only be possible to compare results from different localities or from different seasons, if the equipment used and its subsequent operation are standardized. An obligatory standardisation would accelerate the evaluation of thresholds. Some of the replies made proposals in this direction.

2. Collected data

Analysis of the collected data (tab. 2) showed no essential differences between Coleoptera and Lepidoptera. However it is noteworthy to mention, that the qualitative events of flight phenologies were estimated more often than the quantitative data for establishing the flight activity of the male moths. The phenological dates, as well as the catches per time unit be-

Table 2: **Data collected in forestry**

Number of entries in percent of a total of 21 questionnaires on Coleoptera and of 37 questionnaires on Lepidoptera

Questions on	Coleoptera	Lepidoptera
flight phenology		
beginning	67	72
peak	67	67
end	67	67
shape of curve	57	39
individuals caught		
day	6	25
week	29	31
generation	33	25
flight period	48	47
weather conditions	38	39
densities of developmental stages	0	31
intensity of damages	24	47

came more accurate with increased readings. Besides the question of accuracy, there is another problem in using sticky traps in monitoring forest insect pests. From experience we know that the catches vary depending on the number of individuals adhering to the glue. Saturation can be avoided in exchanging the sticky boards in short time intervals. With the results from short time readings it is possible to draw very accurate flight curves. Catches like these represent the flight activity very well. However, readings taken more often than one per week can not be recommended for field work. Such a system would be too expensive. Therefore non-saturating traps should be preferred in forestry.

3. Interpretation of the data

In this section the evaluation of the replies was especially difficult. The answers were often inaccurate, probably because some of the questions were not clearly formulated. It was asked, whether the number of individuals caught were used: for detection including survey, distribution, flight observation, and quarantine, or for timing of other monitoring methods, and of control treatments, or for risk assessment. The answers concentrated on detection and risk assessment. Timing was mentioned only in 19 resp. 32 % of the replies (tab. 3). Data gathered from Lepidoptera was often used for detection purposes, more than that obtained from the Coleoptera, for risk assessment it was vice versa. A relative high number of replies on Coleoptera stated, that there was a relation between trap catch and popu-

Table 3: **Interpretation of data**

Number of entries in percent of a total of 21 questionnaires on Coleoptera and of 37 questionnaires on Lepidoptera

	Coleoptera		Lepidoptera	
Use for detection	38 (=100)		70 (=100)	
of distribution	50		92	
of flight phenology	100		58	
Use for timing	19 (=100)		32 (=100)	
of other sampling methods	25		50	
of treatments	100		50	
Use for risk assessment	57 (=100)		28 (=100)	
Is there a relation between catch and population density?	75		36	
Is a threshold used?		42 (=100)		82 (=100)
If not reached: no risk? (negative prognosis)		40		75
If reached:				
insecticide applied?		20		0
further observations? (early warning)		40		100

lation density, whereas a threshold catch was seldomly used. In Lepidoptera, there was an obvious higher uncertainty concerning the relation between catch and density. Nevertheless, thresholds were often used. Threshold values, gathered through experience, are applied to determine "negative prognosis" and "early warning". Risk assessment is the most important goal for using traps with attractants in forest protection, however it is far from being reached. Ocassionally the answers in the questionnaires expressed suppositional information rather than well-founded knowledge. Some of those questioned, explicitly advanced the wish for future research to derive a correlation between flight activity and damage, or to estimate an accurate warning threshold. To achieve the first aim special research is necessary, while the second could be attained, if standardized trapping systems would be applied over larger time spans and areas.

At the end of the questionnaire those surveyed were asked: "Are you satisfied with the system you use?" and: "Do you think the effort is justified in view of the results obtained?". Obviously, these questions are difficult to answer. 62 % of the respondents did not answer any of them. 31 % were satisfied with their system, 38 % consider the effort to be justified. The goal of the survey using questionnaires was not only to show the present situation in applying attractants, but also had the function of pointing to the need for further research. Research priorities should concentrate on the development of commercially available traps having high catching capacities without saturation and lure formulations with constant release rates over long time spans. Furthermore, there should be a system of standardized trapping operations and warning thresholds possible through a better exchange of data not only within the WPRS but also with colleagues in the EPRS.

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UTILISATION DU PIEGEAGE SEXUEL POUR LA SURVEILLANCE DES LEPIDOPTERES DEFOLIATEURS FORESTIERS.

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Résumé : Par rapport aux méthodes traditionnelles de surveillance (observation des rameaux attaqués, comptage des oeufs, piégeage lumineux), le piégeage sexuel, grâce à son faible prix de revient, sa facilité d'emploi et sa sélectivité permet de détecter à coup sûr la présence de tel ou tel défoliateur dans un peuplement, même à de très bas niveau de population, et de déterminer avec précision la date du vol des adultes et son évolution dans le temps.
Il ne fournit cependant qu'une appréciation qualitative du niveau des populations sauvages, les corrélations entre ce niveau et le nombre d'insectes capturés par piège étant difficile à établir, surtout en période de forte infestation ou lorsque le peuplement n'est pas suffisamment isolé.

Introduction : Les attaques des défoliateurs forestiers mettent rarement en jeu la vie même de l'arbre mais des défoliations répétées peuvent engendrer des stress aboutissant à des symptômes de dépérissement. Elles peuvent cependant avoir des effets indirects sur l'activité touristique (L. dispar) et lorsqu'il s'agit d'espèces dont les chenilles sont urticantes (Processionnaire du pin, cul brun) il peut s'en suivre des conséquences sur la santé humaine, surtout en forêt périurbaine.

De plus, depuis ces dernières années, on assiste soit à des pullulations d'espèces autochtones jusqu'alors inoffensives (Tordeuse du sapin), soit à la colonisation d'essences exotiques par des espèces jusqu'alors exclusivement inféodées à des hôtes autochtones (ex. Processionnaire du pin sur Douglas). Enfin l'immigration active ou passive d'espèces étrangères (ex. Hyphantria cunea) fait toujours peser des risques sur l'état phytosanitaire de la forêt.

Nécessité d'une surveillance phytosanitaire de la forêt

Les exemples cités précédemment montrent clairement qu'une surveillance efficace de la forêt est nécessaire pour détecter les gradations de populations de ravageurs conduisant aux pullulations, les immigrations accidentelles, les changements d'habitude alimentaire des ravageurs indigènes et leur répartition.

Pour être vraiment efficace, cette surveillance devrait aussi être quantitative c'est-à-dire permettre d'évaluer les pertes de production dues aux défoliateurs forestiers, malheureusement cette évaluation est très difficile à faire et il n'est pas possible de répondre à la question suivante "quelle est l'importance de la compétition exercée par les insectes à l'égard de l'homme pour l'utilisation des ressources forestières ?".

Une bonne surveillance n'est possible que si on prend en compte des données concernant la biologie des ravageurs telles que leurs capacités de dispersion, l'aptitude à la migration, la présence de populations génétiquement différentes, les périodes exactes d'activité des adultes, malheureusement ces données manquent bien souvent et sont peu accessibles compte-tenu des méthodes généralement utilisées (comptage des oeufs, suivi des dates d'émergence des adultes sous cage, utilisation du piégeage lumineux).

Apports du piégeage sexuel des mâles dans la surveillance des lépidoptères défoliateurs forestiers

Le piégeage sexuel grâce à sa facilité d'emploi, son faible prix de revient et sa grande sélectivité permet d'apporter des éléments de réponse aux problèmes précédemment posés et en particulier :
- de détecter avec précision la présence de tel ou tel ravageur dans un peuplement (ex. Choristoneura murinana),
- de déterminer au niveau d'un peuplement la date exacte d'apparition des adultes (Biofix point) et de suivre l'évolution des vols au cours du temps,
- d'apprécier qualitativement les niveaux des populations sauvages par estimation du nombre d'insectes capturés par piège,
- d'estimer quantitativement les risques encourus par le peuplement en établissant des corrélations entre, par exemple, le nombre d'oeufs déposés par unité de surface ou de longueur choisie et le nombre d'insectes capturés dans les pièges (Tordeuse verte du chêne).

Cependant ces estimations ne sont valables qu'en présence de faibles niveaux de population et sous réserve que le peuplement ne soit pas soumis à des émigrations ou des immigrations d'insectes.

Pour être efficace, le piégeage sexuel doit se faire avec des pièges adaptés au comportement précopulatoire des mâles (L. dispar, T. pityocampa) et utiliser des attractifs spécifiques et performants qui ne sont pas toujours le reflet exact du bouquet phéromonal émis par la femelle. Le support de diffusion de l'attractif joue en effet un rôle très important et le taux de diffusion varie avec la nature et la quantité des produits qui y ont été déposés.

Conclusion : Le piégeage sexuel des défoliateurs forestiers n'a été effectué que sur un petit nombre d'espèces , surtout dans l'ancien monde et doit faire encore l'objet d'études approfondies.

Les difficultés déjà rencontrées dans l'interprétation des résultats des captures pour les ravageurs des cultures se trouvent amplifiées en forêt à cause de la complexité du biotope, des difficultés rencontrées dans l'appréciation des dégâts et de nos lacunes sur la biologie de nombreux ravageurs.

Il constitue cependant un outil précieux et extrêmement sensible de surveillance et son emploi se généralisera très probablement dans les prochaines années.

UTILISATION DU PIEGEAGE SEXUEL POUR LA DELIMITATION DE L'AIRE DE REPARTITION ET POUR L'ESTIMATION DES NIVEAUX DE POPULATION DE Choristoneura murinana (HB.) EN FRANCE

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Résumé

Une enquête sur la Tordeuse du Sapin Choristoneura murinana (Hb.) associant piégeage sexuel et visite de peuplements a été menée dans près de 200 peuplements de Sapin pectiné et de Cèdre de l'Atlas. Les résultats révèlent que le ravageur, jusqu'alors presque inconnu en France, y est en fait largement répandu, en particulier dans la moitié sud du pays, où ont été découverts de nombreux foyers de pullulation. Le piégeage sexuel permet de discriminer les peuplements "à risque" mais non d'évaluer l'importance de ce dernier.

1. Introduction

Choristoneura murinana (Hb.) (Lép., Tortricidae), dont les dégâts sont bien connus en Europe centrale, a pour hôte habituel le Sapin pectiné, Abies alba Mill. Ce dernier est largement représenté en France, où son aire naturelle, très morcelée, s'étend à travers les Vosges, le Jura, les Alpes, le Massif Central, les Pyrénées, la Corse et même la Normandie. Jusqu'en 1980, toutefois, C. murinana y faisait figure d'espèce très rare, signalée seulement, outre le versant alsacien des Vosges et la limite orientale du Jura, de trois localités (dont une très douteuse). En 1980, une pullulation de l'insecte fut découverte dans une sapinière du Massif Central, où les dégâts se poursuivirent les années suivantes. On pouvait dès lors craindre que des situations analogues n'apparaissent - si ce n'était déjà fait - dans d'autres peuplements. Aussi fut-il décidé, en 1985, d'engager une étude ayant pour objectifs de délimiter l'aire de répartition de la tordeuse dans le sud de la France et d'y évaluer ses niveaux de population.

2. Méthodes

L'étude, menée avec le concours des Services Forestiers et avec celui du Laboratoire des Médiateurs Chimiques (I.N.R.A.), a consisté en une enquête par piégeage sexuel, qu'ont complétée des visites de peuplements. Elle a porté sur l'ensemble de l'aire naturelle du Sapin pectiné dans les Alpes, le Massif Central et les Pyrénées, ainsi que sur des reboisements âgés en cette essence situés hors des limites naturelles de son aire. En 1988, elle a été étendue au nord-ouest de la France (Normandie, Morbihan) et également, suite à la découverte d'une pullulation de la tordeuse sur Cèdre de l'Atlas, Cedrus atlantica Manetti, à des cédraies du sud-est du pays. Au total, 170 sapinières et 21 cédraies ont fait l'objet à ce jour d'une campagne de piégeage, selon les modalités suivantes : 1 piège par peuplement, non saturable (modèle UNI-TRAP) ; capsule attractive chargée à 100 µg d'une phéromone de synthèse (Z9-DDA + Z11-TDA dans la proportion 10/1) ; relevés bimensuels tout au long de la période de vol. Certains des peuplements, dont tous ceux où l'abondance des captures laissait craindre des dégâts importants, ont été ensuite visités dans le but d'évaluer l'intensité de la défoliation.

3. Résultats

Les résultats de l'enquête démontrent que *C. murinana* est présent un peu partout à l'intérieur des limites naturelles de l'aire du Sapin pectiné dans les Alpes et le Massif Central. Son niveau de population y est très variable. Cinq régions, réparties entre les deux systèmes montagneux, se montrent particulièrement menacées ; 15 sites de pullulation y ont été mis en évidence. La tordeuse est également présente dans les sapinières naturelles de Normandie. En revanche, et fort curieusement, elle est totalement absente dans la chaîne pyrénéenne, ce que ne permettent pas d'expliquer les conditions climatiques.

Hors de l'aire naturelle du Sapin pectiné, l'insecte a été capturé dans des sapinières du massif de l'Aigoual, du département de l'Aveyron et du sud de celui du Morbihan, ainsi que dans 11 cédraies du sud-est de la France (Loire, Ardèche, Drôme, Vaucluse, Alpes-de-Hte-Provence), certaines situées à très basse altitude.

Il ressort de l'enquête que la tordeuse est capable de se développer, et même dans une large mesure de pulluler, dans des conditions climatiques très variées : depuis le niveau le plus chaud, à Pin d'Alep, de l'étage mésoméditerranéen jusqu'à des altitudes très élevées (record observé : 1780 m), où le Sapin côtoie le Mélèze et le Pin Cembro, ou encore jusqu'à des milieux soumis à un climat atlantique accentué (cas du Morbihan et de la Normandie). En fait, le ravageur est sans doute capable de se développer à peu près partout en France (sauf en très haute montagne) dès lors qu'il dispose d'une plante hôte lui convenant.

En ce qui concerne la relation entre nombre des captures par piégeage sexuel et niveau de population, les données recueillies conduisent aux conclusions provisoires suivantes : des captures annuelles (par piège) inférieures à la centaine d'individus correspondent toujours à des densités de population très faibles, ne présentant nul danger dans l'immédiat ; des captures de 100 à 400 papillons environ correspondent apparemment toujours à des dégâts encore très légers, mais un certain risque apparaît que l'insecte n'atteigne en quelques années l'état de pullulation ; au-delà de 400 mâles capturés enfin, toutes les situations peuvent être observées depuis des dégâts encore insignifiants jusqu'à un état de pullulation extrême, et cela que les dégâts pris en considération soient ceux commis l'année du piégeage ou l'année suivante. A titre d'exemple, la défoliation des arbres était quasiment nulle dans une sapinière où le piège a capturé 5000 mâles, mais totale dans une autre où il n'en a pris que 550.

4. Conclusions

En guère plus de 3 étés (l'année 1985 ne comptant qu'à peine), l'enquête a permis d'obtenir des informations détaillées sur la répartition et le degré de nuisibilité dans une grande partie de la France (dont trois vastes ensembles montagneux d'accès souvent difficile) d'une espèce très discrète lorsqu'elle ne pullule pas. Les données recueillies ont, en particulier, totalement bouleversé notre appréciation de l'importance économique de la tordeuse. Elles mettent clairement en évidence, par leur ampleur, la remarquable efficacité du piégeage sexuel comme outil d'acquisition d'informations sur la distribution géographique d'un insecte. En matière de surveillance des populations et de prognose, au moins dans le cas de *C. murinana*, le piégeage sexuel se montre beaucoup moins performant. Il permet néanmoins de discriminer à peu de frais les peuplements "à risque", ce qui est déjà un acquis considérable.

The problem of bark beetle monitoring with aggregation pheromone traps

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Summary

Bark beetle traps baited with aggregation pheromones of Ips species or Pityogenes chalcographus can cause infestations of nearby standing trees, depending on the beetle population density and its regional aggressivity, on the vitality of the trees and on the distances between traps and trees as well as on the distances between the traps along the stand margins. The shorter the distance between trap and next tree or the Conger the distances between traps the higher is the risk of infestation. The modern system of bark beetle control uses pheromone traps mainly to reduce local population densities under the level of infestation risk by establishment of trap lines with distances between traps of 20 - 50 m along stand margin. A modern monitoring system operates a few of these control traps as "monitor traps" with a high surveying frequency to give a rough idea of the regional population trend. The ratio of catch and infestation worses enormously depending on factors as mentioned before. So thresholds of hazard can have a relative status only.

1. Introduction

In Germany, bark beetle pheromones are up to now much more used for mass trapping than for monitoring. I'll try to explain why and to show up some conditions for the possible application of monitoring systems.

2. Some aspects of biology and trapping techniques to illustrate the problems.

In opposite to the sexual pheromones of lepidoptera, the aggregation pheromones of bark beetles lure both, males and females. Normally, the sex which is selecting the host tree - at first being attracted by host borne volatiles - and attacks it first releases the aggregation pheromone which is biosynthezised in the hindguts using the monoterpenes of the host tree (1, 2, 3). Commercial pheromones, availabel for most of the aggressive scolytids in Europe and North America, are identical to the natural ones (2, 4, 12, 13, 14) and released by dispensers, in Europe preferably made of sponge cloth and included in plastic bags.

There are different trap types on the european market representing the two basic designs: the "landing trap" which consists of a pipe and imitates a trunk, and the flight barrier trap. The last named design is, in general, the more effective one because it demands only one action of the beetle: the approach to the flight barrier, all the rest happens "unwillingly" to the beetle which, after contact with the flight barrier, fells down into a collecting vessel from where no escape is possible (9). Field tests in Germany, using a special experimental design to eliminate the adverse effects of position and time, proved the black slot trap to be the best type among different flight barrier and "landing" traps (10, 7). The black colour is an indispensable feature of a flight barrier trap because, on a short distance, the trunk imitating dark silhouette acts as an optical stimulus (5). In West-Germany, about 90 % of all bark beetle traps in practical use are slot traps.

The fact that both sexes are lured to the source of aggregation pheromone explaines why host material can be attacked and colonized in the immediate vicinity of that source. Thus, monitoring bark beetles is at the same time a high enlargement of the infestation risk. Some aggressive species, in Europe first of all Ips typographus, Ips cembrae, Ips sexdentatus and Pityogenes chalcographus, can overwhelm the resistance of even a normal healthy living tree, provided enough beetles are lured to the spot of the pheromone source. And this is the more likely the higher the temperature and the higher the local population density which, for its own part, is depending on the amount of suitable breeding material and hot summers.

The diameter of the endangered zone around a natural pheromone source (e.g. a succesfully attacked tree) or an artificial one (a pheromone trap) depends on the beetle species, its local population density and the actual weather condition (2, 4, 7, 8). Each tree which is colonized acts as a new source of pheromone and of infestation risk for the neighbouring trees. By such chain reactions an areawide outbreak can occur and destroy all older stands of Norway spruce. So, between 1944 and 1951 about 30 Millions of cbm of coniferous trees were killed by bark beetles, first of all by Ips typographus, in Middle Europe (6).

3. Experiences with monitoring bark breeding scolytids by pheromone traps as an inappropriate means to detect the localities of critical population densities.

Our modern integrated control system for bark beetles includes - beside the aspects of "clean forestry", surveying infested trees and eliminating the brood - also traps baited with aggregation pheromones, namely Pheroprax[R] for Ips typographus and Chalcoprax[R] for Pityogenes chalcographus (7, 8).

The first instructions to realize this system in practical forestry implied also monitor traps to find out stands endangered by Ips typographus. These monitor traps were positioned along the margins of the stands outside of them with security-distances between 10 and 15 m apart from the next living spruce in order to avoid pheromone-induced infestations. The allowed distances between traps differed between 100 and 200 m but, in practice, very often only one trap per stand was employed. Following the instructions, the monitor traps should have been checked at least once a week or immediately after a day of flight activity (these are days with air temperature in shadow of at least 18° C and very low wind speed). If one trap on a stand margin had trapped 250 or more of typographers per flight activity day the distances between all traps along that stand margin had to be reduced down to 50 or even 20 m corresponding with the number of beetles catched in the monitoring traps there, that means, the higher the catch the lower the distances between traps. By this means monitoring changes into mass trapping at the particular stand margin; pheromone traps in distances of 50 m or less act as a control system in order to reduce the local population density under a level which is no longer a sufficient basis for a succesful infestation of living trees.

Indeed, experiences in both practice and experiment show that mass trapping as one part of an integrated control system is able to reduce the infestation rate of standing Norway spruce through Ips typographus by 80 to 100 % (7).

But, regarding the monitor traps with their long distances to each other, experience taught too that the demanded frequency of checking catch and possible infestation in nearby standing trees cannot be achieved by practical forestry. Thus, nearly all new infestation spots in forests with pheromone traps were located in the immediate vicinity of the monitor or single traps.

4. Observations on trap catches and infestation rates as a basis to view spatial monitoring

Experimental and practical experiences of 10 years give a rough idea of catches per trap and year which may be correlated with infestations of living trees. If traps are positioned about 10 m apart of the next spruce the critical value is in a range of about 4000 Ips typographus as a mean per trap and stand: some few infestations in this particular stand are likely to happen. Maybe this is the begin of epidemic population levels. In practice a security distance of approximately 15 m is preferred. This will reduce the trap-induced probability of infestations significantly, but not so the trapping efficiency. But, catches will decrease rapidly beginning with distances of 20 m between trap and stand margin; probably because most beetles refuse to leave their habitat over such a distance. On the other hand, distances shorter than 10 m will increase the probability of infestations - for example to a threshold of hazard in the range of about 2000 typographers at a distance of 6 m.

It seems to be much more difficult to give thresholds of infestation hazard for Pityogenes chalcographus which can be trapped by the new commercial pheromone dispenser Chalcoprax[R] at numbers of some 100000 beetles per trap and year.

So we see that such "critical values" are far away from being well defined and fixed damage thresholds. Frequency and intensity of infestations are dependent on numerous parameters such as distance between pheromone source and next tree, susceptibility or vitality of the stand, weather conditions, climatic and microclimatic factors, regional differences in agressivity of the beetles and probably other so far unknown factors.

5. Proposals for the possible use of aggregation pheromones to monitor bark beetles

With respect to the before mentioned problems of monitoring the infestation risk of single stands, another system is about to be introduced into practical pest management. That is to monitor trends or shifts in regional populations of bark breeding scolytids by means of pheromone traps. The problem is to minimize pheromone-induced infestation and to find an adequate sampling size to be representative for the real but unknown population trend of the region under economically reasonable conditions.

In some states of the Federal Republic of Germany such monitoring systems are working. In Lower Saxony, for example, a total area of 100 000 ha of norway spruce is monitored by use of 150 traps for Ips typographus and another 150 traps for Pityogenes chalcographus, all traps distributed over 15 forest districts which are representative for the main forest regions. To avoid pheromone-induced infestations, as they occur with too few traps per stand, our monitor traps are "normal" traps determined out of permanently working "control trap lines" (with distances between traps of 20 - 50 m depending on the local hazard estimated by previous infestations). These determined traps are operated as monitor traps; that means a checking frequency much higher than with the other (control-) traps of the line, i. e. after each flight activity day each monitor trap must be emptied, the catch must be recorded on a prescribed data form and the neighbouring trees must be examined to detect beginning infestations in time.

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TWO METHODS FOR ESTIMATING SPRUCE BARK BEETLE DAMAGE RISKS.

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Summary

Two methods, one based on pheromone traps and the other based on pheromone-baited trees, were evaluated as indicators of tree mortality caused by the spruce bark beetle *Ips typographus* (L.). Both methods reflected damage within forest districts well, indicating that they may be used in assessing risks for damage caused by this bark beetle species.

Introduction

The spruce bark beetle *Ips typographus* is distributed throughout the Palearctic range of its host tree Norway spruce *Picea abies* L. (Karst.). At low population levels the bark beetle is restricted to breed in non-resistent material such as cut timber or windthrown trees. Healthy trees can be killed and utilized for breeding only if the population level is high enough. Very high poulation levels can lead to outbreaks that go on for several years with catastrophic consequences. It would be of value to forest managers if they were able to estimate relative population levels of *Ips typographus* in a given forest district. In a cooperative effort between forest entomologists in the Nordic countries, Denmark, Finland, Norway, and Sweden, two methods for estimating relative population levels and damage risks were evaluated (Weslien et. al. 1989).

Methods

In each of the 4 countries 3 forest districts were chosen, ranging in latitude from 56° N to 66°30' N and in size from 1000 to 9000 ha. Within each district 5 sites for pheromone trap deployment and 5 sites for pheromone baiting of trees were chosen each spring during 1984, 1985, and 1986. The 10 sites within each district and year were generally spaced apart by at least 300 m. At each of the trapping sites, which were located on fresh spruce clear-fellings, a group of 3 pipe traps was set 20 m south of the adjacent forest. The mean catch per district and year was calculated using the trap group as sampling unit (n=5). At the tree-baiting sites, situated along north facing forest edges, a dominant or co-dominant, apparently healthy spruce was baited. The number of spruces killed and successfully colonized at each tree-baiting site was counted in late summer, and the mean number was calculated for each district and year. The mean catch and the mean number of sucessfully colonized trees were compared with results from annual inventories of tree mortality caused by Ips typographus within the districts. The inventories were made in autumn along spruce forest edges that adjoined clear-fellings made in recent years and that contained trees large enough for Ips typographus.

Results

The mean catches ranged from 950 to 46 000 beetles per trap group while the mean number of trees colonized per tree-baiting site varied from 0 to 5 for the different districts and years. The standard errors were low for the mean catches, averaging 15%, while the precision at estimating colonization success was poor (s.e. averaging 44% of the mean). The inventories of tree mortality yielded values ranging from 0 to 150 killed trees per km of spruce forest edge. There was a strong linear correlation between mean catches and log-transformed tree mortality (r=0.82). The correlation between colonization success at tree-baiting sites and tree mortality was weaker (0.59), owing to one deviant observation.

Conclusions

The results indicate that it should be possible to develop systems based on traps or baited trees for estimating relative population levels and damage risks. A trapping system should be useful for following year-to-year regional population trends and for defining situations of low risk. A system based on baited trees may be particularly useful following stormfelling or other catastrophic events, when priority for sanitation must be given to areas with the highest risk levels.

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FORECASTING POPULATION TRENDS OF THE SOUTHERN PINE BEETLE, DENDROCTONUS FRONTALIS

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Summary

Barrier traps baited with the population aggregation pheromone "frontalin" and rapid-release dispensers of pine turpentine are being successfully used to predict annual infestation trends of the southern pine beetle, Dendroctonus frontalis Zimmermann (Coleoptera: Scolytidae) in the southern United States. Using a system developed in Texas, traps are deployed in early spring to sample dispersing populations of D. frontalis and its predator Thanasimus dubius F. (Coleoptera: Cleridae). This predator responds to the same pheromone bait and exhibits a density dependent numerical response to D. frontalis population gradations. Predictive variables from trap-catch data include mean number of bark beetles/trap/day and the relative proportion of D. frontalis to T. dubius. The prediction system shows promise as a useful tool for D. frontalis pest management.

1.1 Introduction

Infestation levels of the southern pine beetle (SPB), Dendroctonus frontalis Zimmermann (Coleoptera: Scolytidae), may vary widely from year to year in pine forests of the southern United States. In east Texas, for example, major outbreaks of this destructive pest have occurred in 1949-50, 1962, 1968, 1973-77, and 1983-86 (Texas Forest Service unpublished data). Forest managers need a reliable means to predict whether SPB populations are likely to increase or decline in the coming year in order to better cope with sporadic outbreaks. A predictive system that uses pheromone-baited survey traps deployed early in the flight season has been developed and is currently being pilot tested throughout the range of D. frontalis.

1.2 Materials and Methods

The pheromone trap consists of a 12-funnel non-sticky barrier trap manufactured by Phero-Tech., Inc. of Vancouver, British Columbia. Each trap is baited with two Eppendorf capsules of pure "frontalin", the aggregation pheromone for D. frontalis (Kinzer et al. 1969). This pheromone also attracts a major SPB predator, the clerid Thanasimus dubius F. (Coleoptera: Cleridae) (Vité and Williamson 1970). To increase the level of response of SPB and its predator, a 250 ml dispenser of steam-distilled turpentine from loblolly pine (Pinus taeda L.) is placed in each trap (Billings 1985).

In 1987, following successful trials in Texas, forest entomologists in eleven southern states cooperated in a pilot test of the survey system. Each cooperator placed two pheromone traps in each of three separate sawtimber pine stands within selected counties or National Forest Ranger Districts. The traps were deployed in March or April to coincide with the spring dispersal of SPB and clerids (Moser and Dell 1980), as indicated by the flowering of native dogwood, *Cornus florida* L. Insects were collected at weekly intervals for four consecutive weeks from 28 localities. The actual SPB infestation trend (increasing or declining) that occurred in each state and locality where traps were placed was determined from aerial detection records of new infestations for 1987 versus 1986.

1.3 Results and Discussion

Southern pine beetles and clerid predators were trapped in each of the 28 localities monitored, but the relative abundance of prey and predator varied widely among localities, depending on infestation level and trend. Two variables obtained from early season pheromone trap catches proved of value for predicting SPB infestation trend for the current year: mean number of SPB/trap/day and "percent SPB", the latter computed by dividing total numbers of SPB by total numbers of SPB + clerids per trap. Based on a plot of these two variables from 28 localities monitored in 1987, four different infestation trend categories were delineated: 1) low infestation levels occurred in localities where mean number of SPB/trap/day was less than 6; 2) declining SPB activity (compared to 1986 levels) occurred in those localities where mean percent SPB was 40 or less (e.g. *T. dubius* outnumbered *D. frontalis*); 3) moderate change or static infestation levels were reported in localities where mean percent SPB exceeded 40 and mean SPB/trap/day was equal to or less than 35; and 4) high or increasing infestation levels developed whenever percent SPB exceeded 40 and mean SPB/trap/day exceeded 35. For localities in which SPB trap catch data indicate a moderate change in SPB activity (category 3), whether infestation levels will increase or decline apparently cannot be reliably forecasted from a single trap catch. In such cases, a comparison of mean SPB/trap/day for the current year with that for the previous year from the same locality would provide a basis for differentiating between increasing and declining infestation levels. The SPB pheromone survey is being repeated in 63 localities within 13 southern states in 1988 to validate this interpretation of pheromone trap results.

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Surveillance de *Lymantria dispar* L. en Pologne

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Lymantria monacha L. est l'un des insectes les plus nuisibles aux forêts de Pologne.

Entre 1946 et 1977, 25 opérations de lutte ont été menées, sur une surface totale de 113 000 hectares de peuplements de pins, de sapins et mélangés.

De 1978 à 1985, *L. monacha* s'est multiplié dans les régions septentrionales de la Pologne à un degré jusqu'alors jamais observé dans ce pays, ni même en Europe. Au cours de cette période l'insecte a atteint des densités de population considérables: on a souvent observé plusieurs dizaines de milliers de chenilles par arbre (sur certains arbres, plus de 100 000 individus ont été dénombrés). Au total, 3,7 millions d'hectares de forêts, principalement de pins, ont été touchés, 3 millions d'hectares environ ont fait l'objet d'opérations de lutte.

Au cours de la seule année 1982, on a lutté contre *L. monacha* sur 2,3 millions d'hectares, ce qui a necessité l'utilisation de 159 avions et de 23 hélicoptères. EN 8 ans, la surface totale cumulée traitée avec des pyréthrinoïdes s'est élevée à 6,3 millions d'hectares.

Depuis 1984, en Pologne, afin de deceler le plus tôt possible les territoires où les pullulations de *L. monacha* sont en augmentation, on utilise le piégeage sexuel des mâles. les pièges sont appâtés avec la phéromone sexuelle de synthèse Lymodor. Leur nombre dépend de l'étendue des complexes forestiers et de leur composition en essences.

A l'heure actuelle, en Pologne, on recommande de placer:

- un piège pour 50 hectares dans les complexes forestiers couvrant jusqu'à 500 hectares,

- un piège pour 100 hectares dans ceux dont la surface est plus importante.

Les pièges sont mis en place dans les peuplements âgés de plus de 20 ans, juste avant le début des émergences des adultes de *L. monacha*. Ils sont accrochés chaque année aux mêmes arbres, à 2 m. environ au-dessus du sol, toujours au même emplacement (durablement marqué sur l'arbre).

Les complexes forestiers où le nombre moyen de mâles de *L. monacho* capturés par piège dépasse 1 500 individus sont considérés comme étant des territoires où la population de l'insecte est en augmentation. L'année suivante, on y place un nombre plus élevé de pièges et on y effectue des observations portant sur:

- l'intensité du vol des adultes (en dénombrant les femelles sur des arbres échantillons),

- l'abondance des chenilles (sur des arbres abattus ou sur des piles contrôlés).

Au total, ce sont 50 000 pièges à phéromone qui sont ainsi répartis dans les forêts polonaises.

Les résultats du piégeage des mâles de *L. monacha* indiquent qu'entre 1986 et 1988 un accroissement de la population de l'insecte -pourtant présent sur tout le territoire polonais- ne s'est produit que dans peu de peuplements, ce qui n'a pas nécessité la mise en oeuvre d'actions de lutte.

L'efficacité des pièges à attractif utilisés pour capturer les Scolytides

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Les forêts de la Pologne, qui couvrent 8,6 millions d'hectares, soit 28% environ de la surface géographique du pays, sont en danger permanent ou périodique à cause des pullulations fréquentes de nombreuses espèces nuisibles, de champignons parasites, de facteurs abiotiques, ainsi que de la pollution atmosphérique, qui tend à croître actuellement.

Les arbres affaiblis et malades sont attaqués par des insectes parasites secondaires, ce qui entraine leur dépérissement en masse. Au cours des années 1970-80, le volume d'arbres abattus à cause des dégâts d'insectes parasites secondaires a atteint 1 à 2,5 millions de m^3 par an. De 1980 à 1987, ce volume a oscillé entre 2,5 et 19,5 millions de m^3 (en moyenne 7 millions de m^3 par an).

Cette situation exige le perfectionnement continuel des méthodes et des moyens de prévision et de lutte contre les insectes parasites secondaires, ainsi que la recherche de méthodes et de moyens plus efficaces. Dans ce groupe, les phéromones d'agrégation sont d'une grande importance; on les utilise le plus souvent pour appâter divers types de pièges, comme attractif des mâles et des femelles.

Depuis quelques années, on utilise en Pologne, pour le piégeage des adultes d'*Ips typographus* L., *Trypodendron lineatum* L. et *Pityogenes chalcographus* L., les phéromones produites par SHELL AGRAR (RFA), respectivement: Pheroprax, Linoprax et Chalcoprax. On les place dans des pièges-barrières, ou dans des pièges à tube qui imitent les troncs d'arbres.

Suite à de nombreuses expérimentations utilisant des pièges classiques en recherche forestière (piège-écran triangulaire en feuille plastifiée de type IBL-2, piège à fente de Theyson et piège-tube de Borregaard, ainsi que le piège modèle 1979 à entonnoirs multiples, semblable au piège canadien), on a constaté que le piège polonais type IBL-2, était le plus efficace. Il unit les avantages des pièges-tubes et ceux des pièges-écrans. La diminution de la surface efficace du piège IBL-2 de 1 m^2 à moins de 0,5 m^2 exerce une influence importante sur l'efficacité des captures pour les trois espèces de Scolytides.

On a comparé l'efficacité des pièges triangulaires (IBL-2) en fonction de leur position (dans le peuplement végétal ou sur surface dégagée; à 10, 20, 40 ou 80 m de distance de la lisière de la forêt) et de leur hauteur au-dessus du sol (2, 4, 8 m). Il apparait que les pièges appâtés avec du Linoprax doivent être placés sous le couvert végétal, à 2 m de hauteur et à 20-40 m environ de la lisière; ceux appâtés avec du Chalcoprax doivent être placés de la même façon, mais à 10-20 m seulement de la lisière.

L'utilisation dans un même piège du Chalcoprax et du Linoprax ne diminue pas l'efficacité du Chalcoprax. En revanche, l'utilisation dans un même piège du Chalcoprax et du Phéroprax diminue d'environ 30% les captures de *Pityogenes chalcographus*.

MONITORING AND LURE AND KILL OF PARANTHRENE TABANIFORMIS ROTT. (LEPIDOPTERA; SESIIDAE)

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Monitoring

In The Netherlands, poplars are planted on a large scale in the new polders. The young trees can be attacked by the wood-boring larvae of Paranthrene tabaniformis; the stems thus weakened can break off, resulting in great damage. In 1984, 1985 and 1986, the sex attractant [(E.Z.)-3,13-octadecadien-1-ol] was used in "Unitraps" to monitor the distribution and seasonal occurrence of this moth. Males were trapped in 10 different locations in the north, centre and south of The Netherlands. Flight occurred from the end of May until early September. The "Unitrap" did not appear to be very effective: only low percentages (12-57%) of visiting males were captured. Diurnal flight activity was monitored in 1985 with a motordriven time sampling trap. Males were caught only in the afternoon, from about 13.00-19.00 h; flight culminated between 15.00-17.00 h.

Lure and kill

In experiments being done to protect young poplar plantations outside the nurseries the males are lured with the sex attractant (chemical attraction) to imitation females (visual attraction) on plastic strips smeared with a mixture of paraffin and the pyrethroid Cypermethrin (0.05% a.i.). In 1987, smooth plastic strips with printed images of a female were fixed to the trees. In further experiments, ribbed plastic is being used to hinder flow down of the insecticide, and 3-dimensional models made of coloured clay are attached to enhance visual attractivity. Lured males try to copulate and thus contact the insecticide. They become immobile after some minutes and die within about two hours. The aim is to prevent the females being impregnated, by eliminating the males and thus reducing the number of infestations in treated areas.

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STORED PRODUCTS AND GENERAL TOPICS

A REVIEW OF TRAPPING TECHNIQUES FOR STORED PRODUCT INSECTS

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Summary

Significant advances in the detection of stored-product insects have been made in the last 20 years, largely due to improvements in trapping. Sex pheromones have been used successfully to enhance traps for detection and monitoring and also to produce control strategies for phycitid moths and some species of the major short-lived beetle pests. Few of the beetle aggregation pheromones have yet been exploited commercially and much laboratory and field evaluation is still required. To improve detection of most storage beetle species it may be preferable to bait traps with food lures.

Introduction

Stored products suffer irreversible losses when attacked by insect pests. As storage hygiene has improved so has the awareness of the contribution made by insect pests to losses. This has resulted in a demand from the trade leading to a widespread increase in the use of detection methods for determining ever lower levels of infestation. In the last 20 years significant increases in the ability to trap storage insects have occurred and this has been coupled with the development of strategies for insect detection, monitoring and control.

This review concentrates on the problems of trapping the major storage insect pests and how these affect the development of control strategies for moths and beetles.

MOTH TRAPPING

The principal storage moths found in Europe and North America are the phycitids, *Ephestia* species and *Plodia interpunctella* and the gelechid *Sitotroga cerealella*. In each case the females produce a sex attractant pheromone which may consist of one or more components. The *S. cerealella* pheromone is (Z,E)-7,11-hexadecadienyl acetate (HDA) and has been used to bait traps for detection and monitoring (7, 28) but work has concentrated on the phycitids, which have a wider economic impact There is a need to trap more than one species and it is fortunate that all the phycitids are attracted by one long-range female produced sex pheromone (Z,E)-9-12-tetradecadienyl acetate (TDA). As the pheromone response is specific to males, traps can be used to detect and monitor populations without the fear of attracting egg-laying females into food areas or attracting such females to commodities that may have become contaminated with the pheromone.

Lures with synthetic TDA pheromone became commercially available in the late 1970's. Traps were used in a variety of storage premises, chiefly for detection and monitoring moth populations. Food factories and warehouses were monitored using TDA-baited sticky fly papers or delta-shaped traps (15,23,25) or using plastic funnel traps (5). Haines (11), Fleurat-

Lessard et al (9) and Fleurat-Lessard (8) tried with limited success to reduce populations of phycitids by release of high doses of TDA, whilst Reichmuth et al (25) used sticky pheromone traps to reduce E. elutella in food warehouses by mass trapping of the male population. More recently, Trematerra and Battaini (27) have reported a reduction in numbers of E. kuehniella by using funnel pheromone traps in the much more difficult environment of a modern flour mill.

Control strategies have been proposed following the first successful use of TDA baited traps. Timing of fumigation in food warehouses and a chocolate factory to control P. interpunctella and E. elutella based upon trap catch was proposed by Reichmuth et al (25). A similar approach by Hoppe and Levinson (15) produced population curves for phycitid moths in a chocolate factory and they proposed the timing of control measures based upon trap-catch data. Reichmuth et al (24) followed this with a specific recommendation that granaries in West Berlin should be fumigated one month after the first peak emergence of E. elutella as determined from trap catch data. Sifner and Zdarek (26) produced an insecticide treatment threshold figure of 42 E. cautella per trap per two week period in a chocolate factory. This figure was derived from accepted levels of pest presence in machinery. They achieved control using only half the number of spray treatments previously used in a year. Cogan (5) reported the use of pheromone-baited sticky traps in a control strategy whose success was measured by the incidence of customer complaints related to moths found in the finished product. Thorough cleaning and spraying contact insecticide in the machinery close to the highest trap catch significantly reduced complaints and trap catch.

In summary, moth pheromone trap data has enabled individual control programmes to be devised and applied successfully in a number of food factories, warehouses and flour mills. Threshold levels of trap catch which trigger remedial action may be set as low as one moth in sensitive areas such as finished products, particularly baby foods and chocolate. In premises with less sensitive products, threshold levels of trap catch may be set to suit local needs and vary within the premises(21). Thresholds have been used for both treating entire buildings (26) or for localised control where the highest trap catch dictates the site of remedial measures (5).

BEETLE TRAPPING

In contrast to the work on moth species, a far greater research effort has been undertaken in laboratories to investigate beetle pheromones but as yet the same level of success in practical applications has not been achieved. The trade needs improved detection but it does not necessarily follow that the identification of pheromones in the laboratory will have any practical application. The pheromones have a number of components and also may be complex and expensive and have to compete with the aromas of the infested commodity. Also, the use of a species-specific pheromone may not be appropriate in a storage environment where it may be necessary to trap any of several species.

Detection of beetles in bulk grain has until recently only been by sampling the grain using a spear or vacuum sampler and sieving the samples for insects. This method is used more because the grain samples are analysed for other qualities than any particular suitability. Indeed this conventional detection has been shown to be extremely unreliable (33,34) Most recent research has utilised insect probe traps (2,19) to detect beetles within grain bulks. Although the traps have proved to be better than conventional sampling methods, laboratory trials indicate that they catch a very small percentage of insects present (6,33). Performance of these traps may be improved by attractants and examples of other traps which have been improved with pheromones include the cardboard refuge (Storgard) traps (1,2) and two types of commercial adhesive trap (3,35).

Pheromones of all the major species of storage beetles have been determined (3,4) but unlike the storage moths few of the beetle species produce a female sex pheromone and those that do are generally short-lived. Some of these sex pheromones have found commercial application. Pheromone baited traps have been used to monitor the seasonal emergence patterns of Lasioderma serricorne in a Japanese cigarette factory (31) and Trogoderma species have been successfully detected and monitored in a number of storage situations in the USA (3). In the majority of beetle species, which are long-lived, the males produce an aggregation pheromone which attracts both sexes. Practical applications of aggregation pheromones have included dominicalure, used in traps for the estimation of aerial density of Rhyzopertha dominica in warehouses (16), Trunc-call for detecting Prostephanus truncatus in farm stores (12) and Tribolium pheromone in field studies to trap T. castaneum.(2). It is unfortunate that inhibitory isomers in the synthetic Tribolium pheromone may result in some reduction in aggregation response (3). Recent improvements in trap design (35) and the production of the pheromone without the inhibitory isomers have enabled Cogan and Sanderson (unpublished data) to successfully monitor T. castaneum in a UK maltings.

The pheromones of the storage cucujid, silvanid and curculionid beetles are more complex. This may be illustrated by the aggregation pheromone components of 3 Cryptolestes and 2 Oryzaephilus species which consist of 7 closely-related unsaturated monocyclic lactones (20). The 3 aggregation pheromone components of one of the species, O. surinamensis have been studied in considerable detail (32). In pitfall bioassays differences in response by the sexes were not only found with regard to individual components but also to alterations in the blend ratio. There was no difference between the sexes with regard to EAG responses which may be explained by assuming a difference in response when the central integration of olfactory inputs occurs. This work demonstrates not only the complex nature of the aggregation pheromone components in this group but the need for all 3 components to be used in a lure and to be used at the optimum blend ratio. It further serves to demonstrate that laboratory work in this field should not rely on a single study such as EAG but should be backed up by bioassay work relevant to the final use of the chemicals in the field.

As storage beetle aggregation pheromones are mostly species specific, mixed lures will be required if they are to be used for general monitoring of stored products. Some mixtures of pheromone components have shown success in interspecific trapping, for example in laboratory studies; sitophinone has been shown to trap 3 Sitophilus species: oryzae, zeamais and granarius (30), whilst in the field, Rhyzopertha dominica and P. truncatus have been trapped using dominicalure (14). Also, Lindgren et al (17) found no inhibition of catch when C. ferrugineus and T. castaneum were trapped using mixed or separate lures. If traps are to be used for detection of many species then the possibility of component interaction leading to a reduction in attractancy as shown by Vick et al (29) with storage moths, must be considered.

In summary, the short-lived storage beetle sex pheromones have found commercial applications for detection and monitoring (2,31) whilst a few of the long-lived beetle aggregation pheromones have been used in storage situations (2,16). The more recent laboratory studies of the cucujids silvanids and curculionids (30,32) show that the pheromone components of these beetles are of considerable complexity and still require much work on their chemistry, production,and response as well as field demonstrations of their value.

The use of food as an attractant to storage beetles has been demonstrated using bait bags (22),whilst Chambers (4) has detailed the use of food attractants for storage beetles. Cogan and Wakefield (6) found that carob (*Ceratonia siliqua*) a constituent of bait bags, enhanced surface pitfall traps in grain but the use of such a food lure may not be commercially acceptable in food production areas due to the risks of insects breeding in lost lures. Chambers (4) records that laboratory tests have shown carob volatiles to elicit attractive responses from all the major stored product beetle pests. Research is in progress at our laboratory to produce a lure which incorporates carob volatiles for use in beetle traps. This lure should overcome many of the specificity problems associated with the use of aggregation pheromones and should the lure be lost it would not provide a breeding site for insects.

Although some attempts at quantifying trap catch data have been made (10, 18) the traps yield qualitative data which is unlikely to become quantitative until trap catch relationships with such factors as type of grain, trapping period, location of traps and the influence of physical factors are understood (33).

CONCLUSIONS

Considerable progress has been made recently for the detection and monitoring of stored product insects. Pheromone components of all the major pests have been identified and many incorporated into traps used in control strategies. Traps incorporating the phycitid moth pheromone TDA are now an integral part of moth control programmes whilst the use of beetle aggregation pheromones may in future be limited to specific pest problems and traps baited with food lures used for general detection. Understanding the relationship between trap catch and infestation levels in grain still requires much detailed laboratory and field studies and it may be some years before this goal is achieved.

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EFFICACITE COMPAREE DES PIEGES A PHEROMONE DANS UN ENTREPOT DE TABAC INFESTE PAR *Ephestia elutella* (Hübner) (lép.,Pyralidae)

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Résumé

La comparaison de 5 modèles de pièges à phéromone a été réalisée dans un entrepôt de tabacs exotiques de l'ouest de la France, infesté par la pyrale *Ephestia elutella*. Un piège lumineux sans attractif a été utilisé en témoin. Les pièges ont été disposés en carré latin avec permutation des positions chaque semaine et renouvellement des diffuseurs à phéromone toutes les 5 semaines. On a observé la similitude du pattern des captures sur l'ensemble des pièges, qui fonctionnent en synchronisme, y compris le piège lumineux. Un piège insaturable ("Moth-trap" de BCS) a permis le plus grand nombre de captures. Le piège à glu ("Local-trap" INRA) donne de bons résultats en dépistage mais, il se sature rapidement dans ce cas de forte infestation, comparé aux modèles de pièges-réservoirs ("Mastrap" d'Agrimont ou "Multi-pher" de Biocontrôle). L'utilisation des pièges est à relier avec le niveau d'infestation des ravageurs, certains convenant bien pour l'avertissement, d'autres pour le piégeage de masse. Des méthodes de lutte d'accompagnement sont nécessaires dans le second cas lorsque l'infestation est importante comme dans la situation étudiée.

1.1 Introduction

L'absence de possibilité d'utilisation d'insecticides de contact dans les entrepôts de tabacs est un des facteurs de la relative prolifération de la pyrale du tabac: *Ephestia elutella* (Hübner), en particulier dans les locaux approvisionnés régulièrement en tabacs exotiques importés en France. La fumigation à la phosphine (PH_3) est autorisée mais, les inconvénients dus à la lourdeur de la mise en oeuvre du procédé et à l'absence de rémanence convient mal à la résolution des cas d'infestation chronique apportée régulièrement avec le tabac qui rentre en stockage.
Le piégeage de masse par phéromone est possible avec divers matériels et peut constituer dans certains cas une lutte curative si l'infestation n'est pas trop importante (Burkholder, 1981). Tous les pièges n'ont pas la même

efficacité qui, dans le cas du piégeage de masse, doit se traduire par le meilleur rendement quantitatif. Une expérience de comparaison de différents matériels de capture des papillons nuisibles a été entreprise dans un entrepôt d'un hectare environ et contenant 12 000 m3 de balles de tabac. L'objectif visé était la comparaison de l'efficacité du matériel de piégeage couramment utilisé mais, dans une situation d'entreposage nouvelle par rapport à celles déjà étudiées par d'autres auteurs (Levinson & Buchelos, 1981; Hodges et al., 1984; Buchelos & Levinson, 1985; Trematerra & Battaini, 1987; Fleurat-Lessard et al., 1988).

1.2 Matériel et méthode

Cinq types de pièges ont été utilisés: un piège lumineux servant de témoin; le Local-trap de l'INRA; le Multi-pher de Biocontrôle; le Mastrap d'Agrimont et le Mothtrap de Biological Control Systems. Les trois derniers modèles sont qualifiés d'"insaturables" ou pièges à réservoir d'insectes. Les 4 pièges à phéromone ont été appattés avec le même diffuseur contenant 5mg du produit attractif (Z,E-9,12-14:Ac). Les pièges ont été disposés en 5 blocs de 5 pièges formant un carré latin. Dans chaque bloc, une permutation des positions est intervenue chaque semaine. Toutes les 5 semaines, les diffuseurs ont été changés au moment où le dispositif revenait dans sa configuration initiale. Le piégeage a été maintenu pendant 28 semaines et les résultats hebdomadaires sont exprimés dans la figure suivante:

1.3 Résultats

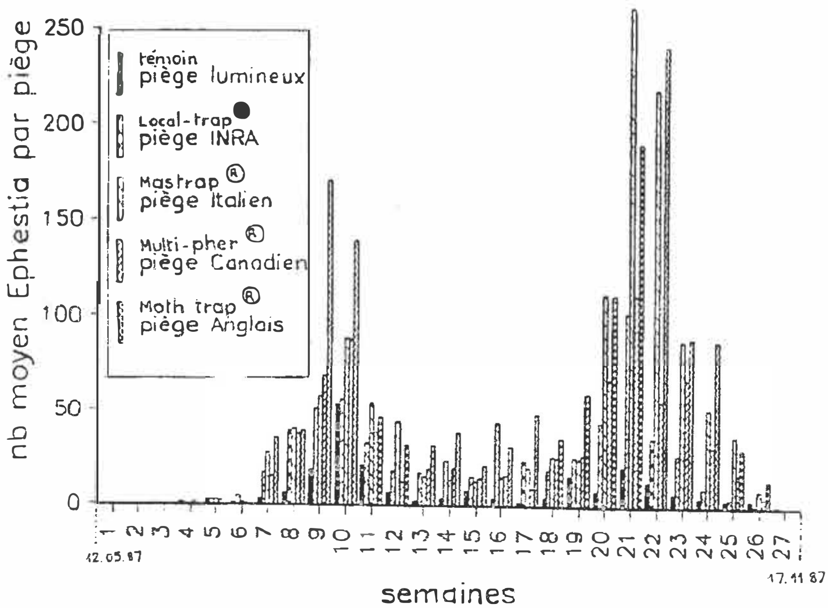

figure 1. *Relevés des captures d'Ephestia elutella en entrepôt de tabac de mai à novembre 1987 avec différents modèles de pièges*

Les principaux résultats observés dans la comparaison des effectifs des captures aux différents pièges sont les suivants:

- La forme des courbes de vol de papillons dans l'entrepôt est bien décrite par tous les pièges, y compris le piège lumineux qui a pu être pollué manuellement par l'attractif sexuel au moment des permutations ou qui a bénéficié d'une imprégnation de l'environnement par le piège précédent, contenant l'attractif.
- Le début des captures est difficilement détecté par le piège "Moth-trap", cette observation pouvant être associée à l'effet répulsif de l'insecticide volatil qu'il contient.
- Sur une période homogène de 7 semaines au centre de la période de piégeage, le plus grand nombre de captures est obtenu avec le "Moth-trap", le plus faible avec le piège lumineux, les autres modèles n'étant pas significativement différents.
- Les effectifs des captures sont corrélés d'un piège à l'autre, mais le piège à glu se sature facilement au cours des périodes de forte densité de papillons dans l'entrepôt.

1.4 Conclusions

Le niveau des captures est resté très élevé en relation avec la forte infestation d'E. elutella qui règnait dans les lots de tabac entreposés. Le total d'insectes capturés (mâles) s'est élevé à 13 296, tous pièges confondus. L'expérience a prouvé que l'imprégnation du produit stocké était importante à partir de la phéromone diffusée et que l'efficacité des pièges dépendait de leur conception, le piège à glu "Local-trap" et le "Multi-pher" étant relativement moins efficaces pour le piégeage de masse que le "Moth-trap" et le "Mastrap", bien que ceux-là soient bien adaptés au dépistage précoce des infestations d'E. elutella. L'expérience est à renouveler pendant plusieurs années pour apprécier la valeur du piégeage de masse en tant que méthode de lutte dans l'exemple d'utilisation étudié où la relation avec les dégats ne peut être réalisée autrement qu'en observant les effectifs d'insectes capturés et en les comparant d'une année à l'autre.

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THE BEETLE IS ALWAYS RIGHT: USING TRAP CATCH DATA AND BEHAVIOURAL RESPONSES TO DESIGN THE ULTIMATE STORED PRODUCT BEETLE TRAP

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Summary

An efficient new trap for stored product beetles makes simple and effective use of pitfall and glue. The design works well even in dusty environments.

Introduction

Stored foods are attacked by a wide range of insect pest species. However, for human foodstuffs in particular the tolerance of pest insects is low and monitoring to detect infestations reliably and as early as possible is an important part of pest management ((3); see Cogan, this volume).

The need for early detection of low population densities of pests requires traps that are particularly efficient - both in encouraging entry and retaining those insects caught. A variety of methods of killing or retaining insects in traps have been used;some such as insecticides are not appropriate for use in food stores.

Our preliminary experiments on glues showed some were very effective if the beetles were dropped onto it. However, grain stores and mills are extremely dusty and unprotected glue surfaces are rapidly made ineffective. The Wyatt-Wynn trap protects the glue by restricting entry of insects (and dust) to the 2 mm wide corrugations of the plastic 'Corex'(Fig. 1). Settling dust does not enter the trap. A second feature of the trap, the pitfall and overhang, provides a solution to the behavioural avoidance of glue by beetles.

Two useful practical features of the trap, now made and marketed by Biological Control Systems Ltd* (Registered Design application No. 1047809), are that it is supplied baited with pheromone and ready to use and that the catch can be quickly scanned through the transparent roof.

The detailed design of the trap was established by laboratory experiments and observations of the behaviour of *Tribolium castaneum* near and in traps baited with 1 mg *R,R* - 4,8 dimethyldecanal (supplied by BCS Ltd), the *Tribolium* aggregation pheromone (4).

Results

The internal design of the trap had a marked effect on the catch. Trap catch was almost doubled by having the inner edge of the corrugations overhanging the glue rather than a simple cliff pitfall of the same depth (df=1,F=128.4, p<0.0001). Increasing the depth of the drop from 1 mm to 3 mm also increased the catch (qv). Where catch was increased this was due to a higher proportion of those entering being caught. This is likely to reflect a greater sensitivity for detecting low population densities.

The standard Wyatt-Wynn trap (1 mm deep) and 3 mm deep version were compared with Storgard (1). All 3 traps were baited with 1 mg *R,R* - 4,8 dimethyldecanal. The Storgard pitfall contained 0.5 ml light mineral oil (Sigma M-3516) and the pheromone septum was placed in the recomended position (1). After 1 h the percentage catches out of 25 beetles (on the glue or in the oil)(mean $\bar{x}$, 95% confidence limits(CL),n=6) were: Wyatt-Wynn trap 1mm: $\bar{x}$=39%, CL=23.5-55.2%; Wyatt-Wynn trap 3mm:x=53%, CL=39.0-67.2%; Storgard: $\bar{x}$=7%,CL=0.05-22.2%. After 20 h the results showed the same pattern. The more rapid capture and imobilization of the beetles in the Wyatt-Wynn trap suggests

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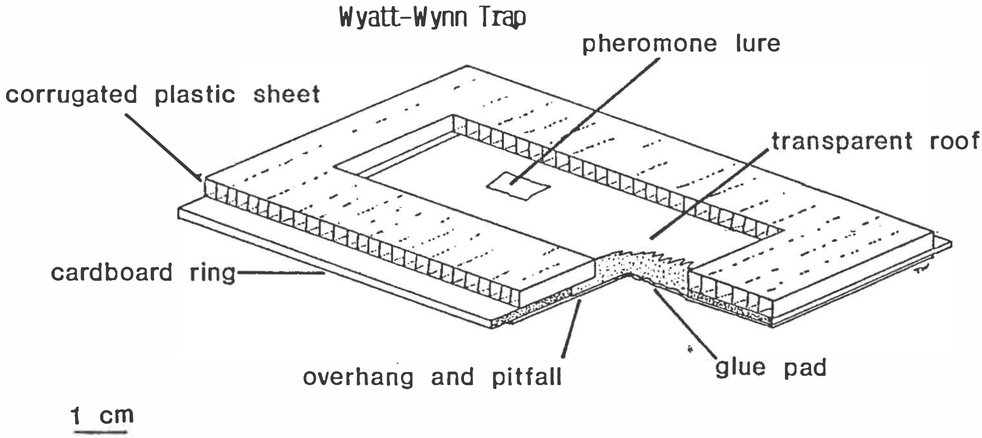

Figure 1. The Wyatt-Wynn trap showing the clear plastic roof, corrugated plastic which the beetles walk through into the trap and the overhang over the glue pad. A cardboard cutout provides the depth for the pitfall effect.

that these traps have a higher trapping effiency and would be more likely to disclose infestations.

Field testing of the trap

The most important test of the traps is in the field - in competition with natural aggregations, other sources of food and shelter. A persistent *Tribolium* infestation at a maltings provided the opportunity to compare the Baitbag (2) and baited and unbaited Wyatt-Wynn traps made by BCS Ltd (P Cogan, MAFF, unpublished data, quoted by kind permission). The weekly catches for the baited Wyatt-Wynn trap (mean, 95% CL, n=60 trap weeks :$\bar{x}$=13.1, CL 9.5-17.2) and Baitbag were very similar (11.9, CL 8.1-16.4) and the 4-week total catches of adjacent traps were highly correlated (r=0.91,n=17, p<0.0001). The unbaited control trap not surprisingly caught fewer insects($\bar{x}$=2.1, CL 1.3-3.1).

The possible promise of the trap for monitoring other stored product beetles including *Oryzaephilus* and *Sitophilus* is currently being investigated.

ACKNOWLEDGEMENTS We thank the Wolfson Foundation for funding, Dr OT Jones, D Pinniger, Dr J Chambers, P Cogan and Dr D Dent for materials, valuable discussions, and permission to quote unpublished data.

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THE USE OF PHEROMONES AND OTHER ATTRACTANTS IN MONITORING POPULATIONS OF S. invicta, A PEST ANT IN THE UNITED STATES

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Insects Affecting Man and Animals Research Laboratory

Summary

Solenopsis invicta was accidentally imported into the United States about 50 years ago and quickly attained pest status. The ants' potent sting, large numbers, and aggressive behavior have created public health problems, and significant damage to several crops. The fire ant currently infests 11 southern states and Puerto Rico, but has the potential for survival in irrigated areas of New Mexico, Arizona, and California. Quarantine measures are in place; however, early warning detection methods are needed. We have initiated research to devise a species-specific trap that will catch foraging fire ant workers. The trap design is a limited access pitfall-like trap that excludes large non-ant insects. We are in the preliminary stages of formulating a fire ant selective food attractant and/or two attractant pheromone systems (worker produced recruitment and queen produced worker attractant pheromones).

Introduction

Solenopsis invicta is a pest ant in the United States that was accidentally imported from South America. Over the 50 years since its introduction it has developed an impressive reputation. Its dominant features are its aggressive behavior, potent sting, and large mounds (nests). Each mound can have up to 250,000 workers and there can be over 100 mounds per hectare.

The major components of fire ant venom are piperidine alkaloids that have a wide range of physiological activities (histidine release, hemolysis, and antibiotic activity). The number of people exhibiting hypersensitivity is about 1% of the population (as in honeybees); however, because many more people are stung by fire ants, the number of reports of deaths and hyper-sensitivity is much greater than for bees. Fire ants are also an agricultural pest and have been shown to affect the yields of numerous crops from potatoes and okra to soy beans.

Currently, the ant infests 11 southern states, as well as Puerto Rico. S. invicta has found its adopted home very attractive and is present in most areas in high densities. The fire ant effectively colonizes new territory because of its high production of sexuals and numerous mating flights; however, transportation of ant colonies in sod and nursery stock accounts for its rapid distribution throughout the Southern United States. The potential range includes parts of New Mexico, Arizona, California, Oregon and Washington that have adequate rainfall or are irrigated. Quarantine treatments with chlordane were used until the late 1970's. Since its demise there have been numerous discoveries of the fire ant in Tennessee and Oklahoma, and west Texas. Two isolated infestations were discovered and eradicated in New Mexico and Arizona. This highlights the need for fire ant-specific detection methods.

Colony Stages of Interest

There are 4 basic colony stages to deal with 1) insemination of a female sexual, which takes place 100-200 meters in the air; 2) claustral colony founding, where the first worker brood is reared by the queen in isolation; 3) incipient colony development, where worker numbers increase along with colony energy flow; and 4) the mature colony, which can contain up to 250,000 workers and produce 5000 sexuals each year. All three of the last stages can be transported by man to other parts of the country, such as california. Isolated colony founding queens are extremely difficult to detect. The most logical target for detection are worker fire ants foraging for food.

Trapping Methods and Specificity

Pitfall traps are currently used in California at potential incipient fire ant population sites. These traps are non-insect discriminant and are labor intensive. Our laboratory has concluded that limited access pitfall traps baited with a fire ant specific attractant would provide the best initial approach to the problem. Small access holes effectively exclude non-ant insects. What remains is to incorporate a fire ant-specific attractant to further exclude non-target ant species.

Research on the feeding preference of a major non-target ant, P. morrisi, indicates a strong preference for soybean oil over pumpkin seed oil. These results are promising; however, further tests are necessary to determine if pumpkin seed oil is selectively attractive to fire ants.

Two fire ant pheromone systems have behavioral properties that may prove useful in developing species-specific traps. Three components from the trail pheromone have been isolated from the Dufour's gland that attracts worker ants. Two of these compounds have not yet been synthesized. Their lack of availability has inhibited our evaluation of this pheromone complex. A second pheromone system is a queen produced worker attractant. Three components are responsible for this activity and have been synthesized but are not readily available. To alleviate the problem of pheromone availability, we recently hired a postdoctoral research associate to synthesize the necessary compounds. Future reports will elaborate on our progress in making fire ant trap detection a reality.

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COMPARATIVE EFFECTIVENESS OF THREE PHEROMONE TRAPS

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Summary

Comparisons were made of 3 types of pheromone traps, an international funnel trap with Vapona[R] 1/ killing agent, and an INRA-designed home made trap with funnel and Vapona killing agent, and an INRA home made design with water as the collecting/killing agent. More Autographa gamma L. were collected in the international trap, 73 percent vs. 21 percent in the home made funnel trap, and 6 percent in the home made water trap. Despite this difference in numbers captured, it is suggested that further tests should be conducted to determine if the higher catch by the international trap is consistent. Syrphid flies, Episyrphus balteatus D., were also more attracted to the international trap, 88 percent, vs. 5 percent and 7 percent, respectively. The yellow and white color of the international trap may have been more attractive to this species than the green of the home made traps. Catches of miscellaneous species of insects and of other flies were similar for each trap, implying that the higher captures of A. gamma and of syrphids might be due to greater attractiveness of the international trap.

1.1 Introduction

A program has been initiated to monitor occurrence and movement of certain insects across Europe. Such an effort should ideally use traps of equal performance in capture efficiency for purposes of comparing catches. Home made traps of the INRA (National Institute for Agronomic Research of France) design and commercially available international funnel traps, either of which could be used in the program for monitoring populations of certain species of noctuid (Lepidoptera) moths, were compared for their relative effectiveness.

1.2 Materials and Methods

An international funnel trap with Vapona as the killing agent, a home made trap with Vapona and funnel insert similar to the funnel entry on the international trap, and a home made trap with water (and detergent) as the

1/ This commercial product is not to be construed as recommended by the USDA to the exclusion of another product producing similar results.

trapping/killing agent were compared. The top half of the international trap was yellow in color, bottom white and cover green; the home made trap was uniformly mat green with a white cover. The pheromone used in each trap was an experimental attractant for Autographa gamma L. (Noctuidae, Lepidoptera), supplied by the USDA Animal and Plant Health Inspection Service. Each of the 3 traps was placed on a pole of adjustable height, 5 m. away from the next trap, in a line. Height of the trap on the pole was adjusted weekly as necessary, so that each trap was just at the height of the growing crop. This 1987 study was conducted in an alfalfa (Medicago sativa L.) field of the USDA laboratory in Behoust (W. of Paris), France. Traps were examined weekly, and each was rotated at that time to a different pole, so as to eliminate any effect on the capture due to location. Fresh pheromone was supplied each month. Numbers of the target insect, A. gamma, were record- ed. Other insects captured were recorded also. For purposes of reporting, they were grouped into common categories, which might be broad or narrow, depending on numbers captured.

1.3 Results and Conclusions

The collection of A. gamma males was relatively low in 1987, totaling only 52 captured during the 25 weeks of the study. Of this total, 38 were trapped by the international trap, 11 by the home made, Vapona trap, and only 3 by the home made water trap. About half (25) of this number was captured during the 4 weeks of June 10 - July 7. A small second generation (9 males) was detected during the 4 weeks, October 1-30. It is considered that the numbers in the catches indicated peak field populations of A. gamma, based on observations and collections of larvae by sweep nets in this and other sites.

Captures of other insects implied a possible cause for this difference in A. gamma numbers. The capture of syrphids, Episyrphus balteatus, was higher in the international trap, numbering 120 of the 137 total captured. The home made trap with Vapona captured 7 and with water, 10. It would appear that the yellow color of the commercial trap influenced this obvious difference. This might lead one to interpret the difference in numbers of A. gamma captured as also possibly due to color attraction. The low numbers collected and the erratic nature of the collection does not allow a definitive conclusion, however.

Other insects captured did not exhibit this strong attraction to the international trap. Captures of flies other than syrphids were similar in each trap: 164 international, 188 homemade with Vapona, 170 homemade with water. Likewise, captures of other insects, excluding sudden one time anomalies, were similar for each trap. This indicates that the three traps had the potential for equal performance with some insect species and suggests that for other species the international trap might have a different capturing effect than the home made traps. Whether this was a function of design or other factor (yellow color) was unclear. Additional tests are warranted to determine whether the differences observed here are consistent for A. gamma and how the traps would perform for other noctuid species which have a different flight behavior, particularly the target noctuids in the international monitoring program.

THE EFFICIENCY OF STICKY TRAPS

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Summary

An attempt to determine an accurate saturation level for small sticky traps was unsuccessful. Although catches of more than 200 *Plutella xylostella* have been recorded using 20cm x 10cm sticky plates, these began to show a decline in efficiency within 2 hours and with catches of about 20 insects. While these are cheap and convenient to use it would be advisable to deploy them only against low density pests and where they can be frequently serviced.

Cardboard traps incorporating sticky bases are probably the types most widely used in pheromone research, but several authors have observed deficiencies in their performance (Houseweart *et al.* 1981; Reidl 1980; Sanders 1978). A decrease of efficiency is generally attributed to the fact that each insect caught reduces the surface area available to catch the next one entering the trap and Daterman (1982) suggested a Population Index which gave an arbitrary weighting to higher numbers using the formula

$$PI = \frac{(Mc-1)\ (Ac)}{Mc - Ac}$$

Where Mc is the maximum possible catch and Ac the actual catch. Daterman also emphasized the fact that the Mc for any insect/trap combination must be accurately determined.

Catches from pairs of sticky traps at 30 sites in South and East England peaked at about 200 diamondback moths (*Plutella xylostella* L.) and occasionally remained at this level for two or three weeks suggesting that this might be a maximum. In an effort to confirm this, a mass culture was established on Chinese cabbage in a glasshouse (7m x 3m). When very large numbers of moths were present in the glasshouse a single sticky trap placed therein appeared to saturate after 70 moths had been caught. This could of course be due to the elimination of all the sexually active males from the culture. Subsequently two 20cm x 10cm sticky plates were placed side by side with the attractant dispenser at the centre. One of the plates was replaced daily, the other was left to accumulate its catch. The two plates caught 85 and 56 moths during the first 24 hours after which the unchanged plate (85) continued to catch at a rate of about 10 moths/day while fresh plates caught 70 moths/day. From this it appeared that the new plates might also be saturating within 24 hours and hourly counts during the next day showed that of the 50 insects caught, 50% were taken during the first 3 hours. The figure of 200 moths was found only once in 10 experiments.

The procedure was repeated with *Autographa gamma* and *Ephestia*. The largest number of *A. gamma* ever caught was seven while *Ephestia*, although considerably larger than *Plutella* could be caught in similar numbers.

Elkinton (1987) has shown reduction of catches in milk carton traps due to decomposition of trapped moths but this is unlikely to have accounted for the decreased catches after only 2 hours with P. xylostella. Sanders also considered that the declining efficiency of sticky traps for spruce budworm was in part due to a repellent odour produced by trapped males but suggested that this olfactory effect could be produced as a result of stress due to capture. While this may be a contributary factor it seems likely that the major part of the loss of efficiency is due to contamination of the surface of the adhesive with scales, not only those deposited by trapped moths in their immediate surroundings but by those that are partially trapped and escape. A considerable amount of work is required to throw further light on this, partly with non-scaly insects such as diptera. The cheapness and convenience of sticky traps means that they are a useful tool for use with low density pests and where they can be serviced daily.

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ORCHARDS AND VINEYARDS

EMPLOI DU PIEGEAGE AVEC DES ATTRACTIFS DANS LA CONDUITE DE LA LUTTE CONTRE LES INSECTES NUISIBLES AUX VERGERS

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Les possibilités de piégeage en verger se sont considérablement accrues au cours de la dernière décennie avec la mise au point d'attractifs sexuels pour une trentaine d'espèces de Lépidoptères nuisibles, quelques cochenilles, ainsi que pour 2 mouches des fruits (Tableau). D'autres médiateurs chimiques sont utilisés comme appât pour : Synanthedon myopaeformis Borkh (liquide sucré), le xylebore Anisandrus dispar F. (alcool éthylique), Ceratitis capitata Wied. (hydrolisat de protéine, trimedlure et dérivés), Dacus oleae Gmel. (sels d'ammonium, hydrolisat de protéine).

Cependant, selon les régions, la fréquence d'utilisation du piégeage pour la surveillance de ces espèces nuisibles est très variable. Nous présentons dans le tableau toutes les potentialités existantes même si elles n'ont été mises en évidence que dans un secteur limité. Il est clair qu'avant toute décision d'application ailleurs des études complémentaires sont nécessaires car de nombreux facteurs influent sur le niveau et la signification des captures. Ils sont relatifs à : la population (importance, état physiologique, fermée ou non...), les conditions de piégeage, les caractéristiques de l'agroécosystème considéré et de son environnement, les conditions météorologiques. Il importe donc de parfaitement définir les conditions de piégeage pour chaque espèce, une certaine standardisation en la matière serait souhaitable.

Le piégeage peut être mis en oeuvre, soit dans le cadre d'un service d'avertissement phytosanitaire agricole pour lequel il contribue à définir un risque moyen régional, soit au niveau d'un verger pour une prévision réalisée dans l'optique d'une lutte raisonnée.

Les interprétations des résultats, qui peuvent être considérés, sur un plan qualitatif ou quantitatif, doivent tenir compte de la biologie de l'espèce, de la phénologie des arbres et des caractéristiques de l'agroécosystème verger. Il ne faut jamais perdre de vue que ce sont seulement les mâles qui sont capturés avec les phéromones sexuelles des lépidoptères, cochenilles et Dacus oleae, alors que ce sont les femelles qui assurent la fonction de reproduction. Pour Ceratitis capitata, on capture essentiellement les femelles avec la phéromone, il en est de même pour Anisandrus dispar avec l'alcool. Les autres médiateurs chimiques cités dans le tableau attirent les individus des 2 sexes.

Le piégeage permet de déceler des insectes de quarantaine (Cydia molesta Busck., Ceratitis capitata), ou des débuts d'infestation toujours discrets (Aonidiella aurantii Mask.). Les périodes et l'allure des vols établies par piégeage contribuent à la modulation des conseils de lutte surtout au niveau régional. Il est évident que s'il n'y a pas de capture, il n'y a pas de risque : c'est la prévision négative.

On peut également déterminer les périodes d'observation en verger certaines espèces présentes en abondance n'étant nuisibles qu'occasionnellement, localement ou au niveau d'une génération. On peut citer par exemple : Cacaecimorpha pronubana Hb., Argyrotaenia pulchellana Hw., Euzophera bigella Zell... Les dates de traitements dirigés contre les jeunes larves à l'éclosion sont calculées d'après la modélisation du développement embryonnaire selon la température (Cydia pomonella L., Adoxophyes orana F.R....). Lorsque la lutte vise les adultes de mouche des fruits, les piégeages indiquent directement le début ou la reprise du risque et la nécessité de traiter à une échelle régionale.

Le piégeage peut servir à contrôler l'efficacité d'un traitement chimique visant les adultes de la génération précédente (Anisandrus dispar) ou les larves de la génération dont ils sont issus : c'est le cas pour les Tordeuses de la pelure.

L'utilisation de seuils de captures pour raisonner la lutte à l'échelle d'un verger concerne plus d'une dizaine d'espèces. Ces seuils ont été définis selon 3 approches : la prévision négative améliorée (Cydia pomonella, C. molesta, C. funebrana Tr., Adoxophyes orana), la corrélation entre les effectifs capturés pour un vol ou une partie de vol et les populations larvaires dont sont issus les adultes (Pandemis heparana D. et S.) ou entre ces effectifs et les attaques subséquentes (Aonidiella aurantii, Prays oleae F.).

Enfin la lutte directe par piégeage intensif a donné, sous certaines conditions, de bons résultats pour quelques espèces.

POSSIBILITES D'UTILISATION DU PIEGEAGE AVEC DES ATTRACTIFS POUR LA SURVEILLANCE DES INSECTES NUISIBLES AUX VERGERS DE LA REGION OUEST PALEARCTIQUE ET LA LUTTE

TYPE D'ATTRACTIF/ GROUPE D'INSECTES PIEGES	AVERTISSEMENT REGIONAL				
	LUTTE RAISONNEE ET INTEGREE				
		Fixation (1) (2)			
	Détection = 0 Vols = X (1)	Périodes observation	Dates traitements	Conduite lutte selon seuil (1)	Lutte piégeage intensif (1)
SEXUEL/LEPIDOPTERES					
Cydia pomonella	X	X	X	X	
Cydia funebrana	X	X	X	X	
Cydia molesta	0 X	X		X	
Cydia janthinana	X				
Anarsia lineatella	X			X	
Adoxophyes orana	X (4)	X	X	X	
Archips podana	X (4)	X	X	X	
Pandemis heparana	X (4)	X	X	X	
Pandemis cerasana	X (4)	X	X	X	
Argyrotaenia pulchellana	X (4)	X		X	
Groupe Tordeuses s/famille Tortricinae (3)	X				
Pammene rhediella	X				
Pammene fasciana	(X)	(X)			
Euzophera bigella	(X)				
Orthosia gothica, O. incerta	(X)				
Enarmonia formosana	X				
Synanthedon myopaeformis	X		X (5)		
Synanthedon tipuliformis	X				
Synanthedon vespiformis	X				
Cossus cossus	X		X		X
Phyllonorycter blancardella	X		X		
Leucoptera malifoliella	X	X			
Prays oleae	X	X	X	(X)	
Prays citri	X				(X)

Tableau : suite

SEXUEL/COCHENILLES					
Quadraspidiotus perniciosus	X	X	X		
Pseudaulacapsis pentagona	X				
Aonidiella aurantii	0 X			X	
Planococcus citri	X		(X)		
SEXUEL/DIPTERES (6)					
Ceratitis capitata	(X)				
Dacus oleae	(X)				
AUTRES MEDIATEURS/ LEPIDOPTERES					
Synanthedon myopaeformis (appâts sucrés fermentés)	X		X		(X)
SCOLYTIDAE (7)					
Anisandrus dispar (Alcool ethylique)	X		X	X	X
MOUCHE DES FRUITS (8)					
Ceratitis capitata (Hydrolisat protéine Trimedlure et dérivés)	0 X		X	X	
Dacus oleae (Sels d'ammonium Hydrolisat de protéine)	0 X		X	X	(X)

(1) (X) Utilisation expérimentale
(2) Intégration de données biologiques et phénologiques
(3) Hedya nubiferana, Spilonota ocellana, Choristoneura hebenstreitella, Phycholoma lecheanum, Cacaecimorpha pronubana, Syndemis musculana, Clepsis spectrana, - Archips rosana, A. xylosteana, A. crataegana
(4) Vérification efficacité de la lutte sur larves dernier stade avec RCI fenoxycarbe
(5) Sur jeunes vergers traitement du collet
(6) En cours d'évaluation seules ou en piégeage combiné/autres attractifs, visuels
(7) Piégeage combiné (visuel et olfactif)
(8) Utilisation seule ou en piégeage combiné (plusieurs attractifs, visuel, phéromone...)

CONSIDERATIONS IN THE USE OF PHEROMONE TRAP DATA FOR THE INITIALISATION AND VALIDATION OF A TEMPERATURE DRIVEN PREDICTIVE PHENOLOGY MODEL FOR *Grapholita molesta*.

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Summary:
A minimum of 4 traps per orchard will normally provide data adequate for the initialisation and validation of a temperature driven computer model of the timing of population events for the Oriental fruit moth (Grapholita molesta). Although one or a few sites in a region suffice to give a useful picture of the spring emergence, disparaties in the timing of events at different sites in the same region become greater as the season progresses. The timing of action based on model runs using meteorological data from one orchard cannot automatically be extrapolated to the region as a whole.

1.1 INTRODUCTION

There has been a recent increase in the use of computer models aimed at identifying the timing (rather than the magnitude) of critical events of importance in the orchard ecosystem. Such phenology models will be particularly useful if they require only easily determinable initialising parameters and basic biological information on the life history of the pest species and will thereafter predict the timing of field events using only abiotic data such as temperature and humidity, which may be automatically recorded.

Validation analyses for the use of a distributed delay based phenology model,the Predictive Extension Timing Estimator (P.E.T.E.) of Welch et al (1978), have been published for the Oriental fruit moth using pheromone trap data only, and the model has been used with considerable success (Croft et al (1980)). In order to minimise the labour inputs required for validation we need to know:

1. How many traps are needed to give a sufficiently accurate picture of population events in one orchard?
2. How far can the events in one orchard be used as a guide to the events in other orchards in the same district?

1.2 RESULTS

1. The number of traps required to achieve a satisfactory level of confidence in the timing of events in any one orchard was examined using the maximum deviation (in days) for each of the possible combinations of any 1,2....8 traps from the mean date of 10%,50% and 90% cumulative trap catch for 9 traps in a 10ha mixed orchard at Kumeu, Auckland, N.Z. over 3 seasons and using 3 generations per season. Maximum deviations in timings were shown to be generally within 4 days of the 9 trap mean when any combination of 4 or more traps were used. When the number of moths caught per generation is high (over 500) the number of traps may be reduced but, as high trap catches tend to occur later in the season when generations may overlap, 4 traps is probably a practical minimum.

2. Spring Generation: The validity of extrapolating event timings from one orchard to the region as a whole was explored using spring emergence data from 6 sites over 4 years in the

Auckland region, taking the 50% trap catch point for each site (4 traps/site) from sine curves drawn through the cumulative trap catch data for each trap. Over the 4 springs, 1980-1983, the variation in 50% cumulative trap catch date between sites was not significantly different (at p=0.05) from that between traps within one site. The mean difference (±s.d.) between single site averages and the regional average was 4.5±3.4 days (max 12 days). In all years the s.e. of the mean was <7days implying that the specific choice of site may not be important in determining the progress of spring flight for the region i.e. the region as a whole was probably relatively climatically uniform. Examination of the site means over the 4 seasons did not show any site consistently early or late with respect to others.

Using data derived from de Montaigne (1979) and Vigneau-Nicolette (1974) for the Toulouse area of France (the 5,10,25,50,75,90 and 95% cumulative trap catch points for spring emergences in 1975-6), site deviations from the area mean were also <7 days in the spring generation. Kolmogorov/Smirnov 2 sample tests of each sites's data against the area mean showed no significant deviations (mean deviations of around 3 days).

Subsequent Generations: An indifference band analysis of the results of a P.E.T.E. model run based on met. and trapping data from single orchards in N.Z. and France showed predicted events to be consistently within 2-3 days of the actual event in the field throughout the first 3 generations of any season.

The position, however, turns out to be quite different when examining predictions for sites at some distance from the met. station. Tomkins et al. (1984) showed that heat unit accumulations from standard met. sites differed by only a few percent from those measured in a range of orchards some miles from those sites. However, P.E.T.E. runs for different sites in a region using only one set of met. data did not produce predictions which were acceptably close for them to be used in planning practical control measures beyond the first generation.

A graphic analysis using a physiological time scale failed to show clear correlations in the timing of generational peaks in the Auckland orchards. Likewise in the Toulouse area the cumulative percentage capture dates were increasingly less synchronised over the region as the season progressed, with some sites consistently in advance of others in terms of population development. Consistent differences of this type were not visible in the intra-site data for N.Z. or France i.e. traps at one site were more consistently similar than the means of sites within an area, even when that area was apparently uniform climatically.

1.3 CONCLUSIONS

Data from 4 traps in a single orchard may be used to initialise model runs in the spring and for model validation exercises. Observed differences in cumulative percentage trap catch dates between sites reflect real phenomena susceptible to the sort of analysis provided by the P.E.T.E. model. However, there are important differences in the timing of population events between orchards apparently experiencing very similar climatic conditions. This makes the use of meteorological data from one site only to model population events across a whole district undesirable, although it is not known whether temperature differences are solely responsible for the inter-site differences observed here.

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DEVELOPMENT AND IMPLEMENTATION OF AN EMPIRICAL THRESHOLD FOR CODLING MOTH CONTROL IN APPLE IPM

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The use of sex-pheromone traps for establishing densities of the codling moth *Cydia pomonella* (L.) has received much attention and various control thresholds based on trap catches have been proposed or implemented (1-3). Our experiments since 1985 onward are aimed at establishing a threshold suitable for integrated pest management (IPM) on apple in the Netherlands.

In apple IPM, 75 -150g a.i..ha^{-1} fenoxycarb is applied after bloom for control of the summer fruit tortrix. The residue kills also eggs of the codling moth that starts egg-laying some weeks later (4-5). The control threshold for this pest should be adapted accordingly.

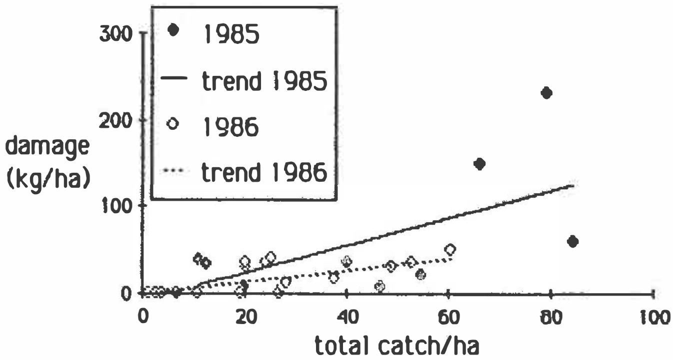
Five pheromone traps (Institute for Pesticide Research, Wageningen) were deployed in several commercial IPM apple orchards in 1985 and 1986. Four of these traps were arranged in a square encompassing an area of approximately 2 ha; the fifth was placed in the centre of the square.

Total trap catches during the first flight - a second one did not occur - were very similar in border and central traps. In 25 out of 40 trials, the numbers of moths caught in the central trap differed less than once the standard deviation from the average of the border traps. The number caught in the central trap was higher than in any of the border traps in 6 trials, and lower in 7. Catches in the central traps were on average slightly lower than (the averages of) those in the border traps in 1985, but higher in 1986. The mean difference over both years was nil. In contrast to our initial expectation, we had to conclude that the square of border traps did not prevent the central one from catching moths from a wider area than the hectare or so surrounding it.

Codling moth entries were scored on 1000-2000 apples - as well as in samples of prematurely dropped fruit - of each variety inside the square of pheromone traps at harvest in 1985 and 1986. This was always done in parts not treated against codling moth. The average damage (in kg.ha^{-1}) was calculated from the total weight of harvested fruits per variety, and the area covered.

The figure compares these damage estimates with the total number of moths caught in 5 traps, divided by the size of the entire orchard (in ha).

The amount of damage exceeded the supposedly critical quantity of 100kg.ha^{-1} in only 2 out of 27 localities. Although the data is rather weak, a total of 50 moths.ha^{-1} was adopted as the critical number for experimental use in 1987.



Then, 107 pheromone traps were deployed in about 40 orchards, each trap covering a block of at most 4 ha. Growers were requested to apply an insecticide – 150g a.i.ha^{-1} diflubenzuron – as soon as 25 moths.ha^{-1} had been caught, but not later than halfway the flight period. The latter moment is assumed to occur at 275DD above 10°C, based on previous observations and on literature data (*e.g.* 3 and 6). The growers were also asked to estimate the damage per block at harvest.

Diflubenzuron was applied in 22 blocks (=21%), although the total catch exceeded eventually 50 in only 4 of these places. In the 85 untreated blocks, both trap catches and damage were usually low:

total number of moths.ha^{-1}	number of cases with damage (%) none	<0.5	0.5-1.0	>1.0
0-10	36	2		
11-20	19	6	1	
21-30	2		1	4
31-40	1	2	2	
41-50	2	3		
51-75	2		1	1

Less than 51 moths were caught in 81 out of 85 blocks; damage exceeded 1% in four blocks. These included two young plantings with relatively few fruits, and one in which immigration of females occurred most probably, leaving a single block where the damage level does not seem to agree with the previous low trap catch.

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UTILISATION DES PHEROMONES SEXUELLES DANS LA CONDUITE DE LA LUTTE CONTRE DES RAVAGEURS DE LA VIGNE

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Développement des phéromones des tordeuses de la grappe, eudemis (Lobesia botrana) et cochylys (Eupoecilia ambiguella)

La composante principale du phéromone d'eudemis est le E7 Z9-12: Ac (E7 Z9-Dodekadienylacetate) décrit en 1973 par ROELOFS et al. Par la suite, beaucoup d'essais de laboratoire et des observations sur le terrain ont été effectués afin d'améliorer le pouvoir attractif du phéromone : recherches de substances mineures qui agissent comme synergiste, étude des formes de piège, leur placement dans le vignoble et aux différentes hauteurs sur le cep, etc. Les captures dans les pièges ont été comparées avec d'anciennes méthodes de piégeage telles que pièges lumineux, alimentaires ou pièges dotés de femelles vierges. On constate assez rapidement que les résultats ne sont pas comparables entre eux, que chaque méthode exige sa propre interprétation et que le meilleur piège n'est pas forcément celui qui capture le plus de papillons.

Aujourd'hui, les pièges à phéromones de L. botrana sont utilisés dans tous les pays viticoles européens.

Le phéromone de cochylis, dont le composé majoritaire est le Z9-12. Ac (Z9 - dodecenyl-acetate) (ARN et .al 1976) a suivi le même chemin de mise au point, pour la pratique viticole, que celui d'eudemis et son utilisation en est, aujourd'hui, tout autant répandue.

Quelles sont les informations utilisables ?

a) Aire de répartition du ravageur

Dans beaucoup de régions viticoles, les deux tordeuses sont installées soit d'une manière isolée l'une de l'autre, soit en population mixte. Les pièges à phéromones sont un outil simple et fiable pour déterminer l'aire de répartition de chaque espèce, sans qu'on puisse se prononcer sur leur importance en valeur absolue. Cette information sur la répartition des espèces pourrait être utile lors du choix des méthodes de lutte spécifique pour l'une ou l'autre espèce, telle que confusion sexuelle, régulateurs de croissance d'insecte.

b) Détermination des dates de traitement et de l'époque d'observation supplémentaires

La courbe des captures dans les pièges à attraction sexuelle n'est certainement pas identique à une courbe d'éclosion de mâle. Cependant, l'expérience pratique dans la même région sur plusieurs années, permet de déterminer à partir de ces captures, d'autres stades phénologiques du ravageur plus important (pontes, éclosion des larves, etc.). L'objectif est de viser soit le stade auquel la lutte doit être menée, soit, dans les cas où on appliquera un seuil de tolérance, le moment idéal d'observation.

Des modèles simples ou plus complexes pour interpréter une courbe des captures ou pour calculer les périodes de risque sont développés à maints endroits. Certains modèles utilisent comme facteur abiotique uniquement la somme thermique (BOLLER 1976 et SCHMID 1980), d'autres introduisent des limites inférieures pour l'activité du ravageur (températures basses, humectation) ou des facteurs mortels tels que températures excessives (TOUZEAU 1987, GABEL 1981, CAFFARELLI et al. 1985).

Actuellement, le modèle utilisé par les services de protection des végétaux français a fait ses preuves dans certaines régions et d'autres modèles semblent être fonctionnels. Les réponses données sur le questionnaire de M. Bues sont malheureusement trop rudimentaires pour expliquer et juger de quelle manière d'autres collègues utilisent les informations venant des captures dans les pièges. Selon une enquête effectuée par l'auteur dans le groupe viticulture de l'OILB (1981), beaucoup d'avertisseurs complètent l'information obtenue par les captures dans les pièges par d'autres observations telles que phénologie de la vigne, pontes ou pénétrations sur grappes, pièges alimentaires, etc.

Tous les modèles mentionnés sont des modèles dits qualitatifs qui simulent quand et comment évoluent les stades du ravageur, mais ils ne quantifient pas l'événement. Néanmoins, tout modèle qui peut déjà donner des réponses sur l'évolution des pontes et des larves est un aide précieux dans la protection des vignes contre les tordeuses de la grappe. Il permet de mieux placer l'observation ou le traitement, de mieux choisir le produit en fonction du stade du ravageur, il facilite la décision de répéter ou non une intervention. Seulement, chaque modèle doit être adapté aux conditions particulières de la région.

c) Estimation du risque

Il n'existe pas de corrélation fiable et constante entre les captures et les attaques de larves (ROEHRICH et SCHMID 1979, OILB 1979, OILB 1981, OILB 1984). En effet, le taux des papillons capturés dans les pièges est très variable selon la topographie, les conditions météorologiques, la densité de la population du ravageur, etc., sans que l'on puisse quantifier ces variations. Le taux de ces captures par exemple, est plus élevé quand les populations sont clairsemées et plus bas quand elles sont denses (ROEHRICH et al. 1983). Une réduction de la dose de phéromone dans les pièges améliore la corrélation entre les captures et l'infestation larvaire, mais reste tout de même trop aléatoire (SCHMID et AGULHON 1986).

Malgré ce manque de corrélation entre capture et attaque larvaire, le piégeage permet, dans certaines situations, la prévision négative, c'est-à-dire qu'en l'absence de captures ou en présence de rares captures, on ose affirmer que les risques de dégâts sont pratiquement nuls (OILB 1979, OILB 1981, OILB 1984, SCHMID et al 1988). Le seuil des captures pour cette prévision négative est à établir région par région, les deux espèces séparément. La première génération où le seuil de tolérance est élevé suscite un certain intérêt a être utilisé plus que les générations estivales où le seuil est très mince. En effet, dans les régions les plus sensibles, ces seuils sont dépassés dans presque tous les cas et d'autre part, les situations à risques faibles sont souvent connues par expérience, sans utilisation de la prévision négative.

d. Contrôle de l'efficacité de la lutte par "confusion sexuelle"

Les pièges à phéromones installés dans les vignes traitées par la méthode de "confusion" donnent une première indication sur le succès ou l'échec de l'essai. En effet, si l'on capture des papillons mâles dans les pièges il y a peu d'espoir d'obtenir un résultat positif par confusion et les contrôles de la diffusion et de l'attaque doivent être entrepris de suite.

Sparganothis pilleriana (pyrale de la vigne) et Peribatodes rhomboidaria (boarmie)

La composition du phéromonesexuelde la pyrale de la vigne a été déterminé par GUERIN et al. (1986).

Actuellement, les attractifs sont utilisés en Espagne, en Hongrie, en Autriche et en Suisse.

Les pièges à phéromones permettent de détecter le ravageur et de délimiter ainsi les zones occupées par la pyrale. Le rayon d'action d'un piège reste à étudier.

Du fait que les traitements interviennent que l'année après le vol, les pièges à phéromones ne fournissent pas d'informations utiles pour fixer la date d'intervention ou de contrôle.

La relation entre captures et attaques larvaires, le printemps suivant, n'est pas étudiée. Mais du fait que la période entre le vol et l'époque de traitement est très longue (automne - printemps suivant), il n'y a que peu d'espoir de trouver une corrélation satisfaisante.

Les composés principaux du phéromone sexuel de la boarmie (P. rhomboidaria) sont Z,Z-6,9-Nonadecadien-3-on. et (Z,Z,Z)-3,6,9-Nonadecatrienne (BUSER et al. 1985). Il est actuellement utilisé en Hongrie, en Allemagne et en Suisse pour la détection du ravageur. Concernant l'utilisation des pièges pour l'avertissement et la prévision du risque des dégâts, les mêmes remarques que pour la pyrale de la vigne sont à formuler.

CONCLUSIONS ET AVENIR

Les pièges à phéromones permettent de déterminer l'aire de répartition des quatre espèces étudiées. Pour les deux tordeuses de la grappe, le piégeage améliore l'avertissement : dates de traitements ou de contrôles, choix des produits, répétition des traitements, etc. Du fait qu'il n'y a pas de corrélation entre capture dans les pièges et attaque larvaire, une prévision du risque de dégâts - élément important dans une conception de protection intégrée - n'est guère possible. Une meilleure connaissance des rayons d'action d'un piège et surtout des études biologiques et écologiques sur les ravageurs sont indispensables pour avancer, à travers la modélisation, dans la prévision du risque.

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USE OF PHEROMONE TRAPS BY SWISS FARMERS

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In order to evaluate the use of pheromone traps by farmers pheromone traps were distributed by our field representatives free of charge. A questionnaire was handed over and colleted at the end of the season. From the use of insecticides (30% used IGR's) it can be assumed that the population of farmers was quite representative. The recommended use of the traps consisted of a weekly check over the whole season, documentation of treatments, trap location and climatic conditions.

In 1986, 150 traps for Cydia pomonella were distributed. Despite a personal introduction by our field representatives, 50 % of the farmers did not use the traps, 12 % made between 1 and 5 and 38 % more than 6 checks.

In 1987 traps were distributed to half the original number of farmers only, but expanded on two other species: Adoxophyes orana and Lobesia botrana. In contrast to 1986, practically all farmers who used the trap, made a reasonable number of 6 to 15 checks. However the percentage of farmers who did not make use of them increased to 64 % 80 % and 74 % for C. pomonella, A. orana and L. botrana respectively.

Possible reasons for the lack of interest from the part of the farmers are:

- For them, there were no problems of timing the applications due to a very good extension service. Therefore there was little incenture using their own pheromone traps.
- Problems with the interpretation of trap catches in the absence of climatic data.
- Too much work during a busy part of the season.
- No experience with pheromone traps.
- Low infestation in most orchards in the case of Adoxophyes orana.

ORGANISATION DE RESEAUX DE PIEGEAGES PAR UTILISATION DE PHEROMONES, DANS QUELQUES VERGERS REPRESENTATIFS DE LA REGION FRUITIERE BELGE

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Résumé
Dans le but de mieux définir le moment de l'intervention contre le carpocapse (Cydia pomonella L.), nous avons mis au point un réseau de piégeages, couvrant les principales régions fruitières belges.

Introduction

La modification plus ou moins fondamentale d'un schéma général de lutte comprend le risque d'une apparition ou d'une réapparition de parasites importants dans le passé. C'est entre autre le cas du carpocapse, devenu secondaire au cours de ces dernières années, suite à la lutte combinée contre le carpocapse et la tordeuse de la pelure (Adoxophyes orana L.), nécessitant plusieurs interventions au moyen d'insecticides.

Dans le cadre de la lutte intégrée, les traitements contre la tordeuse de la pelure seront appliqués au moyen d'un produit spécifique : une hormone juvénile (Fenoxicarb), à un autre moment que dans le passé, c-à-d aux environs de la floraison. Le carpocapse peut alors se développer librement pendant la période estivale et occasionner des dégâts importants. Pour parer à une telle éventualité, nous devons définir exactement les vols, les pontes et les éclosions des oeufs de ce parasite et intervenir en cas de nécessité, au moment le plus opportun, avec un insecticide approprié tel que le Diflubenzuron. Il faut également déterminer le nombre de traitements nécessaires pour couvrir toute la période de vols des adultes.

Dans le tableau ci-joint, sont reprises les données enregistrées durant les 40 dernières années, au Centre de Recherches de Gorsem. On peut en déduire que le début des vols se situe en moyenne autour du 21 mai (l'année la plus précoce est 1952, avec des vols dès le 4 mai), que la fin des vols se situe vers la fin août, que le début des pontes a lieu en moyenne le 4 juin et que les premières éclosions des oeufs se situent vers le 17 juin (l'année la plus précoce est 1960, avec des éclosions dès le 2 juin).

Sur la base de ces données, nous pouvons conclure que pour combattre le carpocapse avec des régulateurs de croissance, il est indispensable de couvrir le feuillage durant au moins 2 mois. Des essais récents ont démontré que le Diflubenzuron possède une très longue rémanence et que son effet résiduel se maintient durant au moins 21 jours. Ceci nous permet de combattre le carpocapse avec 3 traitements : le premier début juin, le deuxième fin juin et le troisième vers la mi-juillet.

Tableau 1 : Observations concernant la biologie du Carpocapse faites au Centre de Recherches de Gorsem durant les 37 dernières années.

Année	Début des vols	Pic des vols	Fin des vols	Premiers oeufs	Eclosions des 1ers oeufs
1949	31/5	4/7	11/8	-	-
50	15/5	4/7	11/8	-	-
51	21/5	8/7	21/8	19/6	30/6
52	4/5	3/7	12/8	4/6	15/6
53	14/5	5/7	12/8	9/6	22/6
54	15/5	13/7	23/8	-	-
55	17/5	27/6	29/7	8/6	21/6
56	30/5	7/7	21/8	9/6	24/6
57	15/5	6/7	20/8	10/6	22/6
58	19/5	28/6	1/8	28/5	15/6
59	10/5	15/6	14/8	24/5	8/6
1960	17/5	22/6	29/8	24/5	2/6
61	14/5	1/7	7/9	29/5	14/6
62	13/6	9/7	3/9	14/6	24/6
63	3/6	5/7	10/9	5/6	19/6
64	28/5	11/6	17/8	30/5	10/6
65	24/5	29/7	24/8	7/6	21/6
66	16/5	12/6	15/8	22/5	9/6
67	17/5	24/6	5/8	27/5	14/6
68	12/5	1/7	15/8	28/5	13/6
69	26/5	17/6	7/8	31/5	15/6
1970	4/6	15/6	7/8	9/6	18/6
71	16/5	10/6	11/8	21/5	12/6
72	5/6	3/7	30/7	17/6	2/7
73	27/5	3/6	3/7	29/5	14/6
74	18/5	5/6	29/8	24/5	4/6
75	16/5	22/6	19/7	5/6	13/6
76	24/5	23/6	19/8	1/6	13/6
77	31/5	25/6	7/8	19/6	29/6
78	26/5	7/7	16/8	17/6	7/7
79	27/5	20/6	7/8	8/6	21/6
1980	26/5	16/6	27/8	12/6	20/6
81	19/5	8/6	4/8	1/6	9/6
82	26/5	11/6	22/8	26/5	4/6
83	1/6	3/7	27/7	7/6	21/6
84	2/6	10/7	5/8	10/6	23/6
85	25/5	18/7	24/7	29/5	9/6
86	20/5	23/6	14/8	1/6	15/6
87	24/5	1/7	1/8	8/6	30/6
88	8/5	14/6	14/8	29/5	12/6

Conclusion

Les moyens chimiques mis à notre disposition sont tels, que la lutte contre le carpocapse des pommes et des poires est devenue aisée. Les centres d'avertissements fourniront les indications nécessaires quant aux dates d'intervention.

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AN INTEGRATED PEST MANAGEMENT STRATEGY FOR THE OLIVE MOTH (PRAYS OLEAE) BASED ON THE RELATIONSHIP BETWEEN THE CATCH OF ADULTS IN PHEROMONE TRAPS AND SUBSEQUENT INFESTATIONS OF OLIVE FRUIT.

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Summary

Monitoring adult Prays oleae was difficult prior to the isolation and identification of its sex pheromone system (1). Since that date, however, sex pheromone baited sticky traps have been developed which take accurate representative samples from olive moth populations (3,2). Generation peaks can be clearly defined and control measures, where required, can be applied at the optimal time (5). Attempts at establishing a correlation between trap catch and subsequent infestation on flowers and/or fruits, however, have proved very difficult. Correlations can be obtained between trap catches and the number of eggs laid in many years (4), but when data from several years are combined, no clear correlations are found. Studies at Granada over ten years have shown that it is possible to combine data from several years provided account is taken of the degree of synchrony between adult emergence and the phenology of the host tree from the point of view of the suitability of the fruit for oviposition as perceived by egg laying females (6). A very good indicator of the degree of synchrony between adult emergence and fruit suitability for oviposition can be obtained by measuring the number of days which elapse between the first catches of adults in traps and the first ovipositions on the fruit. From this measure alone it is possible to classify the year in question under one of the following categories:

(a) Very High - 95 - 100% infestation, less than 5 days between first moth catch and first oviposition on fruit.
(b) High - 70 - 90% infestation, 6 to 13 days lack of synchrony.
(c) Low - less than 25% infestation, 14 to 20 days lack of synchrony.

If the year is a category (c) year, then in Granada no treatments are required because egg predators invariably reduce a 25% infestation to 5 or 10% which is of no economic importance. If the year in question falls under category (a) or (b) the accumulated adult catches from the date of initiation of oviposition will give an accurate estimate of infestation on the fruit throughout the remainder of the flight period.

In a category (a) or (b) year in Granada the decision to spray is dependent on the level of egg predators, especially Chrisopids, which are active in the olive grove. These predators can reduce a potential infestation which could produce significant damage to a level which does not require insecticide treatment. Predator activity can be classified into four categories:

Very High - predator activity and effectiveness greater than 85 - 90%
High - values between 60 - 85% effectiveness
Medium - about 50% effectiveness.
Low - 30 - 35% effectiveness maximum.

Potential infestations in any year can therefore be corrected for egg predation to give an estimate of the Real (or Final) infestation level. This can usually be calculated at a time which still allows remedial chemical treatment to be carried out if required. Real infestations can also be divided into three categories:

High - economic damage with 50% or more infested fruits,
Medium - marginal damage with 25 - 35% infested fruits,
Low - of no economic importance, less than 15% infested fruits.

At present, the only way of measuring the effects of egg predators on populations of P.oleae is to take fruit samples and count under a binocular microscope the number of fruits 'saved' by egg predators - i.e. those where all the P.oleae eggs have been consumed. In the future it would be desirable if an indirect measure of egg predation could be developed, possibly in the form of a trapping device for adult predators. In this way, having accurate measures of both pest and predator populations and of the degree of synchrony between pest and host fruit phenology, a reliable predictive pest management model could be developed which would be operated at the grower level and which would result in dramatic reductions in the use of pesticides against P.oleae on the olive groves in southern Spain.

Several lines of research are currently under study at Granada in an attempt to modify the pest/predator/host plant interactions described above for IPM purposes.

1. It may be possible to increase artificially the gap between the date of first adult catches and first ovipositions. Phytohormone treatments to olive trees are being tested in an attempt to modify fruit suitability for oviposition.
2. Mass releases of Chrysoperla carnea are being attempted with a view to producing conditions of high predator efficiency every year.
3. Mating disruption experiments with the sex pheromone of P.oleae have been shown to be effective when populations of P.oleae are low. This too could be a technique which could be used to reduce the potential population of P.oleae immature stages as another biorational component of an IPM package.

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SYSTEMES DE PIEGEAGE POUR LA SURVEILLANCE DES POPULATIONS ADULTES DE LA MOUCHE DE L'OLIVIER (DACUS OLEAE GMEL.).

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Resumé

D'une manière traditionnelle on a utilisé, pour la surveillance des populations de Dacus oleae, des gobe-mouches en verre, appâtés avec une solution aqueuse de sels d'ammonium ou des hidrolisats de protéines, bien qu'elles présentent le désavantage d'un faible rendement lorsque l'humidité ambiance est élevée, ce qui leur rend inefficaces pendant certaines périodes de l'année. Depuis longtemps on connait l'attractivité que la couleur jaune exerce sur les diptères; en conséquence, c'est développé l'utilisation de pièges formés de plaques de plastique de cette couleur, gommées par les deux côtés. Toutefois, le rendement de ce type de pièges reste faible, donc la distance d'attraction n'excede pas les limites de l'arbre oú ils sont installés (1). Quand ces pièges sont appâtés avec des capsules de plastique, qui contiennent 25 mg. de 1,7 – dioxaspiro (5,5) undecane – le composé principal de la phéromone sexuelle des femelles de Dacus oleae – le rendement de ces pièges jaunes s'améliore nettement (2;4).

A Jaén (Espagne), depuis 1981, nous avons realisé systematiquement des etudes sur la bioécologie de la mouche de l'olivier, moyennant l'application d'une méthodologie parfaitement étudiée et vérifiée (4), dans les quels nous avons utilisé les differents types des pièges décrits antérieurement, et des quels nous pouvons analyser le degré d'efficacité dans la surveillance des populations de Dacus oleae.

Dans le Tableau nous avons montré le bilan des captures moyennes annuelles/piège, pour chaque saison de l'année, pendant la période étudiée.

CAPTURES SAISONNIERES DE DACUS OLEAE EN PIEGES PENDANT LA PERIODE 1981/88. JAEN (ESPAGNE). MOYENNE D'ADULTES/PIEGE.

Captures D. Oleae.	PRINTEMPS			ÉTÉ			AUTOMNE			TOTAL		
	♂♂	♀♀	Total	♂♂	♀♀	Total	♂♂	♀♀	Total	♂♂	♀♀	Total
I. GOBE-MOUCHES APPATES AVEC PHOSPHATE D'AMMONIUM.												
TOTAL	354'4	285'6	631	529'6	445'9	975'5	2243	1684'2	3927'2	3118	2415'7	5533'7
MOY/ANN.	49'3	40'8	90'1	75'6	63'7	139'4	320'4	240'6	561	445'4	345'1	790'5
II. PIEGES JAUNES GOMMES ET APPATES AVEC PHEROMONE SEXUELLE.												
TOTAL	1544'8	196'8	1741'6	858'5	67'2	925'7	4142	383'9	4525'9	6545'3	647'9	7193'2
MOY/ANN.	220'7	28'1	248'8	122'6	9'6	132'2	591'7	54'8	646'6	935	92'6	1027'6
III. PIEGES JAUNES GOMMES.												
TOTAL	166'1	101'8	267'9	54'8	30'3	85'1	762'1	407'6	1169'7	983	539'7	1522'7
MOY/ANN.	23'7	14'5	38'2	7'8	4'3	12'1	108'9	58'2	167'1	140'4	77'1	217'5

De l'analise des données exposées, nous pouvons noter:

- Les captures avec les gobe-mouches et les pièges jaunes appâtés avec phéromones sont supérieures a celles obtenues avec les pièges jaunes, et les différences observées sont statistiquement significatives.

- Il y a un plus grand niveau de captures dans les pièges appâtés avec phéromones, en respect avec celles obtenues avec les gobe-mouches, mais les différences observées ne sont pas strictement significatives. Il y a, par contre, des différences significatives entre les deux pièges, si l'on compare les captures de printemps, ou les mâles et les femelles respectivement.

- Quand on compare les captures avec les pièges jaunes avec ou sans phéromone, il faut remarquer que les captures des femelles sont supérieures dans les pièges à phéromone pendant le printemps et l'été, et se égalent - comme on pouvait s'y attendre - en automne. Une explication à ce phénomène pourrait etre que le spiroacetal agisse comme signal d'agrégation dans les périodes oú l'insect a besoin de chercher des endroits appropriés pour son alimentation (3).

Nous avons etudié les relations capture/infestation observées, pendant la période 1981-1988, pour chaque type de piège. Pour cela, nous avons comparé les captures totales, cumulées depuis la semaine antérieure a celle qui corrspond à la première piqûre des fruits, avec les infestations preimaginales vivantes observées dans chaque échantillonage. Les relations captures/infestation sont bien corrélées, en general, à des fonctions de type logistique, qui ont un sens biologique: $y = K / (1 + e^{\ln B + a x})$.

Les meilleures corrélations ont été obtenues en comparant les infestations preimaginales avec les captures obtenues en gobe-mouches et avec des pièges appâtés avec phéromones bien que l'assemblement de courbes - à l'exception de celle qui correspond à l'année 1983 - est meilleur dans le cas de ces dernières, ce qui peut indiquer que le rendement des pièges appâtés avec phéromone est plus constant et homogène que celui des gobe-mouches appâtés avec du phosphate ammonique.

Nous avons realisé l'analyse de regréssion simple, avec les données captures/infestation considerées globalement pour toute la période 1981-1988 et pour chaque type de piège. Les meilleures corrélations sont obtenues, en tout cas, avec des fonctions de type lineaire, pour les pièges jaunes appâtés avec phéromone et les gobe-mouches avec du phosphate ammonique, atteignent les coefficients le correlation des valeurs admissibles et pratiquement semblables.

Selon les résultats obtenus, nous pouvons conclure que, indépendamment des avantages et inconvenients de chaque système de piègeage, il est bien demontré que les gobe-mouches traditionnels appâtés avec du phosphate ammonique et les pièges jaunes appâtés avec phéromone sexuelle, sont deux moyens appropriés - qui pendant certaines epoques de l'année peuvent avoir un caractère complementaire - pour réaliser des études bioecológiques sur la mouche de l'olivier et pouvoir surveiller convenablement ses populations dans le milieu naturel.

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Monitoring *Dacus oleae* and *Ceratitis capitata* with Sex and Food attractants in Greece.

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Abstract

The olive fruit fly *Dacus oleae,* the most important noxious insect of the olive trees, attacks the fruit from July to the end of May, while the adults fly the whole year. The fly today is rather efficiently controlled by bait sprays consisting of organophosphorus insecticides and protein hydrolysates.
The timing for the sprays is based on catches in McPhail traps, baited with ammonia releasing media (Ammonium salts or Protein hydrolysates). The effectiveness of these traps depends upon many biological and environmental factors, while on the other hand, traps baited only with olive male Pheromone, are inactive during the period of mid May to the end of June. The combination of sex and food attractants in the same trap, gives a more efficient trap, than those which are baited only with one of both combinants.
The Mediterranean fruit fly *Ceratitis capitata,* which attacks a large number of fruit in Greece is effectivelly monitored with Delta traps baited with the male attractant Trimedlure or with McPhail traps baited with food attractants. (Protein hydrolysates). The combination of Trimedlure and protein hydrolysates (Dacus bait(R), in the same trap(McPhail) leads to a powerful trap for mediterranean male flies.

MONITORING AND CONTROLLING *XYLEBORUS (ANISANDRUS) DISPAR* F., A BARK BEETLE ATTACKING ORCHARDS AND VINEYARDS, WITH ETHANOL TRAPS

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In the last years and mainly after the winter 1984 / 85 with severe frost our orchards and vineyards were increasingly attacked by bark beetles. This damage was essentially caused by *Xyleborus dispar.* The species also attacks many deciduous trees in forests from where it often immigrates into the orchards. Chemical control of the insect is very difficult and expensive.

This situation was the reason for our studies on the biology and control of the pest. We have developed a trap which is suitable for monitoring as well as for control purposes.

Xyleborus dispar has one generation per year. As soon as the maximal daily temperatures in spring reach 18-20 °C the beetles start flying and searching for host plants. The flight lasts 3-4 weeks, exceptionally up to six weeks, depending on the weather conditions. Immigrations from forests are still possible at a time when the flight in orchards is already at an end.

It has been known for years that many bark beetle species are attracted to ethanol. In American forests a window flight trap with ethanol as the lure was used for monitoring (Roling and Kearby 1975). Different types of traps (including the window flight trap) and lures were compared in our tests (Mani and Schwaller 1983, Mani *et al.* 1986, 1988). The Rebell® rosso type was found to be most efficient and practicable. The attractant, 250 ml 50% ethanol (denatured with 1% toluol), is filled in a 1 liter plastic flask with 5 holes in the upper part of it. The attracted beetles are caught on a sticky red wing trap attached closely above the flask. When the temperatures are high the ethanol has to be replaced every 2-3 days. The efficacy of this trap was found to be 2-3 times higher than that of the window flight trap. This increase is important in regard to control purposes.

The higher catches with the wing trap can be explained by the flight behavior of the insect, which often does not fly directly into the trap but circles around it and sometimes lands in its neighborhood. Apart of bark beetles the trap caught many indifferent Diptera and only a few beneficial insects.

Most bark beetles are caught on the west and southwest orientated parts of the trap. The main flight activity was between 2 and 4 p.m. In orchards with a high population a distinct swarming of the beetles can be observed at that time. High catches outside orchards in open fields indicate that the beetles can fly over distances of several hundred meters.

The physiological condition of the tree is decisive for its susceptibility to bark beetle attack. Orchards or vineyards with plants damaged by frost or with trees planted 2 years before were most susceptible. Under such conditions the beetle populations were often high and several hundred up to 2000 beetles were caught with 8 traps per hectare. No subsequent tree attack was observed in many of these orchards. However, in some cases control was insufficient. Other factors such as plant produced volatiles and aggregation pheromones might have been important there.

From our experiments the following recommendations are given: One trap per hectare for monitoring and eight traps per hectare for control purposes. The total catch per hectare could be further increased with a higher trap density, but then the method would become less economical.

The ethanol trap Rebell® rosso is now well-established in the control of *Xyleborus dispar* in orchards and vineyards and has largely replaced insecticides. Trapping has to be combined with sanitation (removal of attacked trees) and with optimal cultivation measures in order to promote plant health.

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SEX ATTRACTANTS OF CHESTNUT TORTRICOID MOTHS (PAMMENE FASCIANA L., CYDIA FAGIGLANDANA ZEL. AND CYDIA SPLENDANA HB.)

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Summary
Sexual response of the chestnut tortricoid moth males (*Pammene fasciana* L., *Cydia fagiglandana* Zel. and *Cydia splendana* Hb.) has been tested to several synthetic compounds (saturated and unsaturated aldehydes, alcohols and acetates) having 12 carbon atoms, by electroantennography and field evaluation. The blend Z8-12:Ac/Z8-12:OH (3/1) showed the best attractivity towards *P.fasciana* males and E8E10-12:Ac/ E8E10-12:OH (2/1; 3/1)towards *C. fagiglandana*. The mixtures Z8-12:Ac/E8E10-12:Ac gave no captures of the chestnut moths. The flight periods of the three species have been related to the phenology of the chestnut tree.

1.1 Introduction

Pammene fasciana L., *Cydia fagiglandana* Zel. and *Cydia splendana* Hb.(Lep. Tortricidae) are serious pests of chestnut fruit in Italy and other European and Asiatic countries. The larvae cause considerable damages to the chestnut crops, sometimes producing economic losses that reach even 60% (1).

Such univoltine phytophagous species are strictly bound to the biology of the host plant (2). Present chemical control of these pests leads to unsatisfying results in consequence of the environment (nearly all chestnut trees grow in hill and mountain area), of the big size of trees and of the impossibility to reach larvae. These develop in the chestnut fruits. On the other hand the farmer can not follow the flight activity of the adults and usually controls these pests by frequent treatments with persistent insecticides.

The use of the sex attractants can be of value to improve the control of these pests. The sexual response of these moths to several synthetic compounds having 12 carbon atoms has been tested by electroantennography and field evaluation.

1.2 Description

Electroantennographic study has shown high responses to Z8-12:Ac for *P. fasciana* and to E8E10-12:Ac for *C. fagiglandana* and *C. splendana*.

Field study was carried out during three years (1984-85-87) in several regions of South Italy (Avellino, Catanzaro, Cosenza, Potenza). Traps of the common roof type (Traptest Farmoplant) were baited with synthetic substances, alone and in some of their binary mixtures, in rubber septa.

In a preliminary test (Avellino, 1984) the attractivity of 27 compounds having 12 carbon atoms in unsaturated linear chain has been valued. E8E10-12:Ac and Z8-12:Ac gave higher catches to C. fagiglandana and P. fasciana.

Subsequent studies on attractivity and selectivity in different chestnut areas (Catanzaro, Cosenza and Potenza) in two years (1985-87) were carried out.

The first observations (Catanzaro, 1985) confirmed that Z8-12:Ac and E8E10-12:Ac are active compounds towards P. fasciana and C. fagiglandana. The capture of Z8-12:Ac was significantly higher than total capture (♂♂ - ♀♀) by the light trap. The E8E10-12:Ac, alone and mixed with the respective alcohol, did not show significant difference from the light trap. Moreover, E8E10-12:Ac even if stimulated the antennae of C. splendana has attracted only some males of this species. Maybe other or similar compounds are involved in the attraction of males.The mixtures of the active compounds (Z8-12:Ac/E8E10-12:-Ac) lost the attraction for the chestnut moths.

In the second test (1987) attractivity and selectivity of binary mixtures of E8E10-12:Ac and Z8-12:Ac with respective alcohols were evaluated in different areas (Catanzaro, Cosenza and Potenza). In Cosenza and Catanzaro areas C. fagiglandana was highly captured by E8E10-12:Ac and by its combination with E8E10-12:OH in ratios 2/1 and 3/1.In Potenza area all mixtures showed no significant differences in attractivity. The mixtures showed better selectivity in respect to E8E10-12:Ac by decreasing the captures of Cydia succedana D.& F., C. pomonella L., C. orobana Tr., C. splendana and C. gemmiferana Tr. P. fasciana was efficiently captured by the blend Z8-12:Ac/Z8-12:OH in the ratio 3/1. This blend even if it improved selectivity towards Pammene albuginana Gn., P. gallicolana L.& Z., P. spiniana Dup. and Cydia tenebrosana Dup. did not remove the catches of Cydia funebrana Tr.

The ongoing of field captures allowed to follow the peaks of adult emergence of the three species of tortricoid moths. The flight period of P. fasciana occurs between June and September, with the highest flight peak at the end of June. In this period the chestnut tree is in full bloom and the fruit development is beginning.The flight period of C. fagiglandana occurs between the beginning of July and the end of September.The highest peak of this species occurs in the second week of August. This period is delimited by the flight peaks of P. fasciana and C. splendana. The biological activity of C. fagiglandana is observed between the end of the bloom period and the physiological drop of prickly husks of the chestnut. The flight period of C. splendana starts at the end of August and finishes at the end of September, with a peak within the second week of September.The biological activity of this species corresponds with maturation and fruit-drop.

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TESTS D'ATTRACTIVITE DE DIVERSES COMPOSITIONS PHEROMONALES ENVERS *PANDEMIS HEPARANA* D.&S. ET *CLEPSIS SPECTRANA* TR. EN VERGERS

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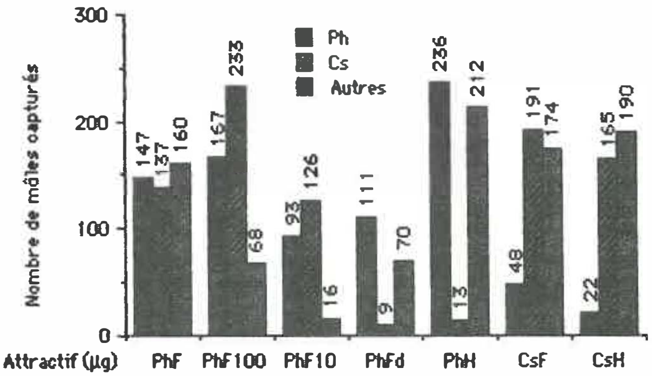
De 1983 à 1986, en Belgique, des piégeages simultanés de microlépidoptères ont été effectués en vergers de pommiers (1) au moyen de pièges appâtés avec différents attractifs sexuels spécifiques de synthèse, provenant soit du Laboratoire des Médiateurs Chimiques à Brouëssy (France = F),soit de l'Institute for Pesticide Research à Wageningen (Pays-Bas = H). Les mêmes constatations effectuées au cours de trois saisons de piégeage (1983-85) concernant le manque de sélectivité des attractifs utilisés pour deux espèces de tortricides Pandemis heparana D.&S. (Ph) et Clepsis spectrana Tr. (Cs) ont conduit à réaliser en 1986 un test comparatif d'attractivité de différentes formulations.

La composition -identifiée par un sigle propre- de chaque attractif dont il sera question ici (un piège par verger) est donnée dans la figure 1 (celles de PhH et de CsH aimablement transmises par le Dr. S. VOERMAN).

Les principaux taux de capture d'individus mâles enregistrés au cours des saisons 83-85 (respectivement % Ph, % Cs, % d'autres espèces annexes; nombre total de captures) sont relatés et analysés succinctement ci-après.
En 1983 (n = 15 = nombre de vergers), l'attractif PhF (40.6, 55.7, 3.6; 2803) réalisait moins de captures de Ph que de Cs, et même beaucoup plus de prises de Cs (70.3 %) que l'attractif CsH (39.2, 49.5, 11.3; 1334) qui lui était destiné.
Pour 1984, trois comparaisons sont permises :
a) (n = 2), entre PhF (71.2, 24.0, 4.8; 417) et CsH (58.8, 31.2, 10.0; 170) où à nouveau la composition PhF a permis de capturer le plus de Cs (65.4 %);
b) (n = 4), entre PhF (49.1, 45.2, 5.8; 1021) et CsF (40.0, 52.5, 7.4; 632) où PhF s'est encore montré le plus attractif pour Cs (58.1 %);
c) (n = 3), pour une période limitée (à partir du 13.08), entre PhF (49.6, 46.2, 4.3; 117) et PhH (64.6, 0.7, 34.7; 147) chez qui l'attractivité semble plus forte pour Ph (62.1 %) ainsi que pour les autres espèces annexes (92.7 %), dont en particulier Adoxophyes orana F.R., et par contre beaucoup plus faible pour Cs (1.8 %).
En 1985 (n = 3), les résultats confirment ceux de 1984, pour ce qui concerne les formulations comparées PhF (36.9, 46.8, 16.3, 566), PhH (54.9, 1.1, 44.1; 565) et CsF (23.5, 50.7, 25.8; 298), avec toujours le maximum de Cs pour PhF (68.8 %).

Figure 1. Nombre de Pandemis heparana (Ph), de Clepsis spectrana (Cs) et d'autres lépidoptères mâles capturés en 1986 dans trois vergers de pommiers, par piégeage simultané au moyen de 7 attractifs de synthèse (1 piège/phéromone/verger).



Attractif (µg)	PhF	PhF100	PhF10	PhFd	PhH	CsF	CsH
Z11-14Ac	900	90	9	850	600	900	900
Z9 -14Ac	50	5	0.5	50	300	100	100
Z11-14OH	50	5	0.5	50	300	-	-
Z9E11-14Ac	-	-	-	50	-	-	-

Le test d'attractivité réalisé en 1986 (n=3) a permis de corroborer les constatations précédentes (fig 1), sauf pour PhF plus du tout sélectif (déjà moins en 1985) vis-à-vis des espèces annexes. Les formulations minidosées à 100 µg (PhF100) et à 10 µg (PhF10) ne se sont pas révélées plus discriminantes à l'égard de Cs mais bien à l'égard des autres espèces. Par contre, la nouvelle formulation à 1.000 µg (PhFd), comprenant l'adjonction du diène Z9E11-14 Ac à 5 % s'est montrée beaucoup plus sélective que PhF face à Cs -autant que PhH- avec également une plus faible proportion d'individus d'espèces annexes mais aussi un plus faible rendement en Ph que la composition PhH. Quant aux attractifs CsF (sur caoutchouc) et CsH (sur polyéthylène), de composition identique, ils sont tous deux aussi sélectifs envers Ph et aussi peu envers les autres espèces quoique différemment puisque le spectre est dominé chez CsF par Eulia ministrana L. et chez CsH par Noctua fimbriata Schr.

Les écarts parfois importants observés au niveau du rendement et de la sélectivité d'attractifs destinés à une même espèce mais de fabrications différentes soulignent la difficulté de l'établissement d'une échelle de référence de captures utilisable en pratique pour l'estimation du risque.

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MONITORING THE CURRANT BUD MOTH EUHYPONOMEUTOIDES RUFELLA USING TRAPS BAITED BY THE SYNTHETIC PHEROMONE PREPARATE OF THE FRUIT TREE TORTRIX ARCHIPS PODANA

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Summary

The synthetic pheromone preparate for *Archips podana*, cis- and trans-11-tetradecenyl acetate (1:1), attracted males of *Euhyponomeutoides rufella*, an important pest of currants in Finland. The field tests showed that the preparate can be used to monitor *E. rufella*. Because of the sporadic occurrence of the species, 3-4 traps/ha should be used. Another species commonly caught by traps was a tortricid *Acompsia cinerella*, which is not known as a pest of currants in Finland.

Introduction

Bud damages caused by the currant bud moth (CBM) *E. rufella* (Tngstr.) became more common in 1970's in blackcurrant cultivations in Finland. The control of CBM is difficult because larvae hatch only a few days before harvesting. The larvae penetrate into new buds, begin feeding in the autumn and hibernate inside the buds. In the following spring one larva injures 2-3 buds before pupating. The recommended spring sprays using pyrethroids eliminate only the larvae which move to another bud during the few days chemicals are effective. In practice the efficacy of control is 50-70 %.

To improve the efficacy of control, studies on monitoring flying periods as well as methods to evaluate the need of the control of CBM were started.

Light traps have been used to find out the flying periods of CBM. Males were attracted well but females were not caught by light traps (HEIKINHEIMO 1978). Females fly only short distances near the bushes; this behaviour seems to be one reason for the sporadic occurrence of CBM.

Preliminary tests using traps baited by virgin females of CBM showed that 3-5 days old females attracted males well (TUOVINEN 1986). At the same time, tests of the pheromone preparates which may possibly be used to monitor lepidopterous pests in Finland revealed that the preparate for the fruit tree tortrix *Archips podana* (Scop.), containing 50 % cis-11-14:Ac and 50 % trans-11-14:Ac, attracted also CBM males (PELTOTALO and TUOVINEN 1986). These compounds in varying ratios are known to be common attractants for many moth species (ARN et al. 1986).

Material and methods

In 1985-1987 traps baited by the pheromone were used altogether in 35 blackcurrant fields, majority being commercial 1-3 ha cultivations. Both delta and wing-style traps were used. The traps were examined about two weeks intervals and the species of Lepidoptera were identified. In following winters the fields were surveyd to evaluate the injuries caused by the larvae. 10-20 branches were collected from the fields and 500-1000 buds/sample were splitted and the larvae were counted.

The efficacy of the two trap types was studied by placing them pairwise in a small experimental field, which was heavily infested by CBM larvae.

Results and discussion

Catches and the corresponding bud injuries in the following winter correlated positively ($r=0.669$, $p<0.01$). The numbers of caught males were quite low, varying from zero to 21/trap. The injuries varied from zero to 15 %. In some cases no males were caught but injuries of 0-2.5 % were noticed, meaning that too few traps were used to cover the sporadically infested fields. According to the previous studies, the control threshold is about 2 % of infested buds. Several traps/field should be used to reveal the presence of CBM, and to get a better view of the flight and the occurrence of CBM, 3-4 traps/ha should be used instead of 1-2 traps/field used in this study. The efficacy of the preparate was good, e.g. in a 0.1 ha plot one trap caught 382 males in 3 weeks.

The traps attracted also males of a tortricid *Acompsia cinerella* (Clerck). Growers might have difficulties to distinguish *A. cinerella* from CBM if the specimens are old ~~and~~ stained with the glue, but if the traps are inspected twice a week no troubles would appear. The traps caught only few other species all of which are easily distinguished from CBM.

When delta- and wing-style traps were compared no difference in the mean catch was noticed (Wilcoxon signed-ranks test, $p=0.6$). A broad delta trap is recommended because of the easier maintenance and better shelter for rain than that of a wing-style trap.

Further studies are going on to develope the method to help farmers to decide the need of control of CBM.

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PHEROMONE TRAPS SHOW POTENTIAL FOR REDUCING INSECTICIDE USE IN NEW ZEALAND APPLE ORCHARDS

Mis en evidence par piégeage sexuel de la possibilité de reduire les traitements insecticides sur pommiers en Nouvelle Zélande

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Summary

Pheromone traps have been used since 1985 to guide insecticide use at trial sites in Nelson and Hawkes Bay. Traps were used to monitor flight activity of three pest leafroller species, *Epiphyas postvittana, Ctenopseustis obliquana* and *Planotortrix excessana,* in sprayed orchards and unsprayed areas adjacent to orchard properties. Trap catches indicated regional variation in species dominance, and indicated high or low risk of infestation near particular orchards. Periods of low leafroller flight activity were identified and insecticide sprays were not applied during these times. Following this programme, two to three applications have been omitted each season, reducing insecticide use by up to 38%, while retaining leafroller control equivalent to the recommended programme in 'Red Delicious' and 'Granny Smith' varieties. This represents savings of up to NZ$ 200/ha, and appears to have the most potential for the Nelson area, where *Epiphyas postvittana* is the dominant species. Careful implementation of this programme is planned, in conjunction with leafroller pheromone trapping in each orchard to check that the orchardist can safely reduce the insecticide programme in this way.

IDENTIFICATION OF A MINOR COMPONENT OF THE SEX PHEROMONE OF LEUCOPTERA SCITELLA. SYNTHESIS AND FIELD TESTS

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Summary

A minor component from the volatiles of calling females of *Leucoptera scitella* has been identified, by comparison with an authentic sample, as 5,9-dimethyloctadecane 2. In field tests, compound 2 appear to sinergize the effect of the major component 1. The activity of the unsaturated compounds 3, synthetic precursors of 1, is also described.

1. Introduction

The sex pheromone of the mountain-ash bentwing Leucoptera scitella Zeller (Lepidoptera, Lyonetidae), an economically important leafminer pest of orchards in some regions of Europe and Asia, has been recently identified as 5,9-dimethylheptadecane 1 by W. Francke and coworkers[1]. We now would like to report the identification of a new, minor component in the volatile extract of calling females of Leucoptera scitella. The compound was identified as 5,9-dimethyloctadecane 2 according to their chromatographic and spectroscopic properties in comparison with an authentic synthetic sample.

In field tests compound 2 seems to behave as a synergist of the main component 1. The activity of the unsaturated compounds 3, synthetic precursors of 1, is also described.

2. Results and Discussion

Volatiles released by 250 virgin calling females were condensed on a dry ice-acetone bath, taken up in nanograde hexane and concentrated to 100 µl. Gas chromatographic analysis in three different capillary columns (SPB-1 25m x 0.25 µm, SPB-35 15m x 0.25 µm and Supelcowax 10 30m x 0.25 µm) showed two compounds in a 92:8 to 96:4 ratio. The major compound turned out to be the expected 5,9-dimethylheptadecane 1, whereas the structure of the minor product is proposed to be its homologous 5,9-dimethyloctadecane 2. Thus, the CI mass spectrum of 2 showed a molecular weight of 282 whereas the EI mass spectrum was almost identical to that of the synthetic material. In addition, both compounds coinject on three polar and non-polar capillary columns (see above).

The synthesis of compounds 1 and 2, in 25.2 and 26.2% overall yields, respectively, from 2-n-butil-2,6-dimethylcyclohexanone, have been carried out by a modification of the procedure described by Kocienski[2] for the synthesis of the sex pheromone of the pine sawfly Neodiprion lecontei.

In field tests carried out near Rosselló in the province of Lleida, a clear synergistic effect was found when compound 2 was mixed with compound 1 at 0.1-1% level. The minor component was intrinsically inactive. On the other hand, in

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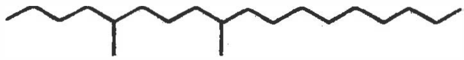

2

3

field trials carried out near Serős in the same province, the enhancement of captures was only moderate. In the same test compounds 3 behaved as synergists when mixed with 1 at 5% level, whereas a clear inhibitory effect was shown in a 1:1 ratio.

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DESIGN AND PERFORMANCE OF PHEROMONE DISPENSING,

CONTRIBUTIONS AND PANEL DISCUSSION

PERFORMANCE CRITERIA FOR ASSESSING LURE FORMULATIONS

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Summary

Dispensers containing insect attractants are routinely used to bait traps for monitoring pest populations. There are many factors in the dispenser design that influence the biological effectiveness of the traps. These include: chemical purity of the pheromone or synthetic attractant, ratio of components in multicomponent pheromones, amount of active ingredient per dispenser, rates of release of each pheromone component, influence of environmental factors on these rates, and stability of the dispenser. Examples are given that show the effect of some of these factors on dispenser activity. Performance criteria (dose, release rate, etc.) are required to assure a highly attractive dispenser for extended field applications. An example of such criteria are those proposed for gypsy moth pheromone dispensers.

Introduction

It is convenient for the scientists who operate insect monitoring programs to assume that the pheromone dispensers obtained from commercial, government or other sources are highly attractive. However, there are many factors in dispenser design and preparation that can cause variable performance in field situations. Although the effect of impurities, e.g., geometrical or optical isomers, on the activity of an identified pheromone is generally reported in the literature, chemical purity is seldom specified on dispenser solicitations. Similarly, reports give the effect of pheromone dose on insect capture but rarely include the actual rates and ratios of pheromone components that are emitted from the applied dose.

1.2 Discussion

The following examples illustrate how some variables in dispenser formulations affect insect capture. Firstly, pheromone purity can be critical in dispenser performance. The presence of 0.1% of (*Z*)-7-dodecen-1-ol significantly inhibited trap capture of the cabbage looper, *Trichoplusia ni* (Hübner) with its pheromone, (*Z*)-7-dodecen-1-ol acetate (1). Similarly, small quantities of the *S*,*Z* enantiomer reduced capture of the Japanese beetle, *Popillia japonica* Newman with its pheromone, (*R*,*Z*)-5-(1-decenyl)dihydro-2(3H)-furanone (2). Components in multicomponent pheromones caused major differences in captures of *Heliothis zea* (Boddie) (3). The problem of specifying the most attractive ratios of components is further compounded by the fact that components with differing volatilities will be released by dispensers at different rates. For example, a rubber septum treated with a blend of *Z*9-14:al, 14:al, *Z*11-16:al and 16:al in a ratio of 19:17:37:27 preferentially released the more volatile C14 aldehydes; as a result, the residual blend had a ratio of 45:31:10:11 after <1 week of exposure (4). Thus, the emitted ratio, which was responsible for insect response, differed widely from the applied ratio. Comparison of applied and released ratios of Z9-14:al : Z11-16:al for polyvinyl chloride (PVC) dispensers showed that captures of *Heliothis virescens* (F.) were the highest when the emitted blends contained 14-40% Z9-14:al as generated by a dispenser containing 6% Z9-14:al, 94% Z11-16:al (Hendricks et al. unpubl.).

The pheromone dose that the insect perceives is also very important in monitoring insect populations. As the pheromone content of a dispenser increases, the emitted amount of lure also increases but the insect capture does not necessarily follow. For example, with the gypsy moth, *Lymantria dispar* (L.), increasing doses from 1 to 20 μg on cotton wicks caused increasing moth capture; at doses of 20 to 150 μg, insect captures remained relatively constant and, at doses of 200 to 2500 μg, moth capture actually decreased (5). The pheromone content required for optimum insect capture varies with dispenser type and with insect species. The emission rate from a dispenser containing a given pheromone dose depends on the permeability of the dispenser matrix and on the chemical characteristics of the pheromone itself. By modification of the dispenser formulation, the emission rate can be optimized for insect capture. Adjustment of release rate requires consideration of the effect of temperature since diffusion of the pheromone through the polymeric matrix and/or evaporation from the surface increases with temperature. For example, laboratory measured emission rates from laminate dispensers for the gypsy moth increased by 3.5-fold for a 10^{o}C increase in temperature.

The establishment of performance criteria, e.g., pheromone content, emission rate, etc., for dispensers is very important to maintain consistently successful insect monitoring programs and is required for the procurement of effective dispensers from competitive sources. The following criteria have been proposed (5) for the gypsy moth pheromone dispensers used in detection programs throughout the U. S.: have an emission rate of 140-600 ng/h as measured in the laboratory at 35^{o}C and 100 ml/min air flow, contain 0.5 to 1.0 mg of (+)-disparlure (>95% purity), and remain highly attractive for at least 3 months. Similar criteria were also proposed (5) for dispensers of the synthetic attractant of *Ceratitis capitata* (Wiedemann), and for the pheromones of the boll weevil, *Anthonomus grandis* (Boheman), and the tobacco budworm, *H. virescens*.

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Meditations around the production of lepidopterous sex pheromones

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Most sex pheromones of Lepidoptera consist of unsaturated straight-chain alcohols, acetates or aldehydes. Much has been published about their synthesis. So far the commercial industry did not show much interest in the production of these compounds. Unless they can be sold with profit this will not change and the research workers themselves are forced to synthesize these compounds in their own laboratories. Compounds which have potential to be used on a large scale, for example for mating disruption, are more interesting for the industry.

A pheromone bank, as we have in our institute, appears to be very useful. Besides pure chemicals needed for reference during analytical work and for special behavioural experiments, we also produce pheromones formulated in dispensers for monitoring and mass trapping purposes.

In 1987 more than 1000 dispensers were sold for each of the following species: Adoxophyes orana, Cossus cossus, Grapholita molesta, Cydia pomonella, Phthorimaea operculella and Synanthedon myopaeformis. We delivered these lures and also samples of pure pheromone to customers in almost every country in West Europe, and also in many countries in North and South America, in Australia etc. We made dispensers for more than 50 different moth species.

The composition of the baits was determined on the basis of our own research and of data from literature. Many times a compromise had to be found between the best composition and the most correct quantity of active material per dispenser. It was also not always clear whether it was necessary to add anti-oxidants as BHT, UOP 88 or UOP 688 or a UV-absorber as Eusolex 4360, let alone to decide upon the quantities of protecting chemicals to obtain dispensers with an optimal attractant action.

More uncertain feelings come up when we had to decide upon the type of dispenser to get - when loaded with the appropriate pheromone or attractant mixture and the right quantity - the best imitation of a calling female. In many cases the evaporation rate should be inversely proportional to the temperature. The dispenser should also protect the active compounds against detrimental chemical and physical influences from outside and must not contain compounds or elements which inhibit or even break down the pheromone or attractant action. Polyethylene vials and rubber sleeve stoppers are used on a wide scale. We found that white rubber septa of Aldrich (type Z10, 075-7) are unsuitable for codlemone (EE8,10-12:OH), whereas similar red rubber septa (sleeve stoppers) (type Z12, 438-9) are reasonably good.

However, for the complicated sex pheromone of Phthorimaea operculella, a 2:3 mixture of EZ4,7-13:Ac and EZZ4,7,10-13:Ac, both types of septa can be used, because this sex pheromone is remarkably stable. After a year in the field the dispensers appeared to be still attractive. The high attractivity for males and the long field half live makes it economically feasible to use this expensive sex pheromone for mass trapping.

For the producer of lures and for governmental officials there are still many questions as to the economics of the applications of traps in the field. How much do the growers save on insecticides when they properly use traps and correctly interpret catches of noxious moths? It is high time that field research workers make up the balance and show with clear figures what the benefits are of our research work over the past 20 years for the growers as well as for the environment.

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Rubber septa - most widely used dispensers of pheromone traps

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The most important requirements towards a formulated bait in an insect attractant trap are that it release the attractant compounds at a rate/ratio optimal for attraction of the species in question, and that it remain active over a prolonged period of time.

These requirements are achieved successfully in many lepidopteran male attractant formulations by using rubber septa as the substrate of the bait. In these cases the attractant compounds are impregnated into the rubber and are released consequently into the air when the trap is assembled.

Main obstacles in the usage of rubber septa based trap baits include the following:

1) Release rate/ratio
Many male moths are attracted to a relatively narrow component ratio released at a given rate. The optimal rate and release ratio for a given species can be determined by empirical testing of combinations on rubber septa.

2) Purity
The purity of the chemicals is very critical, as many species are known to respond better to blends containing minor amounts of synergists, or, can be inhibited by trace impurities.

Even if the original purity of the compounds used is satisfactory, chemically related compounds can be formed under field conditions, for example small amounts of corresponding alcohols from acetates, which eventually can modify the performance of the bait.

In some cases formation of minor contaminants is catalysed by compounds present in the rubber, as for example the formation of acetates from the corresponding aldehydes.

3) Contamination
Rubber septa can easily be cross-contaminated by improper handling of the dispenser, and this can have devastating effects, as attractant components of a given species can be strongly inhibitory towards another pest species. Special care must be taken that the rubber septa to be used are not handled with the bare hands. The widespread technique of placing the dispenser into the sticky layer is just inviting trouble, as the attractant compounds can easily be transferred into the sticky material and thus increase the chances of cross-contamination. Similarly, trap parts of already used traps should not be reused in new traps, as they in most cases contain traces of the previous attractant.

THE "COMPLETE" DESIGN OF LURE FORMULATIONS -A MANUFACTURERS POINT OF VIEW-

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Summary

The title has in it the word "COMPLETE" and the author would like to expand the idea that when an attractant becomes a useful tool for monitoring purposes, the terminology "design of lure formulations" takes on, or should take on, a very broad meaning. This meaning will encompass many things. Many of us consider Formulation Design to be a direct function of the requirements as set out by experimentation and field trials that result in the optimum catch sensitivity to the pest or insect in question. While this is a paramount function, the manufacturer, and indeed the scientist will be face with other criteria that will impinge on the success of a monitoring program, even after the purity of the compound, the correct emission rates, and time spans are solved.

1.1 Discussion

This presentation will touch on the method of formulation design as it pertains to the POLYTRAP System as an example, a patented polymer matrix system used by AgriSense. The designing of the lure to give the basic attraction requirements is meshed with other key factors that also affect the success of a large or extensive Programme. Many of the other factors are physically related, others economically related, yet others, related to such things as logistics of shipping, storage, handling and so on. Above all, the Lure in question should be almost foolproof when it comes to large programme applications in the field. As mentioned earlier, the scientist will sense and identify the areas of short-coming, but it is the Manufacturer who has to solve the problems to produce the required finished unit that ensures a successful Programme that will yield good sound data. Some of the other factors to be considered in the design :

* Ease of applying the lure to the trap
* Elimination of the possibility of contamination around the Trap
* Longer lure life and more efficient use of the active
* Minimizing the worker exposure to complex organic materials over long periods of time
* Minimize the effects of extreme temperature changes on lure performance
* Packaged in a manner to maintain lure integrity over a long period of time
* Packaged to permit easy storage, handling, and distribution
* Produced in a manner that permits maximum economy

1.2 Example

The example here will be the 2 gram Trimedlure Polytrap plug used in monitoring for the presence of Medfly. The criteria for the design was a lure (1) that would last three to four times as long as the Trimedlure liquid placed on a cotton wick; (2) that would maintain an acceptable trap catch sensitivity to ensure the integrity of an extensive Medfly detection system; (3) that would be able to be deployed (with confidence as to the resulting data) by means of reasonably unskilled trap line personnel; (4) a lure whose chemical composition remained stable and consistent to analysis parameters both in the testing laboratory and the field.

POLYTRAP is a system where-by monomers can be selected that permit the right sized cages or meshes to be formed relative to the molecular size and shape of the active ingredient to be time released or metered out as it were. The tightness of the cages holding the active, the percentage loading, as well as the surface area exposed to the air, give variables that permit extreme flexibility. The entrapment of the active is done "in situ" making possible loadings as high as 70-80%

In the POLYTRAP system it is these three main variables that are juggled to design the product. What have we done for the word "COMPLETE"? By use of the variables we obtain the desired time frame and release rates. By using high loadings we kept product size down to fit the trap. We also made it a solid lure for ease of handling, packing and storage. The package design also eliminated contamination of trap site and minimized exposure to the trapper. We are now in the process of automating production for greater economy.

1.3 Concluding Comments

The use of monitoring in detection programmes, in IPM programmes, in programmes that include both Government Agencies and private individuals is on the increase. This valuable tool is now definitely part of the agricultural scene world-wide. The attendant large numbers and types of lures required necessitates the support and involvement of businesses who can supply the many disciplines that are vital to provide the total COMPLETE unit to the field.

MONITORING OF GRAPE PEST INSECTS IN W.-GERMANY - AN ESSENTIAL TOOL IN ORDER TO APPLY THE PHEROMONE CONFUSION TECHNIQUE

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The grape berry moth Eupoecilia ambiguella and the European grapevine moth Lobesia botrana are the major pest insects in German vineyards. Two generations of larvae, the "Heuwurm" in spring and the "Sauerwurm" in summer, may cause serious losses, also due to fungal infections (Botrytis) of damaged parts (3).

Female moths lure their conspecific males; pheromone orientation therefore plays a decisive role in reproduction. BASF have exploited this by optimizing the pheromone confusion technique for the control of Eupoecilia ambiguella to produce a competitive and economically sound product: RAK 1 (1).

In this biotechnical method a great number of pheromone dispensers are distributed in vineyards - 500/ha, slowly emitting the major pheromone component Z9 - 12Ac. Reproduction of the grape berry moth is reduced down to a level comparable to that obtained by classical insecticides (4, 5).

Successful application of this species specific pheromone confusion method, however, is only possible if the presence of other species can be excluded. For this purpose multiple pheromone traps baited with various synthetic lures are essential tools.

They monitor: a) the occurrence of the target pest, b) the presence of secondary pests, c) the onset of male moth flight, d) the annual periods of moth activitiy (i.e. several generations), e) the maxima in male moth flight activity, f) the migration of a test insect, using the mark-release-recapture technique.

A comprehensive survey of the dominant grape pest in various vine growing areas in the Rheinpfalz resulted into rather consistant distribution pattern of Eupoecilia ambiguella and Lobesia botrana. In course of the years, however, fluctuations were observed in case of minor (latent) populations. There appears to be a tendency of Lobesia-immigration into new areas which were, in the past, regarded as pure Eupoecilia-infested regions.

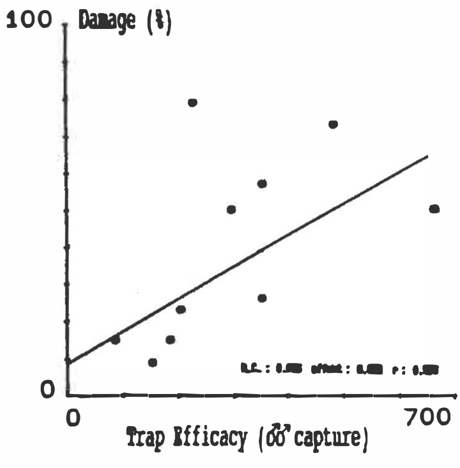

Fig. 1:
Relation between trap efficacy (n = 1-3) and damage
untreated control plots
Eupoecilia ambiguella,
Hainfeld, 1983-85

The occurrence of E. ambiguella and L. botrana and some typical flight activity patterns are demonstrated. The data indicate significant variations in various locations and years. Therefore capture data from a test site should never be applied for other regions or years.

To our experience, there is no significant relationship between trap efficacy and crop damage (Fig. 1); therefore it should be concluded that trap efficacy is, in general, no valid measure for population density.

In field experiments the efficacy of confusion, expressed as reduction in crop damage, was related to the efficacy of traps baited with strong lures (Fig. 2, 3). A high degree of desorientation to attractive traps within a pheromone treated area supports the hypotheses that high dosages of pheromones affect male orientation and sensitivity.

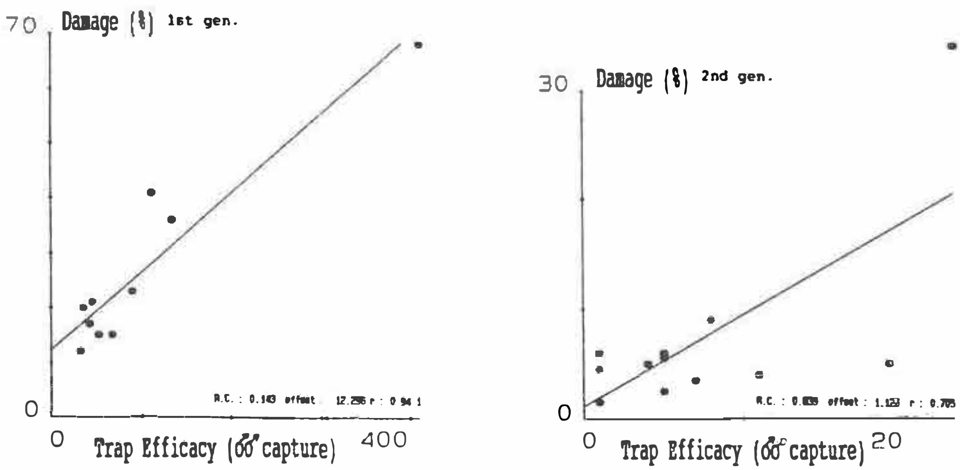

Fig. 2 and 3
Relation between trap efficacy (n = 3) and damage male confusion experiments (0.35 ha/plot, n = 3), Lobesia botrana, Wachenheim, 1987

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RUBBER SEPTA FORMULATIONS AN INDUSTRY PERSPECTIVE

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"Rubber septa" are low cost formulation substrates useful for producing most pheromone chemicals. They provide high quality results in manufacturing, distribution and field application of pheromone attractants. And, they have been used to develop a large number of the monitoring programs, economic threshold and phenology models available. Correspondingly, they should be the standard reference in developing any new pheromone based formulations. Disciplined quality control in the laboratory, plant, and distribution system help insure rubber septa based formulation performance. Proper field techniques and maintenance of monitoring systems add to quality results.

Trece, Incorporated, a California U.S.A. based company, manufactures and markets an extensive line of pheromone based insect monitoring systems. The company, which focuses only on monitoring systems, globally markets its PHEROCON®, STORGARD® and consumer product lines into the agricultural, governmental (exclusion/quarantine), stored products and consumer markets. The PHEROCON line was the first product line commercialized based on pheromones. These products were introduced by Zoecon Corporation, a Sandoz Company, in 1971, who also introduced the STORGARD product line in 1983.

Trece employs commercially available rubber sleeve stoppers as the principal substrate used in its pheromone based formulations. Commonly referred to as "rubber septa", a red or grey colored product is selected depending on the chemistry of each formulation.

Rubber septa are the "work horse" of commercial pheromone formulations used in agriculture. And, they have been the principal formulation substrate used by researchers to develop the detection and monitoring component of the majority of IPM programs since the early 1970's. This is also true for the limited number of economic threshold models based on monitoring systems. Examples are California red scale, *Aonidiella aurantii*, Codling moth, *Cydia pomonella*, Oriental fruit moth, *Grapholita molesta*, and others.

The foregoing degree of scientific support and commercial use suggests great care should be taken in the selection of formulations based on substrates other than rubber septa. It is essential that appropriate data linkages be established between formulations based on rubber septa and those based on new substrates.

Rubber septa are readily available, low cost substrates useful for formulating a wide variety of pheromone products. They are convenient and economical to use in manufacturing and distribution, and for employment in insect detection, monitoring and control programs. Further, rubber septa formulations are reasonably easy to insure for consistent quality and expected field results with a few easily initiated practices.

The best laboratory and manufacturing results are obtained when intensive chemical analysis is conducted on technical ingredients, isomeric mixes, final dilutions and the end product. Though costly and time consuming, such intensity pays dividends in necessary high quality.

High quality packaging and organization and education of the distribution system is essential to insuring that quality products reach the field. Products should be packaged in an environment saturated with nitrogen in a container impermeable to gases and which excludes sunlight. Products should not be subjected to high temperatures and should be stored in cool or frozen conditions. Inventories must be rotated at periods appropriate for each formulation.

Optimum field results can be obtained with strict adherence to recommendations provided by research, extension or the manufacturer. Monitoring systems must be selected and operated with great care. Systems must be placed at the proper time, interval, height and quadrant relative to target insect behavior. Trap designs should only be selected that were used in developing the original monitoring program if results are expected to simulate those developed in research. Lures must be replaced as recommended and great care must be taken to prevent contamination. Handling of a series of different formulations is the most common cause of contamination. But, the presence of various volatile chemicals during the storage, handling or transportation may also affect performance.

Environmental conditions such as wind, temperature and day length may adversely affect trap capture. Care must be taken to include these in all data analysis and pest management decisions.

Rubber septa formulations have limitations for use with certain chemicals, for example the aldehydes and chemical combinations requiring different release constraints. And, they often cannot provide the longevity characteristics needed for applications in programs requiring long replacement intervals such as exclusion/detection projects.

Trece is working with Zetachron, its U.S. research partner, to develop longer acting, high sophisticated formulations suitable for the foregoing chemicals and programs.

A NEW CONTROLLED RELEASE FORMULATION WHICH PROTECTS PHEROMONES FROM ISOMERISATION AND DEGRADATION UNDER FIELD CONDITIONS

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SUMMARY

Most pheromone components can degrade with time as a result of photo-, chemo-, or even bio-degradation. Some pheromone components are more prone to this than others, and this paper describes a formulation developed to protect such compounds under field conditions.

Pheromone components which are particularly prone to degradation are conjugated dienes (1,5) and those with aldehydic functional groups. The ways these compounds degrade can be classified under three headings: (i) isomerisation, (ii) decomposition and (iii) dimer- or trimerisation. Isomerisation is a change in the configuration of the double bond(s), e.g. change of (E,Z) to (E,E) in the pheromone of *Lobesia botrana* (4)(Table1). Decomposition is a change in the chemical structure of a pheromone, e.g. oxidation of aldehyde to acid, oxidation of a double bond to an epoxide, endoperoxide,hydroperoxide or even furan structure (6). Dimer- or trimerisation occurs when two or three molecules join to form more complex structures(3).

Under field conditions, these processes are accelerated dramatically by strong sunlight, high temperatures and the availability of oxygen. When selecting a dispenser system for a particular pheromone and particular application, attention must be given not only to the release rate of the pheromone, but also the degree of protection against degradation afforded by the dispenser. For example, under field conditions in Pakistan, the pheromone of *Earias vittella* remains attractive for little more than one night when formulated in standard polyethylene vial dispensers. Isomerisation of the major component (Table 1) to the(E,Z) isomer inhibits attraction of *E.vitella* and in fact increases attractiveness to the related species, *E. insulana* (2). Many authors have shown that the addition of an antioxidant prevents much of the processes of degradation but they are only partially successful in preventing isomerisation (3). Other researchers have shown that isomerisation of conjugated dienes occurs very readily in standard red rubber septa and that free sulphur remaining from the curing process in their manufacture accelarates it (1,7).

Recent collaborative work between ODNRI and BCS Ltd has led to the development and commercialisation of a thermosetting PVC resin formulation containing antioxidants and UV light blockers. This formulation minimises isomerisation and decomposition of problem pheromones such as those in Table 1, while at the same time it maintains a constant release rate over periods of up to three months. This new formulation is now being used successfully in both trapping and mating disruption applications.

TABLE 1. ISOMERISATION OF CONJUGATED DIENIC PHEROMONES

Species Diene	Exposure Conditions	Days Exposure	Isomer %				Ref.
			ZE	EZ	ZZ	EE	
Lobesia botrana	Direct sunlight	0	-	90	-	10	(4)
	no antioxidant	3	total degradation				
EZ-7,9-12:Ac	+ antioxidant	45	14	18	4	64	
	Direct sunlight	0	-	85	-	15	
	in PVC resin	49	-	81	-	19	
Spodoptera littoralis	Direct sunlight	0	95	-	-	5	(1)
	in rubber septa	35	27	10	3	60	
ZE-9,11-14:Ac	Direct sunlight	0	96	1	-	3	
	in PVC resin	35	84	5	-	11	
Earias spp	Direct sunlight	0	-	2	-	98	
	+ antioxidant in						
EE-10,12-16:Ald	vial	11	17	17	6	60	
	in PVC resin	30	7	14	3	76	

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