Mitteilungen aus der Biologischen Bundesanstalt für Land- und Forstwirtschaft
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Summaries of papers presented at the
Joint FAO/IAEA and IOBC/WPRS Research
Coordination Meeting at Heidelberg
November 7-10 1977

edited by Dr. Erich Dickler

Biologische Bundesanstalt für Land- und
Forstwirtschaft
Institut für Pflanzenschutz im Obstbau,
Dossenheim ü. Heidelberg

Berlin 1978

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Integrierte Bekämpfung des Apfelwicklers unter besonderer Berücksichtigung der Insektensterilisationsmethode

Kurzfassungen der Vorträge, gehalten anläßlich der internationalen Tagung der FAO/IAEA und IOBC/WPRS Arbeitsgruppen in Heidelberg 7.-10. November 1977

bearbeitet von Dr. Erich Dickter

Biologische Bundesanstalt für Land- und Forstwirtschaft
Institut für Pflanzenschutz im Obstbau.
Dossenheim ü. Heidelberg

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CONTENTS

Vorwort

Der Apfelwickler, Laspey!-g pomonellc!:: L., ist weltweit verbreitet und ein Hauptschädling an Kernobstarten und Walnuß. Zur Sicherung der Ernte sind jährlich mehrere Spritzungen mit chemischen Insektiziden erforderlich. Wissenschaftler in aller Welt suchen daher seit einigen Jahren nach Möglichkeiten, die Anwendung der chemischen Insektizide auf ein Minimum zu reduzieren oder durch umweltfreundliche biologische Bekämpfungsverfahren zu ersetzen.

Vom 7. bis 10. November 1977 fand in Heidelberg eine "Internationale Apfelwicklertagung" statt, an der Vertreter der beiden Arbeitsgruppen, der "Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture" und der "International Organization for Biological Control/West Palearctic Regional Section (IOBC/WPRS)" teilnahmen. Das Symposium mit dem Thema "Integrierte Bekämpfung des Apfelwicklers unter besonderer Berücksichtigung der Insektensterilisationsmethode" wurde von der Biologischen Bundesanstalt für Land- und Forstwirtschaft, Institut für Pflanzenschutz im Obstbau, Dossenheim, durchgeführt.

Teilnehmer aus 12 Ländern, Europa, dem Nahen Osten und Nordamerika stellten in 45 Vorträgen ihre Ergebnisse zur Diskussion, wobei Alternativen zur chemischen Bekämpfung dieses Schädlings weiterentwickelt wurden. Schwerpunkte der Diskussion waren natürliche Feinde, Krankheiten, Pheromone, Insektensterilisationsmethode und Ökologie. Die wichtigsten wissenschaftlichen Ergebnisse dieser Tagung sind in den folgenden Kurzberichten der gehaltenen Vorträge zusammenfassend dargestellt. Sie geben einen Überblick über die neuesten Entwicklungen zur Steuerung von Apfelwicklerpopulationen.

Preface

In most fruit growing regions of the world the codling moth, Laspeyresia pomonella, is the key pest of pome fruit and walnut necessitating repeated

applications of insecticides. Research is going on in many places to improve existing control methods and to replace them by ecologically sounder alternatives.

A research coordination meeting between members of two working groups of the Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture and of the International Organization for Biological Control/West Palearctic Regional Section (IOBC/WPRS) was held in the Max-Planck-Haus, Heidelberg, from November 7 - 10, 1977. The meeting was hosted by the Biologische Bundesanstalt für Land- und Forstwirtschaft, Institut für Pflanzenschutz im Obstbau, Dossenheim, Fedetal Republic of Germany. The subject matter of the meeting was "The use of lntegrated Control and the Sterile lnsect Technique for Control of the Codling Moth (Laspeyresia pomonella)". Participants representing twelve countries from Europe, the Near East and North America attended the meeting. During the four days discussions on research results on the use of alternative methods to chemical control of this insect were forewarded. Subjects discussed included: natural enemies, diseases, pheromones, sterile insect technique and ecology. The following summaries contain the main research results presented by the participants and provide an outlook on the current developments in the management of codling moth populations.

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Scientific Secretary
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E. DICKLER
Final editor,
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Joint meeting
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Ecology and biology

Studies on the codling moth (Laspeyresia pomonella L.) and other apple pests in Hungary with regard to the possibilities of including the sterile insect technique into an integrated control scheme

T. JERMY, B. NAGY, L. SZALAY-MARZSO, G. REICHART and F. KOZAR

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The feasibility of the sterile insect technique /SIT/ against the codling moth /CM/ depends on the structure and dynamics of the CM populations, and on the possibilities of its integration into a system of controlling other apple pests. Therefore, the population dynamics of the CM as well as of associated pests were studied in various parts of Hungary, before all in the untreated experimental orchard of the Research Institute for Plant Protection, and in the surrounding area near Budapest. This paper is a short summary of the main results.

The CM has two generations in Hungary. Its flight, monitored by sex-traps, lasted from May to September /1973-1977/. The two peaks and the break between the two flights were always blurred. Thus, control measures should be carried out nearly continuously during the whole season.

Poor crop or even absence of fruits in a restricted area did not stop the flight in the same year and even not in the next one, neither in the orchard nor in the neighbouring forest. This phenomenon was supposedly helped by a higher dispersal activity of adults evoked by the scantiness of fruits /Nagy - Jermy 1972/.

The number of CM pairs was estimated by the release-recapture method as 100 to 500/ha in mid-summer in the untreated orchard. The population level estimated by the captures of 0, 8 to 1, 0 sex-traps/ha increased here gradually from 1972 to 1975, while a relatively sudden drop occurred in 1977 probably

due mainly to unfavourable weather conditions in the spring. Such naturally occurring low population levels could help initiating successful SIT against the CM even in not thoroughly treated apple stands /Nagy 1977/.

Mixed house gardens containing abandoned apple, pear, and walnut trees have tobe considered in Hungary as the main reservoir of the "semiwild type" CM and other insect pests. Oak forest proved to harbour autonomous "wild type" CM populations on wild apple and Sorbus trees. These areas may cause great difficulties for the SIT. On the other hand, the chemically well treated apple orchards have generally very low "farm type" CM populations. The relationship of, and the differences between these three "ecotypes" of the CM are not well known yet /Nagy - Jermy 1975, Nagy 1977/.

Natural occurrence of the CM granulosis virus in larvae developing in wild apples has been found. Transmission of the virus in laboratory rearings by the mite Tyrophagus putrescentiae was detected. Spraying with virus suspensions, fully protected apples against the CM, however, no spread of the virus to neighbouring untreated trees was observed. Occurrence of CM nosemosis was demonstrated both in laboratory rearings and in field collected specimens /Szalay-Marzs6 1972, 1974, Szalay-Marzs6 - Dezsery 1975/.

Among the Microlepidoptera pests of apple in Hungary Spilonota ocellana, Recurvaria nanella, R. leucatella, Hedya nubiferana, Adoxophyes reticulana, Pandemis ribeana and . heparana proved to be the most important species in spring, and Lithocolletis blancardella in summer. Heavy infestation was caused by the latter even in well treated commercial orchards. Infestation of the buds by the former species in early spring of 1972 to 1976 varied from 15 to 45 % in the untreated orchard /Reichart 1977 /.

In orchards adjacent to forests, wintermoths /mainly Operophtera brumata/ may cause heavy damages by destroying the young shoots which may reduce the possibilities of later populations, like Anthonomus pomorum, CM and others, using flower buds and fruits as food.

The populations of Dysaphis plantaginea and Aphis pomi occurring in the untreated orchard showed considerable fluctuations in 1973 to 1977 which could be related either to biotic or abiotic factors. Coccinellids decisively reduced aphid populations in 1974.

The most important scale pest, Quadraspidiotus perniciosus, is generally under detection level in the commercial orchards. In abandoned apple stands the fruits were infested up to 57 % despite of 32 % parasitization. Winter mortality of the scales varied between 38 and 73 % in 1974-1977 /Kozar 1977/.

The great number of apple pests and the high population levels reached by several species in the untreated apple stands indicate that /1/ natural control generally cannot reduce these populations to an economically acceptable level, and /2/ the SIT against the CM must be combined with chemical treatments or other methods against these species.

An economic cJ.ssesment of the SIT against the CM combined with chemical control of other main pests showed that under Hungarian circumstances such an integrated control the amount of insecticides can be reduced, however, the costs would be by 71 % higher comparing to the usual chemical control /Jermy - Nagy - Balazs 1977/.

Observations on the diapause of codling moth originating from different altitudes in Austria

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Method: Investigations concerning the appearance of different races of codling moth have been continued in the past year.

Diapausing larvae of codling moth from different biotops (Vienna, 350 m, and Ladis, Tyrol, 1300 m above sea level) were stored under field conditions in Vienna and Ladis. The larvae material was set within net cages on tree trunks in Vienna as well as in Ladis and the emerging moth were controlled continously. The appearence of moths both in Ladis and in Vienna was controlled daily as well using pheromone traps and these results were compared with the emergence of moths in the net cages.

Results: These comparative investigations show very clearly, that a significant difference in the length of the diapause exists between the larvae from Ladis and Vienna. The larvae of the Tyrolean population (Ladis, 1300 m) terminated their diapause in Ladis as well as in Vienna much earlier than the larvae of the Viennese population.

lt appears that both populations are clearly differentiated genetically with respect to the length of diapause.

Investigations within the near future should determine to what extent other physiological differences exist, e. g. with respect to a temperature-developing point zero.

The differences in diapausal length represents without doubt an exact adaption of the populations to the respectiv climatic conditions effecting both host plants and pest.

The alpine race of Ladis is compelled to take optimal advantage of a host-plant season that begins late and is relatively short. This is shown by the emergence-curve of the Tyrolean population, which shows a remarkably steep rise, thus indicating that practically all larvae have terminated their diapause by the begin of the sommer season.

That the Viennese population require an individually much langer period of time to terminale diapause, can certainly be interpreted as an adaption to the rather protracted begin of the growing season of the host-plant in the Viennese area.

Number of generations and some aspects of population dynamics of codling moth in different altitudes of Iran

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In Iran apple is grown from almost zero meter (Caspian coast region) to the altitudes of about 2200 meters (Zagross and Alborz mountains). Main apple varieties are local ones but recently some foreign varieties like 'golden delicious' and 'red delicious' are going to occupy big plantations especially in the northern parts of the country (Gorgan and Rezaieh). To have a general idea of codling moth situation in Iran we have had to follow our investigations in many different altitudes. To study the number of generations we used various light traps, sex pheromone traps and corrugated paper bands.

As it is mentioned in tab. 1 in the high regions such as Zonouz and Damavand there are still two generations, but the percentage of 5th instar larvae of the first generation going into pupal stage to form the second generation is low. In Zonouz it was 8, 5 % and 11, 5 % in 1976 and 1977 respectively, but in both years the flight of second generation was as important as that of first generation.

To know the exact percentage of the full-grown larvae of first generation forming the second one and also the rate of full-grown larvae of the second generation forming the third one in different altitudes we need some more years of experiments. The induction of the diapause (tab. 2) starts when the daylength is some 5 minutes more than 14 hours. The critical daylength forcing all larvae entering into diapause is 12, 5 hours (Tehran, Evin 1520 meters above sea level).

During 1977 two chemical treatments were carried out against the first generation of codling moth in all districts included in our research work. The first spray was applied at the sign of the first penetrations and the second one 15 days later. The results are given in tab. 3.

The treatments were not satisfying in the regions with three generations, but successful on the Golab variety which was harvested on 25 of June. This is a early local variety and the damage of codling moth is limited to its first generation and a small part of the second one. In Zonouz where the second generation is relatively important the treatments were not satisfying while in Damavand with a less important second generation the treatments were highly successful.

Tab. 1: Number of generations of codling moth in different altitudes of Iran

district	Gorgan	Karadj	Evin	Esfahan	Zonouz	Damavand Abessard	Damavand Ahmadabad
altitude (m)	150	1320	1520	1590	1710	1850	1900
No. generations,	3	3	3	3	2	2	2

Tab. 2 Beginning of diapause of codling moth in different altitudes of Iran

district		Esfahan	Evin	Karadj	Gorgan	Zonouz
latitude		32° 37'	35° 43'	35° 48'	36° 49'	38° 35'
beginning of diapause	1976	July 23	July 19	July 20	-	July 24
	1977	July 22	July 18	July 17	July 17	July 17
all larvae forced into diapause	1976	Sept. 13	Sept. 11	Sept. 13	-	Aug. 23
	1977	Sept. 14	Sept. 12	Sept. 11	Sept. 9	Aug. 21

Tab. 3 Influence of treatments with chemical insecticides against the first generation of codling moth on infestation (%) in different altitudes of Iran

district	Gorgan	Evin	Esfahan 'golden'	Esfahan 'golab'	Zonouz	Damavand	
% infested apples untreated	98, 5	87,0	92,5	62, 5	80,0	32, 5	28,0
% infested apples treated	88,0	64,0	27,0	5, 2	35,0	1, 2	0,9

Influence of beneficial arthropods on the codling moth in an orchard with green covered and clean cultivated soil

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The degree of fruit damage by codling moth, Laspeyresia pomonella, is influenced by soil management. In a triennial field experiment recently published (Dickter, Z. PflKrankh. Pf1Schutz 84, 321 - 333, 1977) in an apple orchard where no insecticidal sprays were applied, codling moth infestation was always distinctly less on plots with green covered than with clean cultivated soil.

The following observations were started to assess the importance of beneficial arthropods in the population dynamics of codling moth in orchards with different soil management. The studies were carried out in a commercial type apple orchard of the experiment field in Dossenheim. The experimental orchard (ca. 0,7 ha) - containing the 5 cultivars 'James Grieve', 'Golden Delicious', 'Cox Orange', 'Goldparmäne' and 'Jonathan' grafted on rootstock M9 - was divided in 2 parts. One half was kept with green covered the other with clean cultivated soil. In 1975 3 rows with 20 trees each received a chemical spray program with broad spectrum insecticides against codling moth, 3 other rows were sprayed with granulosis virus not harmful to beneficial arthropods, 3 others were kept untreated. In 1977 each group was extended by a 4th row. During the hot summers of 1975 and 1976 4 applications were necessary to control codling moth, whereas in the cool and wet year 1977 only 3 treatments were given. In 1975 and 1976 parathion (E 605®, 0,035%), diazinon (Diazinon 25®, 0,1%) and dimethoat (Rogor®, 0,1%) were used as chemical insecticides, 1977 the broad spectrum insecticide azinphos-methyl + demethon - S - methylsulfon (Gusathion MS®, 0,2%) was applied for the first 2 covers and diazinon for the last one. The granulosis virus was sprayed in a concentration of 10^{11} capsules/liter. Skim milk powder was added as sunlight protectant and wetting agent. Besides

codling moth control all trees were treated once a year with mevinphos (PD 5^{R}, 0,05%) to control rosy apple aphid and the experimental orchard received a standard fungicide program against powdery mildew and apple scab.

Since 1975 in both types of soil management codling moth population was studied by pheromone traps, light traps, corrugated paper band traps and assessment of fruit damage. In this long term project we also started to observe the population density of pupae predators (ground beetles) with pitfall traps. In the last season codling moth eggs were exposed in trees at weekly intervals to evaluate the egg predation.

This report concerns first results from observations on the degree of fruit injury by codling moth in plots with different treatments and soil management.

As shown in the table in 1975 codling moth damage was highest in untreated trees with clean cultivated soil, the difference to green covered-untreated is significant. Virus treatments gave best results (89% reduction of damage) in combination with green covered soil. On the contrary, in the sunny and dry season of 1975, the use of chemical insecticides against codling moth neutralized the damage reducing effect of green covered soil. This phenomenon indicates that the lower larval infestation we found without exception in all experiments and all cultivars since 1973, may be partly due to the beneficial arthropods which probably find here a more suitable microclimate and secondary hosts.

In 1976 there was almost no crop caused by frost in early April. In 1977 the difference in fruit damage between virus-green covered and virus-clean cultivated soil was not significant and the effect of natural enemies over green covered soil - found in 1975 - could not be proved during last season with its unfavorable weather conditions.

Table:
Codling moth infestation (%) on trees of the cultivar 'Golden Delicious', treated with granulosis virus and chemical insecticides over green covered (g) and clean cultivated (c) soil.
Dossenheim, 1975

soil	treatment	total of apples	% infestation	% reduction
	virus	2218	0, 7 a	89, 0
g	insecticides	2962	1 , 8 b	72,8
	untreated	3403	6, 6 C	-
	virus	2690	2, 8 d	74,5
C	insecticides	2672	1, 5 b	86, 1
	untreated	2711	10, 8 e	-

Dossenheim, 1977

soil	treatment	total of apples	% infestation	% reduction
	virus	3249	1, 4 a	62,0
g	insecticides	3040	0, 2 b	93,7
	untreated	2378	3, 7 C	-
	virus	2496	1, 6 a	80,4
C	insecticides	3034	0,4 b	94,7
	untreated	3369	8, 2 d	-

aFigures followed by the same letter do not differ significantly (P>O, 05)

Influence of different microclimate conditions on the codling moth in an orchard with green covered and clean cultivated soil (first results)

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The field experiment was started in April 1977 and carried out in the apple orchard described in the previous report. The following measurements of temperature and humidity were made in both types of soil management: soil temperature, 15 cm deep, between the rows; temperature and humidity, 30 cm above soil surface, between the rows; and temperature and humidity, 2 m high, in the top area of the trees. These measurements were recorded continuously on a chart recorder as well as wind speed and wind direction. In order to correlate microclimate with male moth flight activity timed catches were made in an adjacent orchard with a timing pheromone trap. Since 1976, over both types of soil management, one pheromone trap baited with a Codlemone rubber capsule and one light trap was used.

In the season of 1977 weather conditions were unfavorable and we received a diurnal flight distribution over a wide range. Only 60 % of the moths were caught from 9-10 p. m. (sunset) at light intensities between ca 200 and OLux; 15 % occured from 8-9 p. m. 5 % from 7-8 p. m. After the peak of the captures, 10 % flew from 10-11 p. m. No moth was caught from 11. 00 to 11. 30 p. m., but 10 % flight activity was observed from 11. 30 p. m., until 6 a. m.

The number of moths captured in the light traps was very small, whereas the pheromone trap catches indicated in both years an effect of the soil cover on male moth activity. During the hot and dry summer of 1976 with air temperatures often above 25° c at 9. 30 p. m. ca 60 % of the total number of moths were caught in the trap over clean cultivated soil. The extremly hot summer of 1976 was

followed by a cool and rainy year. In 1977 during and after rainfall at sunset the soil temperature in clean cultivated soil often fell to 2°c below the temperature recorded under grass cover. But there was no difference in temperature at 30 cm and at 2 m. Here the data were close together andin the margin of error of Pt. 100 resistance thermometer elements. On these evenings more moths flew to green covered soil. This was found especially in the cool months of May and June.

Later in the season, during sunny and warm days the surface of the clean cultivated soil dryed andin the evenings with favorable weather conditions the soil temperature in open soil was often 5° C higher than in grass cover. But again no difference in air temperature (2 m) was recorded over both types of soil management. Under such conditions the codling moth was far more attracted to the trap over open soil. During favorable flight conditions with no wind, the relative humidity was highest over grass cover, sometimes with a difference of 30-40 % RF.

These first results may indicate that the codling moth flight is affected by the soil surface thermal radiation, even when temperature at 2 meters over both types of soil management is equal.

We assume that the higher fruit injury in 1977 over clean cultivated soil is mainly due to the higher moth activity in July and August over this part of the study orchard. In the cool and rainy month of June the conditions for the somewhat higher population over grass cover were unfavorable for 0viposition and the survival of 1st instar larvae.

A simulation method of biological-time model for monitoring in codling moth control

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The method is founded on the knowledge of the most important biotic and abiotic factors which mainly affected the codling moth phenology. This is an attempt of reasoning almost exclusively mathematic in order to forecast the codling moth phenology for agricultural monitoring.

The basis data used have their origin in :
1- the observations collected during one at some ten years by the agricultural monitoring station of the French Plant Protection Service (temperature summations necessary for adult emergence and for larval or pupal development, evolution of entering in diapause, egg laying in cages).
2- the bibliographical informations, some of them must be precized.

The mathematical model which has been put on computer is a compartment model tobe improved which use. It may be schematically characterized the following divisions :

- Beginning of the calculation at the first adults catches in sex trap.
- Emergence of the adults according to the temperature summatiuns.
- Protandry (expressed in per cent for the 2 flights).
- Factors governing the oviposition =
    . duration of the preoviposition.
    . upper and lower temperature thresholds.
    . duration and rythm of oviposition.
    . longevity of adults.
- Duration of embryonary development related to the temperatures.
- Duration of larval development from the 1st stadium to the last

according to the temperature summations.

- Duration of the pupation related to the temperature summations.

The temperature and biological data card indexing are accounted by the computer.

The elaboration of spraying advices is based on 3 mains criterions :

- The graph of the eggs hatching given by the computer.
- The levels of codling moth population in apple orchards to be integrated on the basis of sexual trapping.
- The insecticidal persistence and the effect of the rainfall.

For instance in the French south-west region the follows advices are given :

1st generation

1st spraying at 5 % of eggs hatching in spring generation.

2nd spraying according to the insecticidal persistence and the rainfall.

2nd generation

1st spraying at beginning egg hatch.

2nd spraying according to the insecticidal persistence and the rainfall.

3rd spraying according to the injuries when the maximum egg hatch has passed away.

This model used in 1977 has given satisfactory results. The provided forecastings on the codling moth phenology are closely related to the really observed evolution.

An optical insect activity recorder developed in Hungary to measure the activity levels of different codling moth populations

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Within the framework of the IAEA-sponsored research project "Developing methods of measuring the competitiveness of sterilized laboratory-reared insects" in the period 1974-1977 several methods and instruments were used to measure insect activity. The instruments constructed on the principle of sound production /the one of M.Melis "Insectophone" and an other of A. Dobrovolszky "Acoustical Insect Activity Recorder"/ worked well under sound-proof conditions, in the open field however they were unable to compensate the background noises.

So we had to try other principles, which could be used under field conditions and constructed an instrument based on interception of light barriers.

Description of the Optical Insect Activity Recorder /OIAR/

The moths are placed into a plexiglass cage which fits into a space of 10x10x20 cm in the middle portion of the instrument. The light sources - producing very thin, parallel light beams - are arranged into rows along the lines of the longitudinal cage walls and more sparsely in the inner portion. Between the cage wall and the light sources also a translucent, red plastic plate is attached to produce red light.

On the opposite side of the cage are placed the corresponding sensor diodes in thin bore holes of a 10 mm aluminium plate. The photodiodes sense only the light emitted from the opposite light source and are not disturbed by other light /e.g. daylight/. The electronic units: pre-amplifiers, amplifier, summarizer are built into the same frame bearing the light sources and sensors. The amplifier ranges and time constants can be altered by orders of magnitude.

Results got with the OIAR

The moth populations /always 3 males and 3 females/ studied in the OIAR seemed to accomodate readily to the conditions of the cage and the aktograms showed clearly the well known diurnal rhytm of codling moths, i.e. the onset of activity in the late afternoon, then a high peak after sunset and a lower peak at dawn. The studies were carried out at room temperature and under natural daylight conditions /September 1977/.

Very marked differences were noted between the activity levels, mating propensity, fertility and longevity of the semi-wild moths and the ones originating from laboratory rearing /Wädenswil strain/. The semi-wild moths /collected as mature larvae in orchards near Budapest and kept until emergence in the laboratory/ showed very high activity in the first 24 hours, with sudden bursts of flight; their activity however decreased considerably on the 2^{nd} and 3^{rd} day. The 3 females laid only 23 eggs in total and only one female contained a spermatophore at the end of the experiment. The moths began to die out on the 4^{th} day and none lived longer than 8 days. The reared moths showed much more uniform activity patterns throughout the 3-day experimental periods, with high activity even on the 3^{rd} day; the egg number laid by the different groups /always 3 males and 3 females/ varied between 135 and 147 eggs, all females contained spermatophores /dissected after their death/ and they showed a longevity of 8-12 days.

The instrument described showed a temperature stability and proved to be insensitive to background effects /e.g. changes in daylight intensity, vibrations, noises etc./ which make it capable to work under field conditions. The adjustable time constants of the integrated circuits make possible to record very slight movements of single moths, so besides studying activity levels, the OIAR could be used in pheromone studies as well.

Results of the works on reproducing potential of carpocapsa (Laspeyresia pomonella L.) in the years 1976 & 1977

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This work, the first part of which was introduced in Vienna (Meeting on control of codling moth by the sterile release method 1975), summarizes the results of the experiences carried out in the last two years. This study, programmed for five years, will be completed with the data corresponding to 1978.

The main objective pursued is the approximate knowledge of the codling moth' s biotic potential in the Ebro Valley and its variation according to the different generations of this insect; though it will be completed with studies concerning the laying natural surfaces chosen by the females when laying, as well as with the existing relations between matings and laying and quality and quantity of the spermatophores contained in the "bursa copulatrix" of the fertilized females of this species.

To go on with this experience, the same apple orchard (mixture of Golden and Starking) continued being used. This orchard was not treated during trials-time to avoid possible interferences provoked by phytosanitary products.

The material used as well as the methodology is the same as described in Vienna (1975).

In table number 1 there are the results corresponding to the studied pairs, sexually mated and having laid, as well as the number of eggs, extreme values and averages.

Table 1

Nr. of pairs	1st flight (1976)	2nd flight (1976)	1st flight (1977)	2nd flight (1977)
Total studied	50	43	43	47
Sexually mated	35	36	37	36
That fulfilled the laying	30	30	30	30
Nr. of eggs				
Total for the 30 pairs	1. 389	2.844	1. 893	2.560
Average per fertilized female	46,3	94,8	63,1	85,33
Extreme values	1-160	8-240	3-167	9-194

Same more data have been obtained and will be analized for 1978 which is the time foreseen for the conclusion of this research program.

Influence of climatic conditions on oviposition of codling moth

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Experiments on the oviposition of codling moths were carried out in the laboratory and outdoors. In each experiment 70 pairs of 1-2 days old adults of our laboratory strain were kept for 3 days. The insects were held in a cage (25x25xl0 cm) whose sides (except the underside) were covered with gauze. The cage was fixed with its opening close to a regularly moving wax paper-band on which females were able to oviposit. A modified chart drive system moved the wax paper with a speed of 1 cm/min. With this system it was possible to register the time eggs were laid with an accuracy of : 5 minutes.

Conditions in the laboratory were normally as follows: temperature: 24° C; photophase: 18 hours (4 - 22 h); light intensity in the cage: 2500 - 3000 lux; air humidity: 70 - 80%. In some experiments temperature, humidity or light conditions (decreasing light intensity before the dark phase) were altered.

In outdoor experiments (July - August 1977) the cages were placed on tables 1, 5 m over the ground in an apple orchard in the shade of the trees.

Results of laboratory experiments

Under standard conditions moths started to lay some eggs 3 - 4 hours before the dark phase. After the begin of the dark phase oviposition increased, reached a peak lasting for about 1 hour, decreased to a low level and continued for the rest of the night. The begin of the light phase was marked by a second peak lasting for about 30 minutes; then oviposition dropped to a few eggs and stopped after about 2 hours.

When air humidity was raised from 60 to 85%, 4 hours before the dark phase,

oviposition started immediately, but the peak followed only after the begin of the dark phase. When humidity was raised 8 hours before the dark phase, oviposition was only slightly influenced.

In experiments where temperature was reduced from 24 to 2o^{o}c, 4 hours resp. 2 hours before the dark phase, oviposition was induced so strongly that the dark phase did not bring any further increase.

When the change from light to dark phase was bridged over by a period of gradually decreasing light intensity (2500 - 0 lux in 50 minutes) oviposition was increasingly stimulated.

Results of outdoor experiments

When experiments were carried out on clear days the sun disappeared locally behind an adjacent building 1 hour before the astronomical sunset, between 19. 00 and 19.15 hours. On such days oviposition started with the disappearance of the sun and remained important for some hours, usually until 22. 00 hours. Some eggs were laid during the rest of the night. In the morning oviposition increased again between 6. 00 and 6. 30 probably due to the sun reaching at this moment the orchard.

On days with covered sky females oviposited already during the day, sometimes already in the morning.

A contribution to the knowledge of Tortricidae as occurring in apple orchards in the Ebro Valley

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This work, which is a sort of inventory of the present or more common tortrix moths in the fruit farms of the Ebro Valley, is a result of the need to know the species which make up the insect communities of apple orchards, in order to be able to safely introduce the techniques of integrated control in such crop. To give an example we can mention the farm "Raymat" (Lerida), where it is not sufficient to control the codling moth, which remains at population levels harmless to the crop by means of one or two applications of Zolone {Phosalone) on the second generation. In fact, "Capua" (A.) may cause serious damage, and its importance may be equal to that of the codling moth itself.

In this advanced account of the results obtained so far, we have tentatively listed, by species, the tortrix moths captured by means of light and food traps and sex traps based on synthetic pheromones. The use of a series of "Tetradecenyl-acetate" pheromones has been possible thanks to the INRA-INIA cooperation.

Three differentiated areas devoted to pome growing were selected for capturing purposes, namely Milagro (Navarra), INIA-Aula Dei (Zaragoza) an Raymat (Lerida). Although they are all located in the Ebro Valley, they have micro-climates and ecosystems which are sufficiently differentiated.

As one might logically expect, some of the species captured are apple pests and others parasitize other cultivated or spontaneous plants. It should be emphasized once more that these are tentative results corresponding to the species that had a high capture percentage.

Among the species captured, the most important ones in frequency and number are the following:

FARM AULA DEI: . rosanus L., A. xylosteanus L., - crataeganus Hb., A. podanus Scop., .!:. pomonella L., !'. heparana Den & Schiff, !!. nubiferana Haw, . ocellana F., G. minutana Hbn., G. funebrana Tr., C. incertana Tr., Cnephasia sp., Pammene sp., Epiblema sp., Aethes sp. and C. posterana.

MILAGRO (NAVARRA): !'.. pomonella L., !'. l cheanum L., !'. heparana Den & Schiff, f. incertana Tr., Cnephasia sp., f. sedana, !!· buoliana Den & Schiff, R. fractifasciana Haw, T. viridana L., Pammene sp. and - posterana.

RAYMAT (LERIDA): !:· pomonella L., - L., C. incertana Tr., Pammene sp., C. posterana and E,. purana.

lt should be pointed out that there are still some gummed trays whose specimens have not been identified yet. Nevertheless, we do not believe this will alter the results in any significant degree.

Pheromone, disorientation technique

Monitoring codling moth (Laspeyresia pomonella L.) with pheromone traps

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In commercial apple orchards in England, although codling moth is potentially a serious direct pest of the fruit, there is only one generation in most years and one or two sprays of a suitable insecticide have provided good control. In young dessert apple orchards, which afford few protected sites for overwintering larvae, damage to the fruit has generally been maintained below the economic injury level of 1%.

In the exceptionally extended and hot summer of 1976, the numbers of the pest and damage potential increased considerably. The main factors contributing to this were probably (1) reduced predation of the hibernating larvae by birds especially tits (Parus spp.) which had poor breeding seasons in 1975 and 1976, and (2) increased fecundity of first generation female moths at the higher temperatures prevailing. There was a marked second generation flight in late July/August.

Sticky traps baited with the synthetic sex attractant Codlemone (trans-8, trans-10-dodecadien-1-01) have provided a more sensitive, specific and convenient sampling tool than light or bait traps. In collaborative work with the advisory service (A.D.A.S.) the commercially-available 'Pherecon 1C' traps have been used for monitoring and for decisions on spray strategy and timing. Until 1974, spray warnings (first spray) issued by ADAS were based on catches in light traps; the first repeated catches were assumed to indicate the onset of mating and oviposition and an arbitrary 10-14 days were allowed for development of the eggs to hatching. At East Malling (1972-1974) moths were caught in pheromone traps 2-3 weeks earlier than in a light trap, but each year there was a substantial

rise or peak in numbers at the same time as the first catches were obtained in the light trap, when the heat sum was 150-200 day ^{0}e. This peak has been used by A.D.A.S. as a basis for area spray warnings, pooling data from several traps. In sprayed orchards with low moth densities the catches in light traps were often too small to provide a useful guide.

At East Malling, for the five years 1972-76, the accumulated pheromone trap catch, as percentages of the totals for the first generation flight, was closely related to the temperature sum above the developmental threshold of 10°e. The catch began at around 100 day ^{0}e, was 50% at 200-250 day ^{0}e and terminated at 500-600 day ^{0}e.

For orchards at East Malling, there was good correlation between the cumulative numbers trapped early in the season (to the date when 200 day ^{0}e had accumulated) and the total catch for the first generation. Hence, decisions on the need for one or two sprays or none at all could be based on the size of early-season catches. Throughout a district or region, however, the proportion of the catch trapped up to 200 day ^{0}e varied from 0 to 60% and hence a treatment threshold based on cumulative catch was impracticable.

Many factors influence the numbers of moths caught in pheromone traps and also the relationship between trap catches and subsequent fruit damage. In a range of unsprayed plots in 1975 and 1976, correlation between the total seasonal catch and percentage fruit damage was poor ($r = 0.6$); but when total catch was below 40 the damage very rarely exceeded 1%. The effect of omitting sprays in orchards where catches remain below a threshold of five moths per trap per week is being widely tested.

Pheromone traps provide early warning of male flight activity, but the information is of little value for timing sprays unless it can be related to the seasonal phenology of the pest. Monitoring for first penetrations of the fruit by larvae is feasible but labour-intensive as a routine method. There is as yet insufficient information to test whether a day-degree relationship between trap catches and first larval

penetrations can be established. Moreover, between individual orchards within a district, trap records show a variation of up to four weeks in the date when catches first exceed the threshold and build up. This throws doubt on the value of an area forecast for spray timing. In the absence of the necessary phenological data on oviposition and hatching of the eggs, a rough guide for timing in individual orchards will be tested in 1977: when the threshold of five moths per trap per week has been exceeded for two weeks, the first spray will be applied after a further seven days. A second spray will be applied two to three weeks later if catches continue above the threshold, and the control achieved will be assessed.

There must be a caveat to the use of such a rule, namely that weather conditions during the 'reference weeks' must have been suitable for mating and oviposition to occur.

Information from the Agricultural Development and Advisory Service and Long Ashton Research Station is gratefully acknowledged.

Analysing the influence of temperature on pheromone trap catches of codling moth (eydia pomonella L.)

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lt is well known that the number of male codling moths caught daily or weekly in a pheromone trap is influenced by temperature. If only because of the rise and fall of emergence curves, the number of moths caught does not show a steady relationship with temperature throughout the season: graphs of catches v. temperature over many weeks always have a wide scatter of points. Over a short period a fairly steady relationship may be maintained.

In 1974 the mean daily catch from three Zoecon pheromone traps in different orchards at Long Ashton were compared with daily maximum temperatures. I selected three periods in which the catches seemed to respond fairly uniformly to differences in temperature. The relationship to temperature was, however, different for the three periods: the multiplicative correction factors were : 1. 34, 1. 62 and 2. 06 per 1°e. The differences do not seem to depend on the mean rates of catch nor on the means of the daily maximum temperatures in the periods concerned; they seem to arise from changes in the responses of the moths to temperature or to the attractant traps.

Because it is more usual to record moth catches half-weekly, I sorted the daily catches into alternating 3-day and 4-day groups. These half-weekly catches (in logarithms) were graphed against temperature (means of the daily maxima in each 3-day or 4-day period). The points for successive periods were serially numbered and joined by lines. In spite of the expected scatter of points, an underlying relationship with temperature could be seen, approximating to a slope equivalent to a factor of 1 1. 52 per 1°e. This mean slope provided a standard for comparing the trends of catches from half-week to half-week in relation to temperature. If we accept daily maximum temperature as an index of the relevant weather conditions, deviations from the general relationship with temperature

can be attributed to changes in the abundance of moths within range of the trap. Only large deviations can be so used, because of the above-mentioned variation in the relationship with temperature. The deviations indicate increases or decreases in abundance, whilst approximations to the mean slope imply a temporarily steady population responding to differences in temperature.

Examination of the catch curves of several years at Long Ashton leads to the conclusion that it is not possible, on the basis of temperature alone, to convert the typical jagged catch curves into smooth curves showing only changes in abundance. However, the above type of analysis takes us part of the way towards using pheromone trap catches as an index of abundance.

Relationships between pheromone trap catches of codling moths, damage to fruit, and seasonal heat sums

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Using data for 1975, 1976 and 1977, I compared (1) annual catches of codling moths in Zoecon traps in various dessert apple orchards at Long Ashton (not sprayed, in the years concerned, with insecticides affecting codling moth), (2) number or percentage of fruits with codling strikes into the core, and (3) the warmth of the summer as measured by the heat sum (total of day-degrees of daily mean temperatures above the codling moth threshold of 10° c).

Trap catches were not clearly related to the heat sums for the same years, but (following a suggestion by Dr. P.-J. Charmillot) they were found to be fairly closely related to the heat sum of the previous year, less well to the number of strikes per tree (and poorly to per cent of fruit struck) in the previous year. It seems plausible that the catch should depend mainly on the population of over-wintering larvae, which would depend on the number of deep strikes the previous year, and therefore al&o on the favourableness of the temperature in the previous year. However, in the old cider apple orchards where birds reduced the over-wintering larvae to very low numbers each winter (Solomon et al. 1977, J. Appl. Ecol. 13, 341-52), the above relationship might no longer hold.

Percentage strike was related only roughly to total trap catch, but more closely to the heat sum for the same season. Nevertheless, in predicting or explaining the amount of damage, one would take trap catches into account, as giving a clue to the size of the population available to react to the temperature conditions.

The ratio, percent of apples damaged/number of moths trapped, was considerably lower at Long Ashton than has been found in some other regions e. g. (in order of increasing magnitude) Madsen et al. (1974, Phytophylactica . 185-8) in South

Africa, Riedl and Croft (1974, Canad. Entomol. !9_, 525-37) in Michigan, Wong et al. (1971, J. Econ. Entom. 64, 1410-1) in Wisconsin, and Paradis and Comeau (1972, Ann. Soc. Ent. Queb. !_?, 7-19) in Quebec.

This is an interim report on analyses still in progress.

Codling moth trapping with the synthetic pheromone: Risk forecasting and supervised control in apple orchards

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The trapping of codling moth (Laspeyresia pomonella L.) adult males by using the synthetic sexual pheromone 8 E, 10 E, ol - 1 dodecadien has rapidly demonstrated a remarkable efficiency which fascinate the fruit growers. The factors influencing the codling moth catches in the sexual traps are numerous. They have been classified and discussed.

Taking in mind a practical utilization the trapping conditions have been defined. One trap is tobe set for one homogenous cultural unit of 1 to 4 ha, and 1 trap/ 4 ha for larger areas. It is in such conditions and for a relatively closed population that the possibilities of utilizing the trapping results will be examined in order to forecast the codling moth risk of attack for a supervised control.

1 - The "negative forecasting" at the beginning and at the end of a flight.

The lack of catches signifies a future absence of risk (negative forecast) and the case of low catches is assimilated, from the point of view of the practical consequences, to a lack of catches (Audemard et Milaire, 1973/1975). The threshold of flight intensification has been empirically fixed upon 3 catches/1 ha/ 1 week (3 successive records). The reduction threshold is therefore of 2 catches. These thresholds appeared to be quite valid during the last years for a practical utilization in apple orchard at the beginning and at the end of the flight. In such case, they allow either to postpone the first, and the most of the time, to suppress the last treatement.

2 - Punctual forecast all along the flight duration.

This method is based on the utilization of the catch thresholds and have been

study the four past years. The thresholds have been fixed for 1 pherotrap on 1, 2, 3, 4 hectares at respectively 3, 4, 5, 6 catches weekly. The variation in the trap collections and the 2-2-3 days spacing of the collections imposes and important margin of safety. In French-speaking Switzerland the threshold for 1 ha is of 10 catches/week (Baggiolini and al., 1977); the difference could be explained by the moth arrival from outside and the use of the I.O.B.C. trap.

The beginning of each risk period is established, once the threshold has been reached, according to the crepuscular temperatures, necessary for the activities of moth mating and egg laying, there according to the embryonic length of development, taking into account the corrected mean temperatures. About the end of the risk, the female length of life, after the disappearing of the males, and the duration of the embryonic development which is tobe added up, may be translated in a fixed number of days for the Rhone valley. In the figure 1, 3 methods of control depending on 3 forecasting systemare presented. The punctual forecast allows to sensibly reduce the number of spraying. It is less marked than in the case of a supervised control.

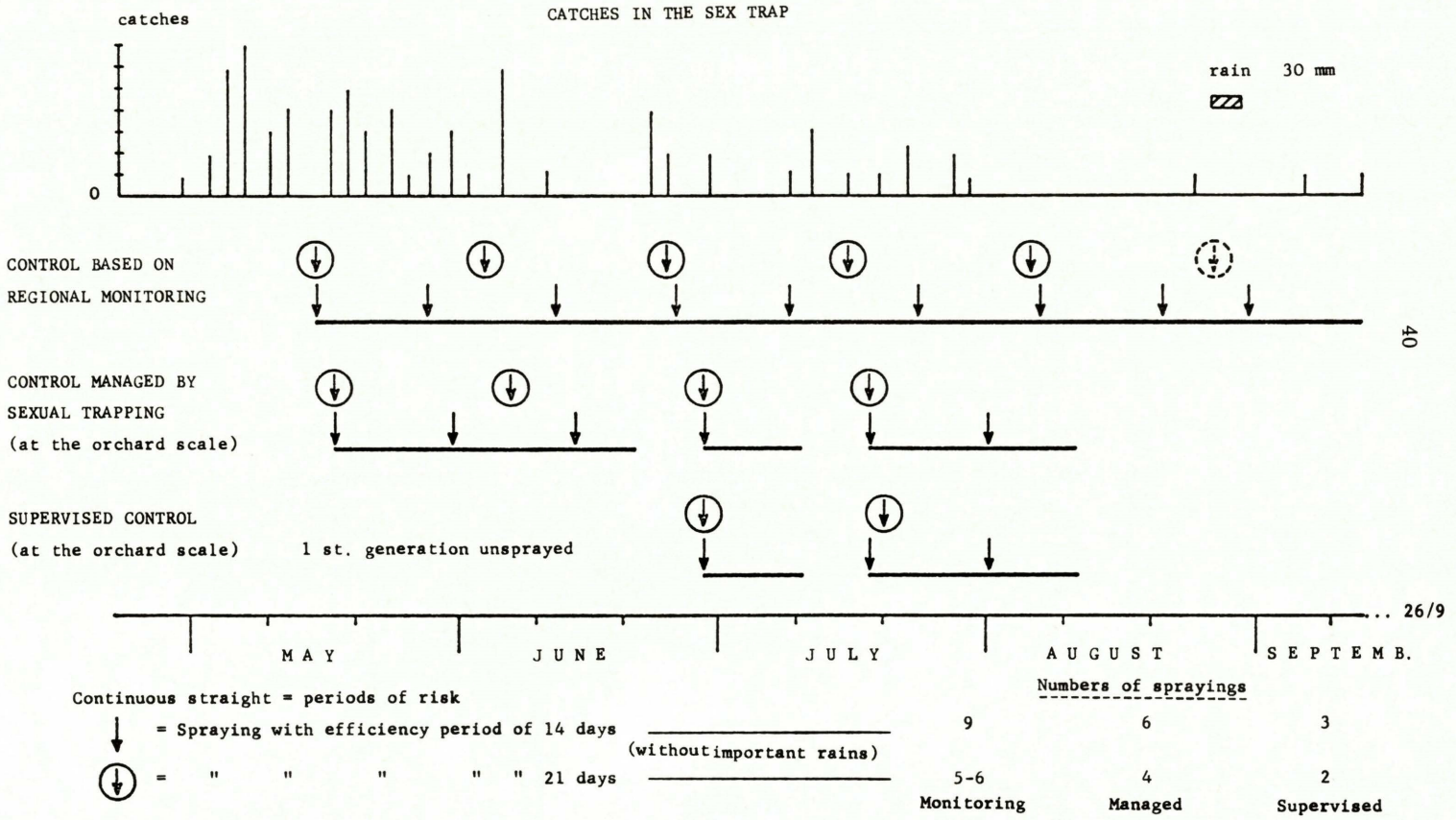
3 - Forecasting at the one generation scale.

Charmillot and al. (1975) have shown up some relations existing between the level of the cumulated catches up to the hatching time of the first codling moth eggs, and the chemical control intensity necessary against the first generation. From there, they have established the catch thresholds for 1 ha allowing to experiment a modulation of the chemical control in French speaking Switzerland: 0 to 20 catches = no spraying; 21 to 50 = 1 spraying; more than 50 = 2 sprayings. This way is interesting and deserves tobe more largely explored by searching the correlation between (a) the cumulated catches just until a chosen point of the graph and (b) the total catches, used to estimate the adult population.

Figure 1

SEXUAL TRAPPING OF CODLING MOTH AND MANAGEMENT OF CHEMICAL CONTROL BY THE USE OF A CATCH THRESHOLD

EXAMPLE OF USE (AVIGNON ; golden, 12 years ; 1 hectare ; 1976)



Study of the efficiency of traps baited with sexual attractant for the codling moth (Laspeyresia pomonella L.): Results of three years experimentation

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The efficiency of sex trap is studied from 1975 to 1977 in 12 apple-orchards of different sizes varying from 0,3 to 10,5 ha. A single trap is placed in the center of each orchard. Male diapausing larvae of codling moth tagged by internal coloration and male larvae of a mutant strain with a uniform grey coloration of the wings are laid in artificial shelters distributed at regular intervals throughout the trial orchards. The emergence of moths is thus synchronized with that of the natural population. The accurate number of males which have left the shelters is determined by counting the exuviae.

Results: The relation between the rate of capture of a single trap placed in the center and the size of the orchard is rather bad since the correlation coefficient is 0,239. For an increase of 1 ha of the orchard area, the efficiency of the trap decreases of only 1,17 %. On the other hand, the space of time between emergence and capture increases strongly in the larger orchards. During the three years experimentation, a single trap catches in average 44,9 : 7,1 % of the emerging males. In 1976, the mean efficiency of the trap is only 3,4 % higher than that of 1977, in spite of extreme meteorological conditions. During cold periods, the delay between emergence and capture is more important, but lifetime of the moths increases considerably, so that the final rate of capture is practically not affected.

Control of the codling moth through mating disruption with the sex pheromone

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In research conducted in 1973, 1974, and 1975 in Yakima, Washington, communication between male and female codling moths, Laspeyresia pomonella (L.), was disrupted by exposure to excess concentrations of the pheromone, trans-8, trans-10-dodecadien-1-01, applied as a spray to the orchard. The result was reduced mating. The pheromone was formulated in microcapsules (NCR) and applied by helicopter. At a rate ol 7, 4 gram per hectare, an 87% or greater reduction in response of males to pheromone-baited traps was observed for 7 days posttreatment. In another test, there was a 95% or better reduction in number of males trapped for 7 days after the one application, but only a 64% reduction the 8th day. A second application was made at this time. No males responded the following 6 days. When the fruit was harvested infestation was reduced 93% compared with the untreated control.

In 1976, Conre{R)chopped fibers were applied to O, 3 or 0, 4-hectare blocks of apples or pears with a special dispenser mounted on a helicopter. Initially, two pheromone emission rates, approximately 62 mg and 310 mg per hectare per day, were evaluated on the basis of the response of male codling moths to virgin female-baited traps. At the lower rate, there was a reduction of 82% or more in the response of males to traps in the treated plots for 16 days posttreatment. At the higher rate, the reduction was 87% or more for 41 days posttreatment, and the reduction never fell below 80% during the 57 days of the test.

In a subsequent test conducted in 1976, chopped fibers were applied by helicopter to 0, 4-hectare plots of apples. The emission rate was 310 mg per hectare per day. Evaluation was again based on the response of males to virgin female-baited traps. During the 26-day test, only two males were trapped in the pheromone-treated plots; 85 males were trapped in the untreated plots, for a total reduction in response of males of 97, 6%.

As a result of the 1976 successes, a test for season-long control of the codling moth on pears was conducted in 1977 in the Medford, Oregon area. The Conrel chopped fiber system containing the sex pheromone was applied by helicopter to 0,4-hectare blocks of pears containing trees of Bartlett and Bosc varieties. The formulation was applied to yield a pheromone emission rate of 310 mg per hectare per day. Evaluation was based on the response of male moths to pheromone or female-baited traps and on the infestation in the fruit prior to and at harvest. Three applications of the pheromone were made during the season, on April 21, May 25, and July 26.

In the two treated plots, control was equal to that obtained in a plot treated commercially with chemical insecticides. The rate of infestation at harvest of the earlier maturing Bartletts in the treated plots was 0,05%, that of the later maturing Boscs was 0,4%. In untreated (no insecticides and no pheromone) plots in the area, the infestation rate at harvest was 4-9%.

In my opinion, use of the codling moth sex pheromone to disrupt mating shows great promise as a method of control. Efforts will be continued to find more desirable formulations to determine optimum timing of application and new techniques and to investigate the effects of the method on existing or potential biological control mechanisms.

The research reported here was conducted in cooperation with D. O. Hathaway and L.M. McDonough, ARS-USDA, Yakima, Washington; T.P. McGovern and M. Beroza, ARS-USDA, Beltsville, Maryland; and P.E. Westigard, Oregon State University, Medford, Oregon.

Male confusion method for controlling codling moth: Trials effected in 1976 and 1977 with synthetic sex pheromone in commercial apple orchards

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The permanent diffusion of the codling moth synthetic sex pheromone (8 E, 10 E ol, 1 dodecadien) in the orchard is able to provoke a confusion action between the males of this species. This should turn out in an important decrease of codling moth injuries on fruits (Audemard and al., 1976).

The quantity of pheromone needed for the present tests has been manufactured by the Laboratory of C. Descoins according to an original synthetic processus (Samain and al., 1977). The dispenser is composed of a rubber tubule (3 mm outside, 2 mm inside diameter) filled with synthetic sexual pheromone and plugged at both ends. In most of the trials a small board gave the tubule some protection against the sun and the rain. This dispenser was suspended inside the crown of the tree. The quantity of pheromone diffused is evaluated by periodical weighging of check dispensers (filled up vs. not filled). It must be acknowledged that this is not a method of high precision. The checking of the results is realized through sexual trapping of the adults, visual checking of the attacked fruits, trapping of mature larvae and of the pupae.

Four trials have been realized in 1976 and 1977 on 3 different apple orchards. Their characteristics and the results are summarized in the table. The population dynamic must be considered for the generation controlled. In the 1976 trials, which aimed both generations, a dispenser was suspended on every border tree and on one tree out of two in the remainder of the orchard. Four series of dispensers have been set up. No catch of moths has been observed in the orchard. The traps set in the surrounding hedges have catched 7 moths in the period connected with the attacks of the young larvae. About 0, 5 per cent of the fruit where attacked

at the harvest. This excellent result is confirmed by the evolution of population which dropped to 1/3 and so brought down under the tolerance threshold (Audemard and al., 1977).

In the A 1 trial of 1977 the suppression of the protecting small board has caused an important lowering of the efficiency on the population dynamic, (only 48 % on the first and 70 % on the second generation) mostly attribuable to the frequent rainfalls which have blocked the diffusion. The first generation only was controlled in the A 3 trial. The used dosage is considerably higher than those of the A 1 trial. The population of the first generation pupae being situated just at the tolerance limit controlling the second generation has not been necessary. Besides the fruit attack at the harvest does not reach 2 per cent. The efficiency on the first generation population is of 90 per cent. The possibility to ensure a satisfactory regulation of the codling moth population through a control by males confusion against one of the two annual generations is so demonstrated. This is very important for the practical application of the method.

In the D 1 trial a phosalone spraying has been necessary on the 23rd of August for maintaining the attack rate at harvest time to the limit authorized by the fruit grower. This was due to every rapid and unforeseen diffusion of the pheromone. The replacement of the dispensers, which was not initially expected, has been effected leaving the orchard unprotected during a week in August. The consequences have been awfully more serious than when a lack occurs during a chemical control protection. The dispenser used should be improved for the further development of the trials.

Table : RESULTS OF THE 1976 AND 1977 TRIALS OF CODLING MOTH CONTROL BY MALE CONFUSION METHOD

Refering of orchards Year (1)	Generation controlled	Amount of : pheromone in grammes hectare setted diffused total / per day	Per cent unmarketable fruits by codling moth injuries at harvest time	Dynamic of codling moth population (3)								Effects in per cent in relation-ship with the generation		
				(2)	Hibernating larvae previous test	Generation					Hibernating larvae after test			
						1st Larvae + Pupae	pupae	2nd Larvae + Pupae	pupae	3rd larvae		1st	2nd	3rd
A 1 1976	1 + 2 + 3	132 84 / 0.55	0.56	a b	89	29 360	28	25 647	21	6 89	31	92	96	93
B 1 1976	0	orchard without control	up to 80		89	360	358	3690	339	252				
A 1 1976	1 + 2	158 84 / 0.31	0.50	a b	28	93 179	21	51 172		0 0	123	48	70	
A 3 1977	1	140 60 / 0.71	1.80	a b	60	34 383	12	98		0 0	120	91		
D 1 1977	2	126 102 / 2.55	5	a b	unknown	59	43	49 351		0 0	65			86 (4)
B 1 1977	0	orchard without control	35 about		89	568	323	1112		0				

(1) orchard area in hectare A 1 = 0.75; A 3 = 1; D 1 = 3; B 1 = 0.75.
(2) a = real population; b = population expected without control.
(3) For 40 trees observed A 1; A 3; B 1; 80 trees observed D 1.
(4) With a phosalone spraying at the 23 of August.

Reduction of codling moth catches (Laspeyresia pomonella L.) by inhibition of males by diffusion of synthetic sex attractant in an orchard

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In a 10,6 ha apple orchard, males of codling moth (Laspeyresia pomonella L.) are released in 8 repetitions during the 1976 season in 6 plots. In 4 of these plots, evaporators developed for this purpose ensure different diffusion levels of trans-8-trans-10-dodecadien-1-ol, the sex attractant of codling moth. The density of evaporators varies between 1 piece for 12,5 m^2 and 1 for 127 m^2 The 2 other plots without evaporators are used as checks. Traps baited with virgin ♀ or with synthetic attractant allows to calculate the inhibition of capture related to the dose of attractant. The evaporation rates obtained in this trial varies between 0,14 and 50,4 mg/ha.h and the inhibition fluctuates between 60 % to 100 %. In the ♀ baited traps, the inhibition of capture is almost total from 1 mg/ha.h. The diffusion of attractant disturbs as much the wild males than those reared in the laboratory.

Codling moth control by disorientation method: 2 years results

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In 1976 a desorientation experiment is carried on in a 0, 7 ha apple plot at Allaman with a high codling moth population. An average of 19 mg per ha and hour is evaporated by placing rubber tubes filled with Codlemone in the trees. Catches with synthetic attractant and female baited traps are considerably inhibited. Fruit attack at harvest is 3 %, largely below expectation. However, the number of overwintering larvae is higher than before, especially along the edge of the plot.

In 1977 similar desorientation experiments are carried on in Allaman (0, 7 ha), Signy (3, 1 ha) and in a untreated orchard in Changins (0, 1 ha) with a huge population. Additional evaporators are placed all around the plots in order to guarantee an even protection of the edges. While the temperature is colder than in the previous year, the average evaporation rate of Codlemone is smaller and sometimes probably too low. The evaporator fence around the orchards seems to play an important part. The population of codling moths decreases perceptibly in 1977 in two orchards and increases slightly in the third one. Table 1 summaries the results of the two years experiment.

Table 1 : Disorientation method against codling moth

			Allaman	Signy	Changins
	orchard area (ha)		0,7	3,1	0,1
1975	Diapausing larvae per corrugated band		5,72	-	-
	% fruit damage at harvest		2,26	-	-
1976	Average evaporation of Codlemone in the orchard	mg/ha.hour	19,0	-	-
	Diapausing larvae per corrugated band		11,6	1,13	120,2
	% fruit damage at harvest		3,15	2,26	60
1977	Average evaporation of Codlemone in the orchard	mg/ha.hour	6,7	3,7	6,5
	Total diffusion of Codlemone around the orchard	g/season	16,0	14,4	1,6
	Diapausing larvae per corrugated band		3,95	1,50	25,1
	% fruit damage at harvest		1,18	0,76	13,29

Inhibition of moth catch by evaporating the pheromone of the codling moth

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The disorientation of codling moth males by evaporation of the sex pheromone (E 8, E 10-dodecadien-1-ol) from three formulations was studied in 1977. Two experiments were carried out with released males in a 1 ha apple orchard with trees about 4 metres high and with a low native population. In the first experiment each treatment was tested in two replications of 3 x 3 trees, in the second experiment in one block of 7 x 7 trees. Plots were separated by 3 - 8 rows of untreated trees.

The following pheromone formulations each at 100 mg attractant (kindly furnished by Dr. C. Descoins, F - 78470 St. Rémy les Chevreuse) per tree (45 g/ha) were compared:

1. Rubber tubes : Two tubes, 20 mm long and 2,3 mm in diameter, containing 50 mg pheromone (Charmillot, in preparation), each covered with a plastic drinking cup for protection from rain were placed at heights of 2 and 4 metres.
2. CONREL-dispensers : Dispensers with 25 hollow plastic fibres, each 10 mm long and 0,03 mm in diameter, containing a total of 4 mg of the attractant (BHT added as antioxidant). Twenty-five dispensers were uniformly distributed over each tree.
3. NCR-microcapsules : Gelatin capsules at 50-250 microns diameter containing 2% pheromone (5% di-tert-pentyl hydroquinone added as antioxydant) in xylene. The slurry (pheromone content 3,3 mg per cm^3) was diluted 3 times with water and sprayed with a knapsack sprayer. Sampling of the leaves demonstrated that the distribution of the microcapsules was quite uniform.

To monitor the effect of the pheromone evaporation, traps were placed in the central tree of each plot. Pheromone-baited traps were hung at heights of 1,5, 2,5 and 3,5 m, female-baited traps at 1,7 and 3,5 m. 500 reared and marked

male m,oths were released in the orchard onc♦ or twice a week.

Results

Table 1 : Moth catches in untreated and treated plots

	first test (3 x 3 trees)		second test (7 x 7 trees)		
	1st week	2nd week	1st week	2nd week	3rd-6th week
untreated	80	51	126	122	463
rubber tubes	14	7	9	7	4
hollow fibres	12	6	13	4	9
microcapsules	20	52	9	69	163

Table 2 : Moth catches in traps placed at different heights (sums of both tests)

		untreated	ruqber tubes	hollow fibres	micro-capsules
Pheromone-baited traps	at 3, 5 m	340	27	34	137
	at 2, 5 m	159	10	8	74
	at 1, 5 m	39	1	0	15
Female-baited traps	at 3, 5 m	274	3	2	85
	at 1, 7 m	30	0	0	2

Moth catch was strongly reduced by all three pheromone treatments (Table 1). The effect of microcapsules dropped after one week. In the plots with rubber tubes or with hollow fibres moth catch was strongly inhibited for the full length of each experiment (2 and 6 weeks respectively). The effects were more pronounced in the second test with larger plot size. It is interesting that two rubber tubes per tree had about the same effect as 25 hollow fibre dispensers.

Traps placed near the top of the trees {in untreated and treated plots) caught substantially more moths than traps placed at lower levels {Table 2). This indicates that good coverage of the upper parts of the trees with the attractant may be important for successful disruption.

Sterile insect technique

Genetic control of codling moth (Laspeyresia pomonella L.) : Releases of substerile moths

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Males of codling moth irradiated at the substerilizing dose of 10 krads were released in a small orchard of the Federal Research Station of Changins during the first moth flight of 1975. In comparison of the previous year the population decreased by more than 50 %. The larvae progeny captured in corrugated bands were kept until the emergence of the adults, which were then crossed individually with moths from the rearings. It could be shown that two thirds of the F_1 0^{σ} of the trial orchard and about half of the F_1 0_{+} had a high level of sterility. Genetic control can therefore be obtained for two subsequent generations by a single release of substerile males.

A semicommercial program of codling moth control in Brit!f8-h Columbia by sterile insect release

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The technical feasibility of controlling the codling moth, Laspeyresia pomonella (L.), by sterile insect release (SIR) in British Columbia orchards was illustrated in the mid 1960s and early 1970s (eg., Proverbs et al., J. Econ. Ent. 68, 555-60, 197 5). To determine the commercial feasibility of the method, a control program was initiated in 1975 in the Similkameen Valley, a semi isolated area of about 640 hectares of apple and pear. The program is financed by Federal and Provincial Governments and cooperating fruit growers.

1975

In 1975, a concerted attempt was made to reduce the wild codling moth population to a low level, by intensive spraying and removal of abandoned host trees, in preparation for SIR in 1976. Sex pheromone traps and fruit examination were used to determine when and how often to spray. Assessment of results, by fruit examination for codling moth injury at harvest, indicated that of the 320 hectares designated for s m in 1976, about 12% still was fairly badly infested and would have to be sprayed next spring.

1976

Sterile (35 krad of gamma radiation) moth release commenced in 280 hectares on April 25 (pink bud stage of apple) andin an additional 40 hectares (after one or two sprays) in early July, i.e., about one week before second brood adults started to emerge. Releases were made two or three times weekly in each orchard until early September. The moths were released from modified Volkswagen cars which were driven through the orchards at about 10 kilometers per hour in premarked lanes 30-36 meters apart. The average number of sterile moths released per hectare per week was approximately 1100 in the first brood and 1300 in the second.

Insects for release were reared on artificial diet (Brinton et al., Can. Ent. 101, 577-84, 1969) and were marked internally with calco oil red. The colony originated from wild insects collected in 1975.

Populations of male moths were monitored weekly by sex pheromone traps used at the rate of about 1 per 1, 5 hectares. The effectiveness of the control program was assessed at harvest in each orchard by examining about 10% of the windfall and harvested apple fruits for codling moth injury.

The 1976 program of SIR in 280 hectares, and spraying (in the first brood) and SIR (in the second brood) in 40 hectares, evidently suppressed codling moth reproduction very effectively. The numbers of wild male moths captured in the sex traps declined from 305 in the first brood to 35 in the second. At harvest, no codling moth injury was found in 50 orchards, 0, 08% or fewer injured apples in 25 orchards, and 1, 6% injury in the remaining orchard. Unfavorable weather for codling moth reproduction in 1976 probably contributed to the success of the SIR program.

1977

The control program was expanded to 480 hectares in 1977. About 12% of the new area received one or two codling moth sprays during the first brood because of excessively high moth populations. In addition, about 40 hectares in which no codling moth injury was noted in 1976 were removed from the release program and monitored with 70-80 sex pheromone traps. Three orchards were involved. In one of these we captured four wild moths, but no infested fruit was found either here or in the other two orchards. Probably neigher SIR nor chemical sprays will be required in these orchards during 1978.

In the release area, the numbers of sterile moths released per hectare was about 63% greater than in 1976, but synchronization of release and adult emergence rates was not improved. Harvest assessment of the program is not complete, but current results indicate very good control in the 50 orchards

that were free from codling moth damage in 1976. The level of damage in all other orchard.s that were under the 1976 release program is about the same as in 1976. In the new release area, codling moth injury began to show up in mid August following a 5-week period of hot weather. Most of these orchards had been sprayed by growers in 1976, but evidently control was not sufficient to permit the high degree of overflooding with sterile insects which is required when weather conditions are near ideal for codling moth reproduction and survival. The percentage damaged fruit in the new release area varies from zero in about 10% of the orchards to a high of about 3% in one orchard.

It is expected that the SIR program will be continued in 1978, but the final decision will depend largely on the level of financial support provided by the Similkameen Valley fruit growers.

Development of mass production gamma sterilization and release of the codling moth, Laspeyresia pomonella L. - Polish strain*

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According to statistics there are 34, 4 mill. apple trees in Poland equivalent to about 180 trees per 1 km^2 of arable land. 50% to 60% of these trees grow in backyards, homegardens e. t. c., and they are practically not protected against pests and diseases. Apple production amounts to about one million tons yearly. 10% to 15% of this amount might be injured by the codling moth (Laspeyresia pomonella L.), if proper control measures are not applied. Control of the pest requires two or three insecticide sprayings at an approximate cost of 100 mill. Polish Zlotys (pesticide cost only) not including labour, machinery e. t. c., and it involves a considerable toxicity hazard, environment pollution e. t. c.

Our research on the use of the S. I. R. technique for the control of the codling moth was initiated in 1973, with the following aims: 1. To develop a technique of mass rearing of the insect on an artificial medium produced from cheap locally available raw materials; 2. To check the effectiveness of the S. I. R. program under the condition of a high density of the host plant and the minimum distance isolation from the reinfestation foci.

Until 1976 it was investigated mainly the ecology of the pest, the effects of gamma irradiation, and different aspects of mass rearing. This research demonstrated that the developmental temperature thresholds amount to 10° c for egg incubation and for post diapause development of overwintered larvae. The diapause development was accomplished after 60 days of chilling at +2° to +10° C, however up to 1, 5% of the larvae were shown to diapause for two years. 48, 8 to 66%

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of larvae overwintered in the insectary have emerged into adults. 2 to 13% of the remaining ones were parasitized by insects and 23 to 40% have died of other causes, predominantly fungal diseases. Birds, and particularly great tits destroyed up to 94% of larvae hibernating in the orchard.

Both laboratory reared and field collected moths showed a definite pattern of adult emergence from pupariae, which is related to diurnal rhythm of illumination. Copulatory activity also showed a diurnal rhythmicity. It seems that readiness for the sexual activity is regulated by an internal clock, while its behavioral manifestation is triggered by the onset of the dark phase of the diurnal cycle. Gamma irradiation at 30 krad decreased mating frequency of apple and diet reared moths by 27% to 42%. However, it was shown later that this debilating effect was mainly due to handling of the moths and to transportation to the irradiation facilities. On the other hand sperm competitiveness of irradiated males was only 0,395 of that of normal ones.

Moths reared in the laboratory for 31 generations showed definite symptoms of laboratory adaptation. Average weight of the moths have increased as compared to the wild population and so did the mating frequency of females. Cross mating between laboratory and wild populations revealed that after three generations the crossmated population was much alike to the laboratory one in respect to most characteristics measured, but diapause onset was considerably more frequent despite of the 18 hrs daylight regime.

A technique was developed which allows to rear up to 10.000 moths per week on an artificial medium, containing the following ingredients: Wheat germ 206 g, dried yeast 30,08 g, Vitamin C 5 g, methyl p-hydroxy benzoate 1,89 g, benzoic acid 1,5 g, formaldehyde 1,89 g, agar 12,06 g, streptomycine 0,01%, benlate 0,02 g, fumagillin/R/ 0,2 g /contains 34% dicydohecylamine/, calco oil red 0,011 g, distilated water to obtain in total 1000 g of the medium.

The program of field release of irradiated moths started on May 12, 1977. Unsexed, 30 krad irradiated moths were hand released three times a week until

the end of August. Over 81, 2 thousand moths were released with the anticipated sterile to native ratio 82:1. However the ratio calculated on the bases of captures in Pherocon CM traps was about 24:1 on the average, and occasionelly it dropped as low as 1: 1.

Results of the first year release estimated at harvest, revealed the percentage crop injury decrease from 33, 1% in 1976 to 5, 4% in 1977; but the number of fruit injured increased from 2. 919 to 3. 197, and the estimated absolute number of insects in the experimental orchard increased from 1482 to 1840 respectively.

This failure of the S. I. R. program might be due to several factors, of which the most important are: too low the ratio of released to native insects; immigration of native insects from the surrounding areas; too poor adaptation of laboratory reared moths to unfavourable weather conditions. The last factor seems particularly important in our opinion, because weather was exceptionally cold and rainy during the period of the codling moth flight. In this condition even a smallest difference in temperature, humidity e. t. c. thresholds of activity between the released and the native moths, might seriously affect the extent of cross breeding between the populations.

Codling moth: Effects of 30 krad gamma irradiation of the male parent in production and fertility of the progeny

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A study was conducted to obtain more information regarding the reproductive potential, survival, and sex ratio of progeny of male codling moths, Laspeyresia pomonella (L.), exposed to 30 krad of gamma irradiation and crossed with virgin untreated females.

Five replicates of 100 male moths were exposed to 30 krad of gamma irradiation in a 60-CO unit. After the irradiation treatment, each male was caged with an unirradiated virgin female and held for 6 days. Any eggs produced were planted on trays of thinning apples and the resultant F_1 adults were outcrossed with the normal laboratory strain.

The average differences in survival between the progeny of treated and untreated males is reported in Table 1.

The 361 treated males that mated successfully produced 34 apparently healthy F_1 adults {all males). Thus an average of 10.6 successful matings between treated males and normal females was required to produce one apparently healthy F_1 adult. The untreated control produced 21 healthy F_1 adults from each successful mating.

The relative vigor of the F_1 adult male progeny produced from the 30-krad male parent showed that mating was reduced ca. 75% compared with the untreated control, oviposition per female was reduced ca. 50%, and none of the eggs hatched.

Table 1. Average production per mated female parent from crosses of untreated or 30-krad treated male codling moths with unirradiated females. /

Developmental stage	Percent survival / Treated males X normal females	Normal males X normal females
Eggs (hatch)	4.3 **	80.1
Larvae (lst-4th instar)	10.0 **	54.0
Larvae (5th instar)	59.2 *	45. 7
Pupae	92.2 *	96.8
Adults (total)	49.4 **	90.5
Adults (healthy)	82.9 *	98.4
Egg to adult	0.09***	16.9

a/ Total females: 0 krad X normal males = 23; 30 krad X treated males = 361.

b/ Statistical comparisons are within rows for untreated and treated males; (*p = 0, 10, ** P = 0, 05, *** P = 0, 01) levels of significance.

Recent developments in sterile insect release research for the control of lepidopteran insect populations

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Considerable progress has been made toward using the theoretical potential of sterile insect release systems for the control of many of our major lepidopteran insect pests. This progress has not been easy and has required input from many scientific disciplines because of the technology, logistics, and handling problems involved in mass rearing, sterilizing, packaging, transporting, and releasing the insects. Encouraging benchmarks include new methodology and techniques that provide a more complete understanding and analysis of movement, migration, behavior, biology, and ecological relationships of target species. Also, much progress has been made in developing insect mass rearing systems. Other major breakthroughs are the recognition of the relationship between sterilizing dosage and insect competitiveness that are manifested in abnormal mobility, mating behavior, and sperm transfer. These have resulted in a better understanding of the complex interactions of sterile released and native insect populations. The discovery of partial and hybrid sterility and the selection and stabilization of morphological marker strains in many insect species are exciting advances that provide the potential for area-wide population suppression of these pests and the development of efficient, effective pest population management systems.

Release methods and dispersal of codling moth

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The dispersal of codling moth influenced by release methods and by origin of moths (diapause vs. non diapause) was studied in 1976. Like earlier experiments (Z. Angew. Entomol. 83: 161-168) it was carried out in the Upper Rhine Valley, a typical U-shaped alpine valley.

Releases were made near Bad Ragaz in the center of an isolated 5 ha apple orchard. The following groups of marked male insects of our laboratory strain were released:

A. Moths from non diapause larvae
B. Moths from diapause larvae
C. Pupae from diapause larvae.

Pupae were placed in open boxes on 6 adjacent trees. The number of emerging moths was registered twice a day and the same number of adults of A and B was released at the same location. In each experiment about 1200 insects were released per group over a period of 1 - 3 days.

Dispersal of moths was assessed by recapture in pheromone traps. 18 traps were regularly distributed over the orchard. 40 traps were placed over an area of 15 km^2 surrounding the orchard. Suchtraps were placed on single trees, on wood borders, or inside of woods. Recapture was registered up to 10 days after the releases.

Results

Table 1 : Recapture of moths (total of 3 experiments)

	released	recaptured			
		inside the orchard		outside the orchard	
		number	% of released moths	number	% of released moths
A. Moths from ND larvae	3450	663	19,2	19	0,55
B. Moths from D larvae	3680	628	17,0	34	0,92
C. Pupae from D larvae	3630	557	15,4	6	0,17

Results show that recapture inside the orchard was similar to all 3 groups. There was no difference in the sites of recapture. Outside the orchard moths of group C were caught in lower numbers than moths of A and B. Maximal distances travelled by recaptured moths were however the same for the 3 groups.

Earlier observations were confirmed that traps placed near prominent silhouettes, like woodborders and large single trees, catch more moths than traps in less prominent surroundings. Traps 100 - 200 m inside of woods caught a few released and native moths. Two traps placed on a mountain, 300 m above the valley and above the next hostplants caught many native moths on warm, but no moths on cold evenings.

Codling moth[1]: Evaluation of vigor indicators and improving field performance of mass-reared adults

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1. Male biotic potential: Evaluation as a vigor indicator in quality control monitoring.

Sixty males from each of three colonies were monitored and compared for biotic potential. Total spermatophores, mean matings per male, total oviposition and egg hatch, mean oviposition and egg hatch on a per male basis, and male longevity were compared. There are no significant differences among any of the facets measured except total spermatophores and mean matings per male. The mean matings per male for the 1974 colony are significantly greatet ($p = 0,05$) than the mean matings per male for the 1960 and 1973 colonies. Longevity, total oviposition, and egg hatch do not correlate with vigor.

First, 2nd, and 3rd matings on days 1, 2 and 3, respectively, all bear the same relationship to each other. The 1960 colony showed no significant difference from either the 1973 or 1974 colony. In each case the 1974 colony showed significantly more matings ($p = 0,05$) than the 1973 colony.

Of these facets of male biotic potential which were investigated, the numbers of 1st matings on day 1; 2nd matings on day 2; etc., and mean matings per male indicate vigor differences.

2. Male mating propensity as a vigor indicator.

Males of the 1960 and 1973 colonies were compared at adult ages 1, 2, 3, 4, and 5 days and dosages of 0, 5, 10, 15, 20, 25, 30, 35, and 40 krad for each day of age.

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[1] Laspeyresia pomonella (L.)

The males of the 1973 colony passed 4 % more spermatophores than did the males of the 1960 colony. This was not significantly different. For males of a specific age treated with a specific dose, there were no significant differences.

3. Stress-rearing for better field performance by released codling moths.

Eggs from the 1974 colony were planted on thinning apples and held under a fluctuating temperature and humidity regime at 16 hours photophase. Temperatures ranged from 19, 4° C to 33, 3° C and 55-93 % RH. The lows and highs varied by a few degrees from day to day and did not always reach the maximum and minimum reported here. 'This colony is referred to as the 1974A strain. The 1974 and 1974A strain mixed-sexes were released in equal numbers at the same time and place.

During the 1st generation (1974A strain) 1432 males from each colony were released and 417 (29 %) from the 1974 strain were recaptured while 358 (25 %) from the 1974A strain were recaptured. There is no significant difference between these figures.

In the 2nd and 3rd generation (1974A strain) releases, 1482 unirradiated and 1482 irradiated males from the 1974 and 1974A strains were released. Recaptures were as follows:

1974	-	0 krad	-	106	(7 %)
1974	-	25 krad	-	74	(4 %)
1974A	-	0 krad	-	231	(15 %)
1974A	-	25 krad	-	154	(10 %)

Recaptures of untreated males from the 1974A strain were signüicantly greater at p = 0, 01 than recaptures of any of the other treatments. Recaptures of irradiated males from the 1974A strain were significantly greater than recaptures of untreated males from the 1974 strain at p = Q, 10 and significantly greater than recaptures of irradiated 1974 males at p = 0, 05. Recapture of

untreated 1974-strain males was significantly greater than recapture of irradiated 1974-strain males at p = 0, 10.

The results clearly show that in rearing codling moths, and probably other insects as well, for field release programs it would be advantageous to vary rearing conditions and subject the colonized insect to stress.

Flying activity study of the codling moth by the release-capture method using sex traps in an apple orchard

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Owing the synthesis of the sexual pheromone and the availability of different sex traps, flying activity of native and reared males (irradiated or not) codling moth was compared by using a release-capture method.

Only individually sexed adult males have been used. The native insects were obtained from overwintering larvae catched in trap bands and kept under shelter (insectarium). The laboratory insects are individually reared on artificial diet (Sender, 1970). The sterile males are treated with 40 krad in a Co 60 unit of 1800 Curies. Twenty-one traps have been installed in 1974 and 7 in 1975 in an 4, 9 acres apple orchard (330 m x 60 m) of 1203 trees. The males were marked most of the time by dusting with fluorescent pigments, but Rhodiamine B and methyl-blue have been also used. The releases always occured 1 hour before the observed sunset, that is between 17:30 and 19:30, depending from the season.

Three particular features are the originality of the present experimental method:
- The number of released moths at each time is very low, 60-80 as a mean, 140 as a maximum.
- Each individual release is carefully effected and the correct taking off is checked. In case of need, other individuals may be released in place of the unefficient insects.
- The traps are set only the day following the release.

1 - Recapture rates -

The physiological status, that is the age of moths, seems tobe the most important. In comparison to the insects 3 or more days old, the individuals 1-2 days old show a significantly higher recapture rate, flight distance, and longevity.

Studying the captured moths according to the number of insects released at every trial there appears an inverse relationship likely linear between percentage catch and number of moths used in every release.

The total results of 9 releases in 1974 and 4 releases in 1975 show that the average rate of recovery is clearly higher in the reared insects. This has appeared in 12 releases out of 13, the last one presenting the inverse result. For insects 1-2 days old, irradiated as adults with sterilizing dose of 40 krad, the recapture percentage does not show significant differences as compared to that of untreated insects of same age. The similar observation may be done for the average flight distances, as well as for the moths' longevity.

2 - Dispersion study -

The catches distribution in traps placed at different distances from the release point is generally taken as dispersion criterion of the insects in an orchard. **Even** if the traps have been set with this in mind the day following the release, this criterion does not seem entirely representative of the phenomenon. In addition these flight distances depend from many factors which are indeed much more tied to the experimental conditions than inherent to the insects. The distances vary depending from the number of traps installed, the position of these traps in the orchard, the surface of the orchard (and its shape for a same surface), the release point, the time of the trap setting and eventually the climatic conditions, the wind having the most important role.

Consequently likenesses and differences will only be taken into consideration in relative value of the mean flight distances according to the results, only the moths more than 3 days old cover shorter distances when compared with the check moths 1-2 days old.

3 - Other results -

On 3 releases concerning a total of 30 males 3 days old, previously mated in

laboratory, 8 males have been recaptured. Three releases of 68 males, after ablation of antenna, have been carried out with 14 recaptures. In the case of traps set before releases the capture rates are higher, 67,7 per cent for native insects and 72,8 per cent for reared ones.

Table 1 : Traps recoveries and flight distances of released male codling moths as a function of the: Origine (Native or laboratory reared moths); age (1-2 or 3-8 days old moths); sterilization (treated with 40 krad or untreated moths); number of moths at every release

	1-2 days old males			
	1974		1975	
	Native	Laboratory	Native	Laboratory
No. traps	21 (+ 2 ext.)		7 (+ 2 ext.)	
No. releases	9		4	
Total no. moths released	302		526	
	151	151	263	263
Average no. moths per release	33,6		131,4	
	16,8 (13 to 20)	16,8 (13 to 20)	65,7 (62 to 70)	65,7 (62 to 70)
Total no. moths recovered	69	93	65	113
Average % moths recovered	45 (26,6 to 61,5)	61,6 (40 to 76,9)	24,9 (18,6 to 33,9)	43,2 (35,4 to 58)
Average flight distances in meters	34,2	44,6	72,1	63,4
Average no. days required for 1st. and last capture	5,7	6	7,7	8

	1-2 days old laboratory males		Laboratory males	
	Irradiated 40 krad	Untreated	3-8 days old	1-2 days old
No. traps	7 (+ 2 ext.)		21 (+ 2 ext.)	
No. releases	5		6	
Total no. moths released	500		360	
	250	250	180	180
No. moths per release	100		60	
	50	50	30	30
Total no. moths recovered	124	127	42	103
Average % moths recovered	49, 6 (40 to 60)	50, 8 (46 to 58)	23, 3 (13, 3 to 36, 6)	57, 2 (46, 6 to 70)
Average flight distances in meters	61, 6	64, 9	37	48, 8
Average no. days required for 1 st. and last capture	6, 5	6, 7	4, 3	7, 3

Biological control, diseases

Field tests using granulosis virus against codling moth (Laspeyresia pomonella L.)

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Positive results on the control of codling moth using a granulosis virus conducted in the USA, Australia and Europe have stimulated the attempt to prove this method also under Austrian conditions.

A private orchard was chosen as a test plot in 1976, where four trees ("Golden Delicious") at a time were treated each either with virus or an insecticide and two trees remained untreated. Four litres of a suspension of virus of $9x10^{11}$ virus capsules {about 9 larvae equivalents) or from a insecticide mixture (Basudin Emulsion 0,1%) were applied per tree by using a manuel rear sprayer. For UV protection and as a sticker 0,6% powdered skim milk was added to the virus suspension. To both the spray mixtures, virus suspension as well as insecticide the fungicides Karathane FN 57 0,1% and Dithane M 45 0,2% against mildew and apple scab were added. The untreated control trees were sprayed only with the fungicides mentioned above. All together four applications were carried out during the season 1976.

The repetition of this test in 1977 was carried out in the same private orchard al,eady mentioned above as well as in the course of the testing of new insecticides in an orchard belonging to the Ministry of Agriculture. Contrary to the tests in 1976 the number of virus capsules was reduced to $2x10^{11}$/8 l H20/tree (= about 2 larvae equivalents). The increase of the amount of liquid per tree was necessary because the larger size of experimental trees and the use of a 100 l motor sprayer. Skim milk powder as well as fungicides were added in the same concentration as to spray mixtures in 1976. Because the minor efficacy of the insecticide Basudin

in 1976 the concentration was increased to 0,15%. The application terms were settled in 1976 and 1977 according to the official warning service of the Bundesanstalt für Pflanzenschutz against codling moth. In 1977 only three applications were carried out.

The evaluation of both experiments was done by examination of fruits, windfall and harvest.

Results of this biennial field tests are represented in tables 1 - 3.

Table 1: Field test 1976, Enzersfeld: Average infestation of fruits from untreated-, virus treated- and insecticide treated trees.

Treatment	Nr. of test trees	Total Nr. of apples examined	Nr. of infested apples	Infestation (%)	Reduction of infestation (%)
Virus $9x10^{11}$	4	7379	474	6,42	88,2
Insecticide Basudin 0,1%	4	4377	1288	29,43	46,1
Untreated control	2	2284	1246	54,55	---

Table 2: Field test 1977, Enzersfeld: Average infestation of fruits from untreated-, virus treated- and insecticide treated trees.

Treatment	Nr. of test trees	Total Nr. of apples examined	Nr. of infested apples	Infestation (%)	Reduction of infestation (%)
Virus $2x10^{11}$	4	1172	140	11,95	78,6
Insecticide Basudin 0,15%	4	3283	449	13,68	75,51
Untreated control	3	881	492	55,85	---

Table 3 : Field test 1977, Hetzendorf: Average infestation of fruits from untreated-, virus treated- and insecticide treated trees.

Treatment	Nr. of test trees	Total Nr. of apples examined	Nr. of infested apples	Infestation (%)	Reduction of infestation (%)
Virus $2x10^{11}$	5	6599	162	2,45	74,21
Insecticide E 605 f 0,04%	6	6407	101	1,58	83,37
Untreated control	5	8008	761	9,50	---

Influence of the concentration on the efficacy of the granulosis virus in the field

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The granulosis virus of the codling moth, Laspeyresia pomonella, applied at a concentration of 10^{11} virus capsules / litre has shown to give control of codling moth comparable to chemical insecticides. The object of this study was to establish a concentration-effect relationship under field conditions and to test the possibility of reducing the concentration of the virus suspension used in the field.

The experiment was carried out in the same spindle bush orchard in Dossenheim as the previous trials (Huber and Dickler, Z. Angew. Entomol. 82, 143-147, 1976). Unfortunately, in 1976 the orchard was heavily affected by frost, thunderstorm, and drought. The crop was reduced to 1/10 of the apples of a normal year. Three different virus concentrations (10^9, 10^{10}, and 10^{11} capsules / litre), at a rate of 1-2 litres / tree, were applied four times during the summer with a motorsprayer equipped with handguns. On a fourth plot a virus suspension containing again 10^9 capsules / litre together with 0,1 % "Shade", a commercial UV-protectant, was used. To all the virus suspensions 1% skim milk powder as sticker/protectant was added. For comparison a further plot in the same orchard was treated four times with diazinon, another left untreated. Each plot contained 20 to 30 trees. Codling moth infestation was evaluated by examining each apple for codling moth injury. In order to sample the overwintering codling moth population, all the trees were provided with cortugated cardboard bands (protected with wire gauze against birds) to collect the diapausing larvae. As there were so few apples on the trees, the method used in former years to measure the activity of the virus deposit on the trees (placing neonate codling moth larvae in the laboratory on apples picked from the treated trees) was unsuitable. Instead the bioassays were carried out following a method developped by Mayas (These Fac. Sc. Paris, 1969): neonate codling moth larvae were fed for 24 hours on pieces of apple leaves from

the sprayed trees. Afterwards they were transferred to artificial medium and checked for virus mortality after 2 weeks.

As shown in the following table, the efficacy of all the treatments, including the one with chemical insecticides was poor, probably due to the lamentable state of the orchard in this year, though codling moth infestation on the untreated trees was not extraordinary high (25 - 30 %):

treatment	reduction of CM damage %	reduction of diapausing larvae %	mortality in bioassay %
virus 10^9 + Shade	14,6	59,7	83,9
virus 10^9	18,7	72,9	86,7
virus 10^{10}	33,5	83,2	96,6
virus 10^{11}	60,4	93,3	100,0
diazinon	47,3	20,7	100,0

If the percentages are plotted on a probit scale against the logarithm of the virus concentrations, three nearly parallel lines (corresponding to the three different effects measured), with a slope of 0,6 can be drawn through the points. This means that a tenfold dilution of the virus concentration in the spray reduces the efficacy of the treatment by 0,6 probit (e.g. from 90 % to 75 %), regardless whether it is measured by the activity of the spray deposit on the leaves, by the reduction of codling moth damage on the fruits, or by the reduction of codling moth population. Thus, the effects of the virus treatments are much less susceptible to changes in the spray concentrations than treatments with chemical insecticides, where doubling the concentration usually has already a marked effect on the efficacy of the treatment.

With the virus, doubling the concentration would change the efficacy by only 0,18 probit, e.g. from 87 % to 90 %. The addition of the UV-protectant "Shade" to

the spray did not give better results. The concentration of 0, 1 % probably was too low to show any effect. The concentration recommended by the manufacturer (1 - 3 %) on the other hand, would be to expensive with the large water volumes used for spraying in apple orchards.

As in earlier years, the efficacy of the virus concentration 10^{11} was even better than the chemical insecticide, especially regarding the reduction of the overwintering population, which was again much higher than the reduction of infestation. But as there are better chemicals for codling moth control than diazinon, a lower virus concentration than 10^{11} capsules / litre at the moment is not advisable if comparable crop protection is wanted.

Mist blower application of granulosis virus

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In earlier successful experiments with the granulosis virus for control of codling moth, Laspeyresia pomonella, the virus suspension was applied with a motorsprayer equipped with handguns (Huber and Dickler, J. Econ. Entomol., 70, 557-561, 1977). The aim of this study was to test the virus under more practical conditions by utilizing spraying equipment more commonly used in commercial apple growing.

The trial was performed in a 0,4 ha commercial double pillar "Golden Delicious" orchard in the Upper Rhine Valley near Karlsruhe. A 0,11 ha plot (90 trees) in this orchard was treated 4 times during the season with 120 l of virus suspension (10^{11} virus capsules / litre, + 1 % skim milk powder), using a "Holder" mist blower (pump Z 73, ventilator TU 60 A). For comparison another plot in the same orchard was sprayed at the same dates with diazinon (Diazinon 25 Emulsion 0,10-0,15 %). Codling moth infestation was sampled by examining all fruit (including windfall) of 6 trees in the middle of each plot (= ca. 1500 apples) for codling moth injury, differentiating between wormy apples (deep entries) and apples only superficially damaged by codling moth (stings). The activity of the virus deposits on the trees was bioassayed in the laboratory by feeding neonate codling moth larvae on apples picked at random from the treated trees. The mortality of the larvae was recorded after 14 days.

The results were as follows:

	untreated check	diazinon	granulosis virus
% deep entries	63,4	6,0	7,4
% stings only	6,8	4,3	5, 2
% total CM damage	70,2	10,3	12,6
% reduction by treatment		85, 3	82,1
% mortality in bioassay		93,7	76,1

In the bioassay the mortality on apples, picked immediately after the mist blower application of the virus, was lower than in the earlier experiments with the band sprayed trees, where more than 90 % of the larvae died. Nevertheless, the reduction of codling moth damage by the virus application was nearly as good as by the chemical insecticide. The percentage of apples with "stings only" was nearly the same in all the treatments. The apprehension that with the virus treatment the larvae would die only after having already injured the fruit by boring an entrance hole, did not prove correct. In another field trial for control of codling moth with dimilin, which acts also as a feeding poison with retarded effect (mortality occurs at the earliest during the first moult), the percentage of apples with stings only was not higher than with usual insecticides acting on contact. lt is possible that the neonate larvae ingest the agent already on their way to the apple, nibbling at leaves or drinking contaminated dew. At least in the laboratory neonate larvae feed easily on leaves. This might also explain why in spite of only 76 % mortality in the bioassay with apples picked immediately after the spraying (going down to 13 % in the 2 weeks following the treatment), the efficacy of the virus application with the mist blower was quite high.

Codling moth control with granulosis virus; its effect on other major apple pests

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In the fruit growing areas of the Rhine Valley of Germany codling moth is bivoltine and of prime economic importance. Besides this key pest serveral other arthropods, especially the European red mite and several leafrollers and aphids cause damage to leaves and fruits. The importance of these species varies from season to season and region to region. In the Heidelberg area in some years fruit damage by the leafroller Adoxophyes reticulana compares with codling moth in severity. In commercial orchards where standard spray programs with chemical insecticides are applied, compounds used in codling moth control are also effective against . reticulana.

In a 4year field experiment carried out in an apple orchard in Dossenheim and other commercial orchards in Southern Germany (Huber and Dickler, Z. Angew. Entomol. 82, 143-147, 1976) the application of granulosis virus gave a good protection of the fruits against damage by larvae of the codling moth. The granulosis virus used is highly virulent and in an apple-biocoenosis specific to Laspeyresia pomonella. Until now besides codling moth only two other species, the Oriental fruit moth Grapholita molesta and the European pine shoot moth Rhyacionia buoliana (Huber and Dickter, J. Econ. Entomol. 70, 557-561, 1977) are known tobe susceptible to the virus.

This report concerns preliminary field experiments to study the population development of leafrollers and the density of hibernating stages of several apple pests in a commercial apple orchard where granulosis virus for codling moth control is used.

The observations were carried out in the same orchard of the experiment field in Dossenheim, already described in the other papers.

In 1975 and 1977 60 and 80 apple trees, respectively, received a standard spray program with broad spectrum organophosphorus insecticides against codling moth. A plot of the same size was sprayed with granulosis virus and the same number of trees was kept untreated. The study orchard was divided into 2 parts, one with green covered the other with clean cultivated soil. In 1975 harvested apples of the cultivar 'Golden Delicious' and in 1977 harvested apples of 4 cultivars were observed and the feeding damage done by early instar larvae prior to their entering diapause was evaluated.

As shown in table 1 in 1975 plots sprayed with granulosis virus in both types of soil management had the highest percentage of fruit injury done by leafrollers. The damage was even higher than in the untreated trees. The lowest damage was found in the chemical insecticide sprayed trees over green covered soil. As demonstrated in table 2 these results were absolutely confirmed in 1977. There was almost no yield in 1976 as a result of frost damage in early April. In both cultivars (tab. 2) the highest percentage of fruit damage was always found in granulosis virus treated apples, whereas the application of the broad spectrum Gusathion MS^{R} led to a satisfactory protection against leafrollers also. In both years there was always a significant difference between virus and insecticide treated apples. Corresponding results could be observed in the cultivars 'Cox Orange' and 'Jonathan'. At this time we have no explanation for the phenomenon that leafroller damage on virus sprayed apples was always higher than on untreated ones. As shown in both tables in granulosis virus and untreated apples leafroller damage - in correspondance with codling moth injury - was also distinctly higher over clean cultivated soil.

In February 1977 samples of shoots were taken from each tree and hibernating stages were counted following the method of Vogel and Wildbalz (1956). The density of aphid eggs, winter moth eggs, early instar larvae of tortricids and psylla eggs was very low and no influence of the different treatments could be

observed. The application of organophosphorus insecticides consequently resulted in the highest population of winter eggs of the European red mite whereas the number of E. ulmi eggs was lowest from trees treated with granulosis virus. The density was even lower than on untreated trees.

These results are the first of a long term project to study the effect of codling moth control with granulosis virus on the arthropod fauna in an apple orchard. Further research is needed to reduce leafroller damage to an acceptable level in integrated spray programs where granulosis virus for codling moth control is used.

Table 1:
Leafroller damage on apples harvested in an orchard treated with granulosis virus and chemical insecticides against codling moth, Dossenheim 1975

	'Golden Delicious'			
	green covered soil		clean cultivated soil	
treatment	total of apples	% damage	total of apples	% damage
virus	430	15, 6 a	975	20, 1 a
insecticides	905	4,8 b	510	11,0 b
untreated	834	8, 8 C	579	18, Oa

[a] Figures followed by the same letter do not differ significantly (P >O, 05)

Table 2 :

Leafroller damage on apples harvested in an orchard treated with granulosis virus and chemical insecticides against codling moth, Dossenheim 1977

'Golden Delicious'

treatment	green covered soil		clean cultivated soil	
	total of apples	% damage	total of apples	% damage
virus	2912	23, 6 a	2245	34,8 a
insecticides	3025	2, 8 b	2986	2, 2 b
untreated	2173	22, 7 a	2852	28, 9 C

'Goldparmäne'

treatment	green covered soil		clean cultivated soil	
	total of apples	% damage	total of apples	% damage
virus	984	26, 6 a	1196	36, 1 a
insecticides	2250	3, 6 b	1377	3, 1 b
untreated	1726	21, 9 C	1426	29, 9 C

[a] Figures followed by the same letter do not differ significantly (P >O, 05)

Preliminary experiments on the use of Beauveria bassiana against Carpocapsa pomonella

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Our experience concerning firstly the entomopathogenic fungi and secondly our knowledge of the investigations carried out abroad, chiefly by Canada and USSR on the potentialities of Beauveria bassiana as a microbiological control agent against the codling moth, have encouraged us to investigate this field of research. We infected the last-instar larval caterpillars between the moment when they leave the fruit and that when they weave the hivernaculum in the protection of which they continue developping.

These experiments have been carried out near Paris, in August, during a period when there are no more fungicide treatments to avoid the incompatibility between the control of Oidium and Tavelure by fungicides and the control of the codling moth by Bacillus thuringiensis, on the first generation diapausing caterpillars and on the whole second generation larval population.

A preliminary field experiment was begun on Summer 1975. The carrying out of this experiment has brought about three great problems
- the selection of the strain of Beauveria bassiana
- the dose of the entomopathogenic preparation used
- the date of the treatment(s)

The strain Beauveria bassiana no. 93 was selected as the most virulent one and multiplied on millet seeds. The date of the first possible intervention was determined by the field observations which have been carried out for several years in the experimental orchard. On each application, each tree was given an inoculum of 6×10^9 conidia. This dose was determined in relation to the possibilities of multiplication of the fungus in Roux flasks on millet seeds, to the

total number of apple-trees under experiment (120) and to the number of treatments provided. The partial and cumulated numbers of the caterpillars caught in the experimental apparatus are presented in table 1.

lt is remarkable that most part of insects (119 out of 254) were caught on the last fortnight of trapping, which supposes necessarily that the biological preparation has been efficient at least for two months (or, if not, it supposes the repetition of the treatment).

In table 2 are noted, given in percentage of the numbers of caterpillars caught, the numbers of mycoses, counted immediately after the collecting of the trap-bands or after the incubation in climatized chamber. In the lot of the 30 reference trees, the natural endemism of the mycosis appeared only on the last period of trapping. In the three other lots, it appeared only on the two extrem periods of o?servation and apparently regardless of the modalities of treatment. So the muscardine appeared at two different periods : at the beginning of August and at the end of September. As shown by the data collected in the experimental variant, with only one intervention on the 4th of August, the inoculum was efficient during at least six weeks, which would allow to provide in the future only one treatment, at the beginning of August.

By cumulating the results obtained every fortnight during the two month capture of the caterpillars in the orchard, one can notice that the total efficiency of the treatment(s) is rather low since about 50 % of the insects only have been killed by the white muscardine. This result confirms nevertheless the starting hypothesis about the kind of field intervention (Infection of L5 caterpillars rather than infection of Ll caterpillars) and encourages us to carry on our investigations. These are developed at a greater scale by increasing the concentration of the pathogenic inoculum so that to obtain a more important decrease of the diapausing population of the pest and to precise the modalities of treatment and of development of the mycosis.

Table 1 : Partial and cumulated numbers of caterpillars collected in the band-traps each fortnight, from the 4th of August to the 1st of October 1975

Fortnight	30 reference apple-trees	30 apple-trees treated only once	30 apple-trees treated twice	30 apple-trees treated three times	cumulated numbers
August 4-19	7	17	15	16	55
August 19-September 2	9	13	10	16	48
September 2-16	11	4	7	10	32
September 16-October 1	34	29	26	39	119
Cumulated numbers	62	54	58	81	254

Table 2 : Development of the infection by Beauveria bassiana in relation to the conditions of the treatment and of the capture of Carpocapsa pomonella caterpillars (given in % of the number of caterpillars collected)

	30 reference apple-trees	30 apple-trees treated only once 8/4/75	30 apple-trees treated twice 8/4/75, 8/19/75	30 apple-trees treated three times 8/4/75, 8/19/75, 9/2/75
August 4-19				
- caterpillars dead of mycosis when collected	0 %	29 %	40 %	18 %
- caterpillars dead of mycosis during rearing	0	53 %	26 %	63 %
- total of mycoses	0	82 %	66 %	81 %
August 19 - September 2				
-	0	0	0	0
-	0	0	0	0
-	0	0	0	0
September 2-16				
-	0	0	14 %	0
-	0	0	0	0
-	0	0	14 %	0
September 16 - October 1				
-	0	15 %	19 %	31 %
-	6 %	55 %	31 %	36 %
-	6 %	70 %	50 %	67 %

Biological control, natural enemies

Preliminary experiments using Trichogramma sp. against the codling moth in apple orchards, in the parisian region

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First investigations were undertaken in France by Goujet, Martouret, Voegele (1976) to study the conditions under which the use of Trichogramma could contribute to maintain the rate of Laspeyresia pomonella L. populations at an economic tolerance threshold.

Experiments are being carried out since 1975 in two apple orchards in the parisian region, in order to define the most effective conditions of oophagous parasite release.

These orchards are subjected to the minimal number of pest control measures: their nature and their frequency are always fixed according to the most favourable occasion, in relation with the rate of phytophagous arthropods populations recorded, and with the economic threshold.

The tests of Trichogramma releases used
- either natural populations of codling rmth eggs which were in the orchards during the experiment;
- or regulated populations, that is to say numbers of eggs having been set on a tree or part of a tree temporarily isolated within an ovipositing cage.

Diverse strains of Trichogramma were tested concurrently. In the form of Anagasta kuehniella Zell. parasitised eggs, stuck on papered plaquettes, Trichogramma were introduced in the trees as soon as the first adult parasites

began coming out. Four successive releases are generally made with regulate intervals of 8 to 10 days.

In plots, the parasitic action of Trichogramma was estimad by :
- the rate of parasitised eggs, following the successive releases of parasites
- the damage on collected fruit caused by the codling moth populations
- counting the residual populations of larval codling moth that caused damage.

1) Interaction between host-density and parasite-density : The parasitic efficiency increased as a function of the number of Trichogramma; the efficiency does not seem maximal with 1000 Trichogramma per tree and per release. Significant differences in parasitic activity are noted between the periods : the periods with a rise in the middle daily temperature together with an increase of the range of temperature seem less likely to favour the Trichogramma activity.

2) Dispersal area : The parasitic activity appeared more than 30 m away from a point of release where 26 codling moth eggs out of 95 were parasitised (27, 3 %) by the strain no. 19 T. cacoeciae pallida (from USSR). The residual population of larval codling moth tended to lower when the distance from the central release point decreases; this tendancy was very strong with the strains T. embryophagum no. 45 (from Les Deux Alpes France) and no. 2 (from Yougoslavia).

3) Parasitic efficiency in orchard : A "full sized" experiment was begun in the fruit hedge on a plot of 1 ha devoted to the releases of Trichogramma, comparatively with a non treated plot : 120 points of release were selected. Three tests on the parasitised eggs were carried out at the rate of two during the ovipositing period which is that of the first flight, and the third one after the laying down of the eggs resulting from the second flight.

The results are reported in the table

Dates	hatched eggs	parasitised eggs	all eggs	% of parasitism
June 18 - 22	167	10	177	5, 64
July 8	80	45	125	36, 00
August 12	27	53	80	66, 25

The control of the damage observed on the fruits collected from the 120 trees bearing the parasite releases showed a highly significant difference between the reference plot and the release-plot where the middle gain concerning the non attacked fruits reached 13, 2 %. On the other hand, counting the residual larval populations on the same trees, revealed no difference between the plots.

The sempling method for the evaluation of the parasitic action of codling moth eggs is necessary for every direct estimation of the real efficiency of the released Trichogramma though their activity can also be revealed on the residual populations of larval codling rmth and on the collected fruit. The selection of the ecotype seems essential as some of them succeed in parasiting up to 65-67 % of the codling rmth eggs.

Studies on the rearing of Trichomma enecator (Ichneumonidae), a parasite of codling moth

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Investigations on the parasitation of hibernating larvae of codling moth carried out over the past years show that besides Ascogaster quadridentatus (Braconidae), Trichomma enecator is also an important antagonist of the codling moth.

In our endeavour to integrate the control of codling moth with many other biological methods (SIT, granulosis virus, Ascogaster) and also chemical control methods, we began to breed Trichomma under laboratory conditions.

In order to ensure an optimal utilization we are using the laboratory-reared parasites to test the side-effects of pesticides on this species (similar to the investigations on Ascogaster).

The breeding of Trichomma on codling moth is currently conducted using the breeding method which already proved extremely successful with Ascogaster.

Nevertheless the application of this method for Trichomma is beset with a number of difficulties. It is therefore necessary to adapt this individual breeding method for better results, a problem we should be able to solve within a relative short period of time.

The laboratory breeding of Trichomma at 25° C and 18 hour photoperiod has hitherto been possible up to $F_{6.}$ Suitable experiments to improve the parasitation performance are planned and beyond that we expect to clarify the biology and embryology of Trichomma.

Preliminary results of breeding Trichomma:

Presently we are able to breed Trichomma under laboratory conditions until the F_6.

Third stage codling moth larvae feeding in glass-tubes on a semi-artificial medium were offered to the parasite for parasitation in small plastic cages.

Females and males introduced in these plastic cages were still alive after an average period of 3 - 4 weeks. Copulation also takes place in these cages.

Sometimes the copulation seems tobe impossible for up to now unknown reasons and in such cases the percentage of males increased to 100 %.

Unfortunately the number of individuals was not high enough to guarantee a better parasitation in our rearing.

During our preliminary experiments the following parasitation rate was observed:

	parasitation %		♀ %
P (wild strain)	5, 9		
F_1 (lab. strain)	16, 3	46,4	53, 6
F_2	10, 2	80,7	29,3
F_3	9, 6	69,8	30,2
F_4	3, 1	47,1	52,9
F_5	7, 9	62,0	38,0

Investigations on the sound production of Ascogaster quadridentatus Wesm., a parasite of codling moth

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In the course of different investigations on Ascogaster quadridentatus Wesm. it was possibly to conduct studies on certain sounds produced by the parasite (Braconidae).

In breeding containerS'which contain both females and males of Ascogaster it is possible even without the use of technical devices to hear a "song" of the parasites, which is very different from normal flight sounds.

The first observations of these sounds permit the assumption, that they have something to do with the copulatory behavior of Ascogaster. In order to find a solution to this problem a series of observations and investigations was begun with the goal of determining, whether or not these sounds are signals which facilitate partner location or are otherwise useful to the parasite.

Above and beyond this aspects these investigations are also designed to determine a method of using these sounds (pulse) as a parameter within the framework of a quality-control of the parasite. For these investigations we used a bioacoustic laboratory at the Bundesanstalt für Pflanzenschutz, Vienna.

Preliminary results of investigations:

Males (and sometimes also females) of Ascogaster emit in rapid series sounds which according to investigations up to now can be considered as "stress sound". The pertinent "pulses" are above all emitted when two males confront each other. The sound emitted at this time is very similar to normal flight sound, except that the parasites are sitting and not flying.

The two males facing each other first trill with their antennae and then "sing" a short strophe of signals in short intervals, where upon the distance between them increases. If a new encounter occurs even after a short time interval the situation is repeated.

As can be proven by numerous tape recordings that females also sometimes emit similar signals, but the frequency of these puls is significantly higher.

Experiments with males, whose hind wings were amputated show that these sounds can be produced by the forewings alone, however in a lower pitch.

A frequency analysis of the signals of the male show that above all frequencies between 150 and 600 Hz are emitted. These occur prominently in dense frequency bands in the ranges of 150, 300, 450 and 600 Hz. To what extent these bands are the result of frequency superimpositions could not be analysed to date. Investigations to this intent are underway.

Possibilities of quality control:

The continous appearance of frequency bands in all signals as well as the relatively slight individual deviation from the song pattern allow the possibility of using these acoustic signals as a parameter to compare populations of different origin. A suitable research method is under consideration.

Pupal parasites of codling moth

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A parasite that attacks the pupae of its host in spring would be particularly useful in an integrated control programme for codling moth, as it would reduce damage to fruit in the same year, unlike larval parasites, which can achieve reduction in damage only in the year after attack.

Pimpla turionellae L. {Ichneumonidae) has been found attacking codling moth pupae in a little-sprayed orchard at Long Ashton for three years, since 1975. This parasite is widely distributed in woodland and hedgerows throughout Europe, and·has a wide host range, comprising Coleoptera (Curculionidae) and many families of Microlepidoptera and Macrolepidoptera.

In 1975, on trees protected from bird predation, 50 % of pupae that had overwintered as larvae beneath bark were attacked, mostly by E. turionellae, but in one case by Pimpla aquilonia Cress. In 1976, on trees similarly protected, 42 % of pupae were parasitized by E. turionellae, but on unprotected trees, where pupae were sparse, only 22 % were attacked. In a more detailed study in 1977, E. turionellae comprised 76 % of all parasites reared from codling moth pupae {the others have not yet been identified).

Time of attack by Pimpla turionellae

We have evidence that Pimpla turionellae overwinters beneath the bark of old apple trees in our orchard, then emerges at about the time when codling pupae are available. In 1977, the time of activity of adult parasites was investigated by 'lobster pot' traps designed to catch adults searching the bark of tree trunks. To investigate the actual time of attack, overwintered codling larvae were induced to spin cocoons beneath flakes of bark in the laboratory in April, then the flakes with the cocoons were glued to the bark of trees in the orchard. Each

week, 50 cocoons were taken from the trees, and replaced with 50 fresh ones that had been kept in an outdoor insectary. Examination of cocoons at time of collection showed how many had pupated, then all were kept in an outdoor insectary to allow adult parasites and moths to emerge.

Codling larvae pupated from mid May until early July, but 80 % had pupated by 8 June. Adult moths started to emerge in mid June, but not in significant numbers until the beginning of July. Thus most of the codling moth population were present as pupae during June, although some were still larvae, and a few had emerged as adults.

There were two peaks in abundance of P. turionellae adults in 'lobster-pot' traps, one in mid June and one in mid July. The first peak probably represented adult parasites searching for pupae, as the number of codling pupae parasitized also increased to a peak in mid June. Thus the parasite is searching for, and attacking, pupae when most codling moths are in the pupal stage; i.e. it is well synchronized. The second peak in parasite abundance probably represented those emerging from codling pupae, as P. turionellae emerged from pupae in the insectary throughout July and early August. Presumably the parasites would have then attacked other hosts, but we do not know their identity.

Percentages parasitized at different host densities

In the experiment just described, flakes of bark with cocoons were glued to trees in densities of 1, 3, 6 and 12 per tree. With one cocoon per tree, 25 % were attacked, rising to only 37 % with twelve cocoons per tree. Thus pupal parasites showed little response to host density, but this would not be a serious drawback in integrated control orchards where densities of codling pupae would always be low. It is remarkable that as many as 25 % of pupae were attacked at low densities, and it may be possible to boost this further by releasing adult parasites in the orchard.

Survival of mature codling larvae in relation to predation by birds and beetles

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Invertebrates are thought to be important predators of mature codling larvae seeking cocooning sites, and birds are important predators of larvae in cocoons. In our experimental orchard, ground beetles (Carabidae and Staphylinidae) are the most abundant invertebrate predators, so we exposed mature codling larvae to different levels of predation by ground beetles and birds to test their relative importance in determining survival of larvae.

In 1975, we excluded birds from trunks and branches of eight trees by terylene netting, whilst the bark of eight others was exposed to birds. The ground beneath eight of the trees was sprayed with fenitrothion (before codling larvae emerged from apples) to decrease the number of ground beetles, and the ground under eight trees was sprayed with water only. Re-invasion of sprayed plots by beetles was prevented because the ground beneath all trees was surrounded by a vertical polythene barrier 45 cm high and dug 15 cm into the ground. Treatments were combined in a Latin square arrangement.

We estimated larval numbers by examining apples on each tree in summer 1975, then estimated the number of adults surviving on each tree the following spring by enclosing trunk and main branches in black cloth emergence traps, dug into the soil at the base of the trees.

When birds were able to attack larvae, larval survival was much lower, at 5-10 %, than when birds were excluded. However, even in the absence of birds only 50-55 % of larvae survived to become adults. Since earlier experiments in the orchard showed that few or no cocooned larvae were killed in the absence of birds, it seems likely that in the present experiment, 45-60 % of larvae died or left the tree before building cocoons.

Various observations indicate that ground beetles take larvae seeking cocooning sites. However, although fewer moths emerged from trees with large numbers of beetles there were fewer larvae initially on these trees; there were no differences in survival of larvae between trees with many and few beetles. Thus beetles must be feeding on larvae that would be lost from the tree anyway. We therefore investigated the fate of larvae that spin cocoons on the ground. In autumn 1975, we induced larvae to spin cocoons in soil and litter in petri dishes, then attached the cocoons to small squares of nylon netting, and placed them on or in the ground, where they were either exposed to predators or enclosed in predator-proof cages. Of 288 larvae, only one survived the winter, in a dryish position at the base of a tree. Of the others, 283 disappeared and four were killed by fungi. All larvae disappeared from predator-proof cages.

In 1976, to find when larvae disappear from cocoons in the soil, cocoons were placed on or in the ground beneath trees, either in late August, when the soil was dry after prolonged drought, or in mid September, when the soil was moist after recent rain. Larvae from both groups disappeared from late September onwards when rainfall increased considerably and the soil became waterlogged. By mid December, none was left. The last larvae to disappear were those in dryish positions near tree trunks.

We conclude that larvae on or in the ground are unlikely to survive the winter due to our damp soil conditions, unless they are at the base of tree trunks, where emerging adults would be included in catches in emergence traps placed round trees anyway. Thus it seems that approx. 44 % of larvae failed to build cocoons on or at the base of the tree, and died; and 47 % were taken from their cocoons by birds, mainly blue-tits, Parus caeruleus.

Timing of bird attack

We glued flakes of bark, hiding larval cocoons, to trunks and branches of trees in the orchard in early August 1975 and 1976, when larvae were starting to emerge from apples and build cocoons. 93 % of larvae had been removed from cocoons by

birds after 3 weeks in 1975; in 1976 larvae were taken more slowly, probably because more larvae emerged from apples in that year, and it took 7 weeks for 93 % to be removed. However, this was still a rapid rate of loss, and these results indicate that birds feed on codling larvae mainly in late summer and early autumn. By winter few larvae are left. Only 20 % of larvae, put out in the orchard in a similar manner in April, were taken during 6 weeks - a much slower rate of predation; because few larvae were left beneath bark in the orchards, birds were presumably searching there less intensively.

Different rates of predation by birds on male and female larvae

Each year since 1972, more male than female moths have emerged in black-cloth traps placed round trunks and branches of trees in our orchard: during the 6 years, 90 males and 49 females have emerged. When birds were excluded from eight trees in 1975-6, however, equal numbers of males and females emerged (67 of each sex).

In an aviary experiment, blue tits were presented with two logs, one with ten male and one with ten female larvae hidden in cocoons beneath the bark. Birds took female larvae faster than male larvae, and left more male than female larvae after a 50 min. test.

Predation on cocooned larvae of codling moth (Cydia pomonella L.) by birds in dessert apple orchards in S.W. England

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Experiments in cider apple orchards with large, old trees at Long Ashton showed that tits (Parus spp.) took about 95 % of overwintering codling moth larvae (Solomon et al. 1976, J.Appl. Ecol. 13, 341-52).

To examine whether similar predation occurred in dessert apple orchards with relatively small, smooth trees, tests were made in orchards at the Research Station. Most of the trees used were Cox's Orange Pippin, but a few were Worcester Pearmain. Birds, including blue tits (Parus coeruleus (L.)) were often seen in the orchards, but were not observed systematically.

We released fully-grown larvae of codling moth on to small branches cut from trees similar to those in the relevant orchards. The larvae were allowed to spin their cocoons in natural crevices on the branches, or under flakes of bark fixed in place with water-proof cement. The positions of the spun-up larvae on the branches were recorded in sketches, then the branches were tied into trees in natural positions, so that they were difficult to distinguish. The added flakes of bark were also inconspicuous. At intervals of about one month the site of each cocoon was examined to determine whether it was intact, or had been opened up by birds.

In one orchard, 51 larvae on 13 branches were put out on various dates from 17 November 1975 to 15 January 1976. By 26 May 1976, 38 of the cocoons had been torn open and the larvae or pupae taken (74, 5 % mortality). In contrast, 28 larvae on six further branches that had been caged in wire netting (13 mm mesh) when they were placed in the orchard on 26 November were all present in intact cocoons on 26 May as larvae or pupae, although two had died. This site was

surrounded by other orchards, but with domestic gardens within a few hundred metres.

A second orchard was also fairly close to gardens, and to woodland and scrub. Here 22 larvae on eight branches were put out on dates from 12 December 1975 to 27 February 1976. By 25 May, 15 of the larvae had been taken (68 % mortality).

Thus, birds can remove many of the larvae or pupae in cocoons in dessert apple orchards. The effect is likely to depend on the nature of the trees and the surroundings. There may be scope for attracting tits by providing nest boxes and/or feeding stations.

Codling moth parasitism in U.S.S.R.

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The codling moth is presently existing in the Soviet Union to Novosibirsk in Siberia. The quarantine service of the U.S.S.R. is considering as unavoidable its diffusion in all the apple growing regions of Siberia (Konstantinova, 1976).

The studies concerning the composition of the codling moth parasite complexes found on larvae and pupae, has been developed during the last years in U.S.S.R (see table Tchekmeniov, 1976). They have allowed to put in evidence situations particulary interesting in the following regions, where codling moth shows 3 generations / years.

1- The south-east of Kazakhstan, toward Alma-Ata (literally "father of the apple"), aera situated in the original region of the apple and probably of the codling moth: The specific parasitic structure (studied by Zlatanova, 1976) is poorer than in the two yearly generations area, but the total parasitic efficiency attained in neglected orchards 25 to 90 per cent. The main species are Microdus rufipes Nees and Ascogaster quadridentatus Wesm. (Braconids). M. rufipes is by far the most active: it represents the 7/10th of the total parasitism; in Netherland it is mentioned as a parasite of Spilonata ocellana.

The laboratory rearing of . rufipes and the definition of chemical control conditions, susceptible to save it, allows considering its use for a biological control. Other parasitic species are present in the south Kazakhstan where the researches have begun in 1976.

2- The Central Asia, Uzbekistan particulary, where the codling moth entered relatively recently without its parasites. In the Tashkent region andin the Fergana Valley, Abdullaev (Tchekmeniov, 1976) has found 24 natural enemies of the

codling moth, including 3 new ones appear to be the most important: the ectoparasite Mastrus sp., which attacks 60 % of the larvae, Liotryphon punctulatus 50 % and the mite Pyemotes which kills 30 % of the pupae and larvae. Moreover Ascogaster quadridentatus, in the Namagan region, destroys up to 50 % of the larvae. These rates prove the existence, in those area, of a natural regulation in the codling moth population by parasitism.

The problem of using entomophagous, parasiting larvae and pupae, in the range of an integrated control against the codling moth is now set on new basis because of: (a) the possible acclimatization of efficient larvae and pupae parasites and the constitution of parasitic complexes; (b) the way of selective control methods against the codling moth, insuring the respect of the introduced fauna.

List of the most effective parasites of codling moth larvae and pupae presents in U.S.S.R.

(from TCHEKMENIOV, 1976)

	Species of parasites or predators	Rates of parasitism or predatism	Aeras	Authors
	Pristomerus vulnerator Panz (Ichneumonidae)	82	Ukrainia, 1965	V.A. GRODSKI, 1967
	Microdus rufipes Nees (Braconidae)	14 - 60	Kazakhstan 1965-1970	A.A. ZLATANOVA, 1970
	Ephialtes sp. (Ichneumonidae)	25 - 60	Alma Ata	idem
N	Liotryphon punctulatus (Ichneumonidae)	50	Tachkent - Ouzbekistan	E.N. ABDOULLAEV, 1972
	Ascogaster quadridentatus Wesm. (Braconidae)	50	Namangan - Ouzbekistan	idem
N	Mastrus sp. (Ichneumonidae)	60	Fergana - Ouzbekistan	idem
N	Pyemotes sp. (Pyemotidae - Tarsonemidae)	30	Tachkent	idem
	Epiurus tenchaus Rtzb. (Ichneumonidae)	30	Kirghizia	N.L. BOGDANOVA, 1964
	Neoplectops pomonella (Tachinidae)	26	Kiev 1970	V.M. TKATCHIOV, 1974

N = new enemy of codling moth

Infection of the braconid parasite Ascogaster quadridentata (Hymenoptera: Braconidae) by a microsporidan of its host Laspeyresia pomonella

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As examples in Austria had shown that mass breeding and release of the braconid parasite Ascogaster quadridentata was able to increase natural mortality of the codling moth remarkably, such a parasite rearing was started in Stuttgart, using the Austrian parasite strain and the own host codling moth strain. In spite of identical rearing conditions, the longevity and survival of the parasites in Stuttgart was low initially and went down to almost zero.

Histopathological studies revealed heavy infections by the microsporidan Nosema carpocapsae in nearly all larvae, pupae, and adults of the codling moth and in most pupae and adults of the parasite. In the endoparsitic larvae, although surrounded by heavily infected host tissues, foci of microsporidan infection were only observed in the epithelium of the anal vesicle. In addition, the later final instar of the parasite, feeding directly on host fat body, harbours masses of microsporidan spores in its large blind-sac midgut. While the solitary parasite larvae are emerging and spinning their cocoons outside the host the infection is spreading to many organs and tissues. Thus, extended foci of microsporidan reproduction were generally observed in the pupal midgut epithelium, silk glands, and Malpighian tubules. Other pupal organs may be infected to a lesser and varying extent. Heavily infected pupae often are not capable of developing to adults. Adults that managed to emerge mostly showed heavy or varying degrees of practically generalized infection. Such individuals rarely mate and their life-span is drastically reduced.

These observations explain the breakdown of the rearing of : quadridentata and demonstrate the inherent danger of using infected host material for parasite rearing. In the case of codling moth, this is not easily avoided because of the wide-spread occurrence of chronical infections by - carpocapsae.

Investigations on the effect of pesticides on the parasitation performance of Ascogaster quadridentatus Wesm.

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Ascogaster quadridentatus Wesm. is one of the most important parasites of codling moth. Especially by releasing large numbers of the parasites it is possible to achieve a high rate of parasitation.

In connection with studies on the integration of different pest control methods, it is planned to depress the codling moth population during the growing season by releasing large numbers of the parasite. Due to the fact, that the use of chemical plant protection agents is still an essential tool in integrated pest control, it will be necessary to test the side effects of such agents, especially those affecting the parasitation performance of the parasite. Therefore work has begun on a method to determine parasitation performance of Ascogaster under laboratory conditions.

Method of investigations: Eggs and larvae of the codling moth, reared on a semiartificial medium (Shorey and Hale) are used as hosts. In order to guarantee an uniform egg-laying of the codling moth, a special "egg-laying device" was constructed and tested for its suitability. This egg-laying device consists for the main part of two cubic egg-laying chambers, two sides of which are covered with square glas plates (10 x 10 cm). The inner area of both chambers is completely laid out with a rough plastic covering which prohibits egg-laying on these surface. Eggs are only laid on the glass plates. To insure an uniform egg deposit on the two opposite glass surface both chambers are attached to a shaft with a variable turning velocity. By removing surplus eggs it is possible to arrive at a standardised number of eggs for parasitation experiments.

Orientation experiments performed up to now on the side-effects of pesticides show that among insecticides there are very toxic compounds, whereas fungicides are relatively less injurious. Preliminary guidelines for the investigations on the side-effect of pesticides on Ascogaster were prepared.

Chemical control

Control of codling moth with diflubenzuron

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In laboratory bio-assays in 1974, newly-hatched larvae of Laspeyresia pomonella were placed on apples sprayed with concentrations up to 500 p.p.m. of diflubenzuron (Dimilin) and the insecticide had no effect on development to the adult stage; in a field trial, however, it gave excellent control due to ovicidal effects. Field trials on apples from 1975-77 were of randomized block design with 6-8 replicate plots per treatment, of 2-4 trees in 1975-76 and 12-16 trees in 1977. High-volume sprays were applied by lances to 'run-off' on dates considered optimal for organophosphates (OPs) and carbaryl i.e. first spray when the eggs began to hatch. Table 1 shows that diflubenzuron provided control at least as good (not significantly better, $E = 0,05$) as that provided by azinphos-methyl at standard rates and at concentrations down to 100 p.p.m. in 1976, a season in which the attack was unusually heavy.

Table 1. Results of field trials with diflubenzuron, 1974-76: percent codling-damaged fruit, including drops. Percent control, compared with untreated plots, shown in parentheses

No. of sprays/ concentration, p.p.m.	1974	1975	1976
Untreated	3,8	5, 8	8, 1
Azinphos-methyl			
2 x 330	0, 4 (89 %)	0, 8 (86 %)	2, 4 (70 %)
Diflubenzuron			
2 x 500	0, 1 (97 %)		
1 x 500		0, 6 (90 %)	
2 x 250		0, 2 (97 %)	
1 x 250		0, 5 (94 %)	1, 8 (78 %)
2 x 100			1,7 (79%)
1 x 100			1,9(77%)

Table 2 shows the results of a trial in 1977 in which diflubenzuron at two low rates was compared at an 'early' and a 'late' timing in relation to the phenology of the pest, as determined by pheromone trap catches and accumulated heat sum. Oviposition and hatching of the eggs commenced on about 21st June and 5th July respectively. First generation catches in Codlemone traps totalled 90-160 moths and there was a light fruit load. However, fecundity was probably low in this cool, wet season, and damage by codling on unsprayed plots was patchy and rather light. The control obtained from both timings using 50 or 100 p. p. m. diflubenzuron was satisfactory and of the same order. The apparently greater damage with treatment 4 (Table 2) may have been due to the lower fruit load. On large adjacent plots receiving three sprays of azinphos-methyl (2, 1 1/ha Gusathion on 5th and 19th July, 2nd August) the percentage damage was 0, 9 %.

Table 2. 1977 trial: percent codling-damaged fruits, including drops.

No. of sprays/ concentration, p. p. m.	Dates of application	% damaged fruit	No. of fruits/tree
2 x 50	21. 6. & 5. 7.	0,69	168
2 x 50	5.7. & 19.7.	0,65	153
2 x 100 +	21. 6. & 5. 7.	0,59	236
2 x 100	5.7. & 19.7.	1,35	87
Untreated		4,50	100

+ 100 p.p.m. is equivalent to 1 kg/ha.

Three other plots of 0, 5 - 1 ha in size were power-sprayed in 1977 using 0, 25 kg diflubenzuron (= 1 kg Dimilin 25 w) in 1000 l water per ha on 5th and 19th July (one plot on 5th July only), compared with 0, 46 kg azinphos-methyl on 5th and 19th July, and 2nd August. Damage was below 1 % on all plots.

The toxicity of diflubenzuron to the phytoseiid Typhlodromus pyri, and to

Panonychus ulmi as prey, was tested in 1974 and 1976 by spraying infested potted Prunus rootstocks in a greenhouse. In assessments up to 5 weeks after single sprays were applied, 330 p.p.m. azinphos-methyl killed 100 % of .!· but 250 and 500 p.p.m. diflubenzuron caused no reduction when compared with untreated check plants. In both pot and field trials it was not toxic to _!l. ulmi.

In a replicated trial in 1974 on hedges of Alnus glutinosa, 500 p.p.m. diflubenzuron reduced numbers of immature mirids, Blepharidopterus angulatus, but caused no reduction in adult numbers 1, 3 and 5 weeks after spraying on 25th July, compared to a drastic reduction caused by 330 p.p.m. azinphos-methyl. In a similar trial in 1975, spraying earlier (10th July) in the seasonal development of !3. angulatus, 250 p.p.m. diflubenzuron caused 95 % reduction of immature mirids within 2 weeks, and consequently few adults developed. Diflubenzuron was toxic also to immature Anthocoris nemoralis but not to adults.

In a five-year study in an experimental orchard the relationship between '!:.. pyri and .E. ulmi has been unstable; and this instability may result from predation by !3. angulatus on _!. pyri when spider mite numbers are low. If this is so, diflubenzuron - toxic to !3. angulatus but not to '!:.. pyri - may be an ideal agent for control of codling moth in an integrated pest management system.

Codling moth control: Results of the diflubenzuron tests

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The insecticides strictly acting by ingestion on the Lepidoptera as the codling moth (Laspeyresia pomonella L.), bring forward an extensive interest for the integrated control, due to their ecological selectivity. The diflubenzuron (= Dimilin) insecticide which has just detained a temporary authorization for sale in France, in view of the codling moth control seems to answer to these requirement (Audemard and al., 1975). Practical efficiency tests have been realised in 1975, 1976 and 1977 in the Avignon region on complete apple orchards in full commercial production. Their planning organization has taken its origine from the schedule presented to a preceding meeting of our working group (Audemard 1975/1977).

In 1975 the spraying has been delayed to 14 days; the dosage of diflubenzuron was of 30 g. a. s. /hl. (gramme of active substance per hectolitre) which allowed to obtain an excellent result: (a) the interruption of the control at the beginning of August; (b) only 0,3 per cent of unmarketable fruits at the harvesting period (due to codling attacks); (c) a complete elimination of hibernating larvae.

After this result the dosage was lowered to 20 g, in 1976. The sprayings were adjusted depending upon the interpretation of adult catches by sexual traps and from the pupae evolution. The control has been suspended at the end of July in spite of a partial third generation. The attack at harvesting time has only of 0,5 per cent and the population has been strongly lowered. This efficiency is similar to that observed on an adjoining orchard sprayed with the phosalone.

In 1977, in the two trials, only the 2nd generation is controlled in order to see the incidence of the attack traces on the economic result. The spraying dates are depending from the observations, but the 1st spraying is applied at the beginning of the laying period in order to obtain an action on the eggs. The theorical spacing between two applications is brought to the maximum of 3 weeks.

An acceptable economic result has been obtained: 1, 0 and 0, 7 per cent, respectively of fruits attacked. The population has strongly increased, but this is only due to the abnormally high proportion of 1st generation diapausing larvae (more than 70 per cent); this is consecutive to the exceptional climatic conditions. The control strategy against the only second generation has been in such case totally inadequate.

In other regions some trials have been realised this year on the 1st generation only. In the mean Rhone Valley the lack of protection, because of the rainfalls, have involved less good results. In the Central region, where 2 sprayings have been used and the first one early, the efficiency is very good.

A particular attention is to be given to the other Arthropod pests present in the diflubenzuron treated orchards. Panonychus ulmi Koch does not seem to have been favoured; on the other hand the population of Lithocolletis blancardella L. undergo a depressive action.

TABLE 1: CODLING MOTH CONTROL BY I.G.R. DIFLUBENZURON

RESULTS OF PRACTICAL EFFICIENCY TESTS 1975, 1976, 1977

Years / Amount of diflubenzuron in g. active substance hectolitre	Generation controlled / Numbers of sprayings	Fruits damaged unmarketable p. cent / confidence limits (1)		Population dynamic (on 40 trees)				Numbers of acaricidal sprayings
		1 st. generation	harvest time	Hibernating larvae Beginning of the year	1 st. generation sum = diapausing larvae + pupae	2 nd. generation sum = diapausing larvae + pupae	3 rd. generation hibernating larvae at the end of the year / direction of evolution population	
1975 30	1 + 2 (partial) 6 sprayings (2)	0, 60 0, 36-0, 84	0, 30 0, 13-0, 47	200 * (3)	3 0 + 3	0	0	2
1976 20	1 + 2 (partial) 4 sprayings	0, 40 0, 20-0, 60	0, 50 0, 28-0, 72	55 *	16 3 + 13 *	6 1 + 5	5	2
1977 20	2 3 sprayings (2)	0, 90 0, 60-1, 20	1, 00 0, 69-1, 31	5	120 104 + 16 *	13	117	1
1977 20	2 3 sprayings (2)	0, 70 0, 44-0, 96	0, 70 0, 44-0, 96	10	202 166 + 36 *	23	189	2

(1) Confidence limits for P = 0, 95.

(2) One of them due to rainfall 1975. Interval between sprayings non observed because of rains.

(3) Catches in trap band 760. The number of coconing sites had restricted the population to 200.

(4) Hibernating larvae = diapausing larvae of 1 st. generation + 2 nd. + 3 rd. (eventually).

* Exceeding the threshold. Without control the damages would be exceeding the 2 p. cent limit.

Insecticide tests for codling moth control: Perfecting the experimental processus

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The Biological Tests Commission of the French Society of Phytiatry and Phytopharmacy has entrusted a working group to revise the Coutin (1964) test method of practical efficiency for chemicals to be used against the codling moth (Laspeyresia pomonella L.).

This working group shall submit to the B. T. C. an experimental test processus following the orientations determined by Audemard, Coutin, Hennequin (1977, unpublished data). It must be born in mind that the tested insecticides aim to control the codling moth by significantly rising the mortality at the stadiums of egg and young larva. The objective is to collect precise informations on the efficiency of these insecticides against the codling moth. This is tobe obtained through tests under artificial conditions and in the orchard, in order to get to a method of real practical value.

The experimental processus includes the following three steps:
1 - Trials on green apples under controlled conditions. They allow (a} to make a choice between the most interesting chemicals; (b} to determine the active dosage and in the mean time the residual action. The trials can be repeated the same year and are very precise. The harvested fruits are: maintained under shelter at the outside conditions, protected from rain, infested by eggs from reared females for ovicide or larvicide tests.
2 - Tests of "Chemical behaviour" in highly infested orchards (natural population or population reinforced by artificial infestations). They enable to make a comparison between: the che.nicals, their dosage, a check situated outside and a check chemical in regard to which a classification is obtained.

After the two first steps, it may be decided to put a term to the experiment.

3 - Practical efficiency trials in a commercial orchard. They are carried out on a complete small orchard according to the principles of the Audemard tests (communication at the preceding meeting group, 1975). They allow to investigate the methods of application of the chemicals and to well appreciate their action on the codling moth population dynamics as well as their secondary actions. These trials are safe for the crop and to susceptible tobe repeated.

In this way, efficient and well known chemicals are offered to the fruit growers limiting in the mean time the expenses devoted to the experiments by the firms.

Recommendations

1. The International Working Group on codling moth should continue as now envisioned to maintain a high degree of communication between institutes and countries involved. Direct information exchange and coordinated work between all interested institutes, esp. between the working groups of IOBC - WPRS and - EPS on codling moth, on integrated control in orchards and on apple-pear-ecosystem should be encouraged.

2. There is a serious need for accurate forecasting of population and determination of factors influencing various monitoring methods. In this regard, the reliability of band traps in different countries should be determined. The isolation of a female attractant could be a useful tool in population monitoring systems.

3. Evidence for races, biotypes and inter-habitat movements must be investigated in more detail. More critical assessment of populations developing in forests on wild hosts is needed.

4. More information is needed on egg mortality, on early instar mortality and on egg production in the field in order to understand more thoroughly the dynamics of the local codling moth populations.

5. Further evaluation of predator, parasite and pathogen complexes on codling moth is needed. Cultural practices must also be considered in this regard.

6. Research on disorientation techniques as commercial control methods should be supported by the group. A common effort by the group may alleviate the problem of obtaining pheromone and pheromone formulations.

7. There is a significant need for the development of highly automated mass-rearing systems. for codling moth and othsr lepidopterous pests that could be used on a commercial scale for production of parasites, pathogens and utilization of the SIT. Quality control must be an integral component of such systems. Dr. Russ of the Bundesanstalt für Pflanzenschutz, Vienna and Dr. Szalay-Marzs6 of the Research Institute for Plant Protection, Budapest expressed a willingness to conduct quality control tests for members of the group. A need for more communication among mass rearing specialists was recognized.

8. Technical feasibility of the SIT for codling moth control has been demonstrated. Initiation of new programs should be done only after thorough investigation of the ecology, costs and efficiency of rearing, competitiveness of moths and potential cost benefits as it relates to the cropping systems.

9. Safety and efficacy testing, registration formalities, and commercial utilization of the granulosis virus should be fully supported by national and international organizations.

10. The lethal and sublethal effects of pesticides on codling moth and natural enemies should be investigated further. In addition, the stages actually affected by field applications of pesticides should be determined, i.e. neonate larva, eggs, moths etc.

11. More research is needed on the interaction of pests in apple, pear and walnut orchard ecosystems. Due to the specificity of control methods, as SIT, application of granulosis virus etc., the population dynamics of other species in these ecosystems should be determined as it relates to such control measuires.

12. Cooperation with universities, perhaps by supporting graduate students, in answering specific research problems should be promoted.

The participants of the Joint
FAO/IAEA and IOBC;WPRS
Research Coordination Meeting
at Heidelberg

Alphabetical List of Authors

Die „MitteiIungen aus der BioIogischen BundesanstaIt für Land- und Forstwirtschaft BerIin-DahIem" erscheinen in zwangloser Folge als Fortsetzung der „Mitteilungen aus der Biologischen Reichsanstalt für Land- und Forstwirtschaft in Berlin-Dahlem".

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