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Mating disruption and working group in retrospect

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Abstract: Almost immediately after the establishment in 1975 of the IOBC/WPRS Working Group 'Use of Pheromones in Integrated Control', mating disruption became a major topic in most of its meetings. Research and development of mating disruption with all its ups and downs are clearly reflected in the Working Group's activity reports.With the help of the proceedings of the various Working Group meetings I will describe how mating disruption developed to a full-grown insect control method during the 25 years of the Working Groups' existence.

Key words: dispensers, formulations, IOBC/WPRS, IPM, meeting place, semiochemicals, sex pheromones

Introduction

Some months ago I paid a visit to the BBA Institute at Dossenheim near Heidelberg in Germany. During summertime Heidelberg is full of tourists and all hotels appeared to be full. My colleagues were able to find a room for me at a 'Winzerei' (vinery), located in the hills just outside the town. The vineyard was completely surrounded by mixed forest and quite isolated. Every evening I drank a glass of wine with the grower and he told me that since 10 years his vineyard was successfully treated with pheromone mating disruption to control the leafrollers. I was really impressed by the grower's enthusiasm for this 'wonderful' method. He liked mating disruption as he was able to protect his crop by means of an environmentally benign method without detrimental effects on his financial outcome. He further told me that most of his colleagues in the region also used mating disruption to their great satisfaction and that the use of pheromones in vine-grapes had increased to approximately 20,000 ha in 1999. As I had not closely followed the developments since 1997 it came as a surprise to me that mating disruption became such a big success in the Palatinate and other regions of southwest Germany.

Inwillingly my mind wandered back to the meeting of this Working Group held in 1986 at Neustadt an der Weinstrasse in Germany, in the middle of the wine-growing region, not far from Heidelberg. I remembered the stimulating atmosphere at that meeting where it was clearly demonstrated in extensive trials that effective mating disruption of grape moths was feasible. But I also remembered that the atmosphere in the successive Working Group meetings had its ups and downs, which I believe was

strongly influenced by the prospects of pheromone application, particularly of mating disruption. I think that this festive silver-jubilee meeting provides the right opportunity to review the status of mating disruption in the subsequent working group meetings. Before doing so I like to present a brief summary of the Working Group's activities and a short general introduction into mating disruption.

The Working Group

The major aim of the Working Group is to bring together people interested in the use of pheromones and other semiochemicals for environmentally safe control of noxious insects in agriculture, and to collect information about this field.

How did it all start? The idea to create a special working group on pheromones was born at a meeting of another IOBC/WPRS Working Group, held at Wädenswil (Switzerland) in November 1973. The programme dealt with IPM in fruit orchards and at least 30% of the contributions presented at the meeting was devoted to pheromones. The pheromone researchers assembled there began to realize the great significance of their own area of interest and found it appropriate to have 'their own' meeting place. So, after approval of the IOBC/WPRS Council the Working Group 'Use of Pheromones in Integrated Control', later renamed as 'Use of Pheromones and Other Semiochemicals in Integrated Control' was established. Its first meeting was held in 1975 at Wageningen (The Netherlands) with 32 participants from 8 different countries.

Since then the Working Group has met at 15 other occasions, including the 25th anniversary meeting at Samos (Greece) in September 2000 (Table 1). It has traditionally served as a meeting place for basic and applied research workers on semiochemicals. This research area has an outspoken multidisciplinary character and to make progress in application it is essential to bring colleagues together from academic and governmental research institutions, plant protection industry and extension services, who have knowledge of insect behaviour and sensory physiology, chemistry and formulation technology, and of applied entomology and integrated pest management. The Working Group meetings turned out to be extremely useful to European specialists in the first place, but were often attended by colleagues from outside the WPRS-region, such as the USA, Canada, Australia and Japan.

Mating disruption: general aspects

Minks & Kirsch (1998) characterized mating disruption as permeation of the air over the crop to be protected with synthetic pheromone. Male moths are then unable to locate their female mates when using their own pheromone system and mating is therefore reduced or even eliminated.

Table 1. Meetings of the IOBC/WPRS Working Group on Semiochemicals since 1975 (update from Minks & Voerman, 1996)

Convenor: Albert Minks (1975-1985)			
Wageningen	NL	1975	Introductory meeting, various topics
Harpenden	UK	1977	Chemistry and biological activity of pheromones
Wädenswil	CH	1979	Fundamental and applied aspects
Nyon	CH	1982	Mating disruption in fruit and grapes
Hamburg	D	1984	Pheromone and attractant chemistry
Balatonalmádi	H	1984	Joint meeting with EPRS Working Group
Convenor: Heinrich Arn (1985-1995)			
Neustadt/Weinstrasse	D	1986	Mating disruption: behaviour of moths and molecules
Avignon	F	1988	Insect monitoring and attractants
Granada	E	1990	Pheromones in Mediterranean pest management
San Michele all'Adige	I	1992	Mating disruption
Chatham	UK	1993	Insect pheromones
St.Peters Insel	CH	1994	Use of mating disruption in practice
Convenor: Peter Witzgall (since 1995)			
Montpellier	F	1996	Technology transfer in mating disruption
Budapest	H	1997	Pheromone lures for detection and monitoring
Dachau	D	1998	Scents in orchards
Stuttgart/Hohenheim	D	1999	Pheromones for insect control in orchards and vineyards
Samos	GR	2000	25th Anniversary Reunion

They also stressed the point that slow-release formulations are absolutely essential for pheromones used in mating disruption. They prolong the release and efficacy of the highly volatile pheromone compounds and provide in-field stabilization of pheromone remaining in the formulation. While formulations can be sprayable (e.g. microcapsules), at present most commercial formulations are designed for hand application by clipping, hanging or twisting them around stems or branches of the crop. Table 2 shows a list of the best known pheromone formulations.

Mating Disruption and Working Group Meetings

WG meeting at Nyon in 1982

At the first three meetings mating disruption was discussed in various sessions, but major attention was aimed at other areas such as chemical identification, biological

activity, and pheromone trapping. But the fouth meeting, held at Nyon, was exclusively devoted to the technique of mating disruption in fruit orchards and vineyards. Approximately one year before the meeting the Hercon laminate flakes (Table 2) came on the market. Several reports were presented at that meeting on effectivity tests of the flakes, but also of self-made dispensers, such as rubber tubing made from bicycle-tyres. The main conclusion was that 'despite intensive research efforts, progress has been slow and practical application is still far away. Prospects in wine growing are better than in fruit orchards, probably due to a much simpler pest situation in grapes. More attention to basic studies on behaviour, formulation techniques and on damage assessment methods is recommended'.

Table 2. Pheromone formulations used commercially in recent years (update from list in Minks & Kirsch, 1998)

Laminate flakes (Hercon, USA)
Twin-ampullae dispensers (BASF Doppelampullen, Germany)
Twist-tie polyethylene dispensers (Biocontrol/Shin-Etsu, Japan)
Polymer dispensers (TNO, the Netherlands)
Isagro cellulose fibre dispensers (Donegani, Italy)
Consep membranes (Consep, USA)
Biosys polymer dispensers (Biosys, USA)
Scentry micro-fibres (Ecogen, USA)
Microcapsules (3M, USA)
Metered Semiochemical Timed Release System (MSTRS, USA)
Paraffin emulsion dispensers (USA)

WG meeting at Neustadt in 1986

I earlier mentioned that the atmosphere at this meeting was full of expectations. This was stimulated by promising results obtained with mating disruption of the grape berry moth, *Eupoecilia ambiguella,* in trials over an area of more than 100 ha of grapes by the colleagues at Neustadt, and on another 30 ha by others working in the region along the river Moselle. Both groups used laminate flakes or the newly introduced twin-ampullae in their tests. As the outcome looked sufficiently reliable over a period of 5 years, the synthetic pheromone of *E. ambiguella* could be registered in Germany for control of this moth by mating disruption, initially only against the second generation, later also against the first generation (it took another 8 years before the pheromone of the grape vine moth, *Lobesia botrana* was registered*!).* Heinrich Arn, the new convenor of the Working Group called this 'a breakthrough where

many pheromone researchers in Europe are hoping for and perhaps the signal for developing other applications'.

But in other areas, for instance, fruit growing, research on mating disruption appeared to proceed much slower with a significant percentage of failures, often for unknown reasons. Prospects for codling moth looked better than for leafrollers and in 1986 the Swiss authorities accepted a provisional registration of the pheromone of the codling moth, *Cydia pomonella*, primarily based on an extensive 10-year testing programme in that country.

Despite these positive developments, one can conclude from the proceedings that a better knowledge of the mechanisms of disruption is still urgently needed, so that growers or advisors can be told when the method will or will not work, and what and how much the dispensers should contain and when and where in the treated area they ought to be placed for best results.

WG Meeting at Granada in 1990

This meeting successfully linked the research activities in North- and Central Europe with applications in the Mediterranean region. In various countries mating disruption tests were set up: in Israel as well as in Spain for the pink bollworm, *Pectinophora gossypiella* and the armyworm, *Heliothis armigera* in cotton, in Italy and Spain for the peach moths, *Grapholita molesta* and *Anarsia lineatella*, in Italy also for codling moth and apple leafrollers, and in Spain for the grape vine moth, *Lobesia botrana*. All these trials were in the experimental phase and executed on plots of a few ha at most. A significant improvement was the introduction of the twist-tie polyethylene dispenser (see Table 2) into most of the tests.

The only large-scale commercial application of pheromone mating disruption was reported from Egypt against the pink bollworm on several hundreds of ha of cotton. However, our colleagues involved pointed out that, although it had considerable success and proven advantages over broad-spectrum insecticides, pheromones have yet to be generally accepted or applied on a broader basis in Egypt. A fully integrated IPM system for control of cotton pests in Egypt needs to be developed first, before control by pheromones can really become effective.

WG Meeting at San Michele all'Adige in 1992

I remember in the first place that the wine and food has never been so good as at this meeting: the arrangements of our Italian collegues were outstanding! But Heinrich Arn wrote in his report for the General Assembly of IOBC/WPRS when referring to this meeting 'that mating disruption, the most successful of the control techniques employed with semiochemicals, is in a crisis'. His was right. Most studies on mating disruption presented at this meeting showed the same trend: mainly positive results, but some failures. This created a lot of frustration among the participants, the more as

most of these failures could not be properly explained. Inadequate performance of the dispensers could be the cause, although the two mostly used dispensers, the twisted-tie ropes and the twin-ampullae were experienced as an improvement. Also high populations densities or migration were suggested as the problem, but it was all speculative. It came back to the old problem of a lack of knowledge of mechanisms and the actual conditions for successful control, such as the composition and protection of the active ingredient, its dosage and dispersal in the field.

So the major recommendations of this meeting were: 1) Continue with implementing mating disruption at its current technological state in integrated production, 2) Study the mechanisms of mating disruption in order to optimize active ingredients and application techniques, and 3) Improve the reliability of controlled release formulations.

In connection to this it is worth mentioning that a portable EAG apparatus for the measurement of pheromone concentrations and dispersion in the field was demonstrated at this meeting by Koch and co-workers: an important breakthrough that will enable us to optimize the formulation of the active ingredient in the dispensers.

WG Meeting at Chatham in 1993

This was a large meeting with 134 participants from 30 different countries, that brought together colleagues from both the ‘developed’ and the ‘developing’ countries with the aim of reviewing the current state of pheromone technology in Europe and whether and how this technique might be transferred to developing countries. The presentations covered the whole field from basic science to field applications with special attention devoted to Eastern Europe, Africa, Asia and South America. In addition to Europa experimental studies on mating disruption were reported from the Ivory Coast, Pakistan, Egypt, and China. Large-scale commercial application of the pink bollworm sex pheromone in Egypt was successfully continued in 1992 over more than 20, 000 ha of cotton. Two formulations were used: the twist-tie dispensers and microcapsules in combination with one or two treatments of conventional pesticides, if necessary. Worth mentioning are also 1) the mating disruption project against the rice stem borer, *Chilo suppressalis*, in Spain on 4000 ha, using self-made hand-applied dispensers, and 2) the area-wide application of Oriental fruit moth mating disruption in the Tulbagh valley in South Africa over approximately 2000 ha..

Basic research presented were among others: analysis of pheromone plume structure in the field by means of single sensillum recording, evaluation of disruption mechanisms in field wind tunnels, and laboratory studies on insect behaviour. Of a more applied character were the tests of two new dispensers: the TNO polymer dispenser and the Consep membrane (Table 1). A strategic study was devoted to the registration of semiochemicals as pest control agents.

WG Meeting at St. Peters Insel in 1994

This was a special meeting for which a small group of pheromone experts was invited in a courageous attempt to set up practical guidelines for a better, more effective use of the mating disruption technique. Unfortunately the meeting stranded in endless discussions, for instance, on the definitions of the various terms and standards to be used in this area. The guidelines were never finished.

WG Meeting at Montpellier in 1996

Only 4 years after the crisis meeting at San Michele the atmosphere had changed to moderately positive at Montpellier. The new convener, Peter Witzgall, wrote in his preface: “the proceedings show evidence that the mating disruption technology has reached maturity”, may be at first sight a surprising change in opinion, indeed! But it was a fact that the number as well as the size of successful mating disruption projects had grown significantly in those years. Minks & Kirsch estimated that the world-wide application of commercial mating disruption products increased to 300,000 ha in 1996. More than 80% of this acreage was on cotton against *P. gossypiella* in Egypt, the south-western states of the USA and in Mexico, and 5% respectively on pome fruit against *C. pomonella* in the north-west of the USA and in N. Italy and on grapes against the grape moths *E. ambiguella* and *L. botrana* in south-west Germany. And is also true that in several cases mating disruption has become an integral part of pest control programmes, and may even appear to be more (cost-)effective than conventional pesticides.

It is also undeniable that in past years considerable progress has been made with the industrial synthesis of pheromones, controlled release technology and the in-field measurement of airborne pheromones. And with the increasing importance of mating disruption growers and advisory organisations have acquired more knowledge in how to apply the technique.

Our convener rightly observed that, now we have arrived at this point “we must consolidate the recent achievements and establish mating disruption as a reliable and cost-effective technique. Our success will determine the public interest in further research in the field of olfactory communication and chemical ecology.

WG Meetings at Dachau in 1998 and at Hohenheim in 1999

These meetings showed a steady increase of the major commercial mating disruption operation in Europe: in grapes in the Palatinate region on 20, 000 ha, to which should be added several thousands of ha from other regions in Germany, 4500 ha from Switzerland and 1500 ha from the Trentino region in Italy. However, in fruit there was an unfortunate set-back, as the project in South Tyrol in Italy almost disappeared, mainly because of a lack of financial support. But in the western USA the

codling moth area-wide management programme was extremely successful and grew further to 24,000 ha in 1999 and to probably 40,000 in the 2000 season. Also cotton control by pheromones continued to increase.

Conclusions

My conclusions can be brief. Although the development of pheromone mating disruption has progressed much slower than was anticipated in the 70's and the early 80's, we can only point to a limited number of successful introductions, I still think that it is the best insect control method that one can imagine. Because of its environmentally friendly properties it ideally fits in integrated and biological control programmes, for which there is an increasing public demand. So I believe it is well worth to continue or even to intensify our efforts to work on our case and to make pheromones ready not only for mating disruption, but also for monitoring, mass trapping or attract and kill, depending on the pest and the crop situation.. In doing so I really hope that besides the practical work my younger colleagues will get the opportunity to proceed with basic and strategic research, as this is indispensible for a further successful development of mating disruption. For the moment, though, I am not really worried as I am pleased to see in the programmes of the Working Group Meetings that more than half of the contributions deal with basic studies.

Undoubtedly our Working Group will continue to play an crucial role in these developments, just as it has done in the past 25 years. It has been and still is an important meeting place for all who feel themselves involved in the field insect semiochemicals. Long may the Working Group live!

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