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LUTTE BIOLOGIQUE EN VERGERS
BIOLOGIE ET LUTTE CONTRE LE CARPOCAPSE

BIOLOGICAL CONTROL IN ORCHARDS
BIOLOGY AND CONTROL OF CODLING MOTH

WYE (U.K.)25-29.3.1980

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

INTERNATIONAL ORGANIZATION FOR BIOLOGICAL CONTROL
OF NOXIOUS ANIMALS AND PLANTS

STANDING COMMITTEE ON AGRICULTURAL RESEARCH OF
THE COMMISSION OF THE EUROPEAN COMMUNITIES

BIOLOGICAL CONTROL
OF PESTS IN ORCHARDS

BIOLOGY AND CONTROL
OF CODLING MOTH

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REPORT OF THE MEETINGS ON BIOLOGICAL CONTROL IN ORCHARDS, AND BIOLOGY AND CONTROL OF CODLING MOTH, AT WYE 25-29 MARCH 1980.

1. Organization of the meetings

These two meetings were held consecutively because of the many points of contact between the two subjects.

The first meeting (on biological control in orchards) was organized by the working party on integrated control in orchards of the International Organization for Biological Control-West Palaeartic Regional Section (IOBC-WPRS); it was also accepted as an 'exchange of scientists' by the Standing Committee on Agricultural Research of the Commission of the European Communities (EC), as a part of their programme on biological and integrated control of pests.

The second meeting (on biology and control of codling moth) was organized by the codling moth group of IOBC-WPRS.

Thirty-two people from nine countries attended one or both meetings.

2. Summary of the main results

Biological control of Panonychus ulmi by native phytoseiid mites has proved very successful in the UK and the Netherlands. Possible causes of failure in other European countries, such as climate or the use of certain pesticides, should be investigated urgently. Predatory Heteroptera could temporarily suppress, but not lastingly control, P. ulmi. Stethorus punctillum effectively controlled P. ulmi in the Emilia Romagna region in Italy.

Electrophoretic and video recording techniques showed promise for unravelling details of predatory behaviour in the field. A laboratory technique for testing the effect of pesticides on phytoseiid mites has been developed.

Anthocoris nemoralis proved an effective predator of pear psylla in several countries. Biological control was, however, easily disturbed by measures directed against other problems, but certain pesticides if carefully timed could successfully be combined with biological control.

The complex of aphid predators reduced, but could not prevent, damage by aphids.

Apple leaf midge has increased in several apple growing regions. During studies on the parasites of Dasineura mali, another probably phytophagous gall midge, Macrolabis sp., was found in the southern part of Europe. Several parasites of leaf midges were found but their impact, as well as that of midge predators including phytoseiid mites, is not yet sufficiently known.

Cultural measures severely affected the abundance of ground predators in orchards.

Selective control of codling moth and other insects allowed fruit-surface feeding tortricids to increase. The study of natural control factors of these tortricids has begun and should be expanded.

The fungus, Beauveria bassiana, and the egg parasite, Trichogramma, affected codling moth populations to some extent, but insufficiently for economic control.

The alternatives to pesticidal control of codling moth studied most intensively in the last two years were granulosis virus and mating disruption by pheromones.

Fiels tests with granulosis gave positive effects of variable persistence. Collaborative tests under different climatic conditions are proposed for 1981 with material produced in the USA.

Mating disruption by evaporation of pheromone gave positive results in several tests but was disappointing in one test. The causes of this difference, which may be connected with the population pressure of codling moth, will be investigated if the supply of the pheromone and of formulations permits.

The largely selective compound diflubenzuron has proved its very long lasting efficacy.

New data on the behaviour of moths, such as dispersal, orientation to visual and chemical cues, mating, oviposition, and on the dynamics of populations help to understand the mode of action of alternative control methods.

3. Further details

Details of the matters discussed can be found in the summaries of the papers presented.

4. Standardized experimental procedure

During the discussion on biological control of spider mites, attention was focussed on the fact that phytoseiids are effective biological control agents of P. ulmi in some countries but not in others. Because several conditions differed between the experiments in the different countries, it was not possible to identify the causes of the different results. Therefore, a standardized procedure, particularly as far as pesticides are concerned, was deemed necessary. A proposal for a standardized procedure was briefly discussed at the meeting and amended afterwards by several participants (see Annex 1).

5. Conclusions and recommendations

1. It was useful to have a joint meeting on biological control in orchards and on selective control of codling moth. The need for alternatives to pesticidal control has become very urgent in recent years because of increased resistance in certain pests, such as pear psylla. Evidence for the potential value of phytoseiid mite and insect predators for biological control of spider mites, and of anthocorids for the control of pear psylla, is accumulating in several countries and is beginning to influence commercial fruit growing in practice. To enhance the contribution from natural enemies it will be necessary to develop selective control of codling moth and various tortricids. Methods of achieving such selective control by the use of viruses or pheromones have made considerable progress. We are aware that an EC group is considering the requirements for toxicity tests and the health hazards in relation to biological pesticides. We consider this subject to be highly important and our orchard group would appreciate hearing the results of discussions by the EC group.

2. A considerable part of the work discussed at these meetings was supported by EC funds, which shows that the IOBC working party on integrated control in orchards and EC are aiming at the same goals. We wish to record our appreciation for this

funding and for the further support of the EC in funding the attendance of a number of participants.

3. There is a need to study how the activities of IOBC and EC in the field of integrated control in orchards can best be harmonised, in order to use funds and resources to best effect.

4. With regard to future activities of the Integrated Control in Orchards group, we recommend that these should include a meeting at which nonpesticidal control techniques, especially biological and cultural methods, are considered for the following groups of pests:

   (a) codling moth and other tortricids
   (b) phytophagous mites
   (c) pear psyllids

   It could be advantageous to hold such meetings on consecutive dates, in about two years.

5. There is a growing need for standardised procedures for field trials to investigate the value of natural enemies and of other non-pesticidal techniques under the conditions of different fruit-growing regions.

April 1980,

J.E. Cranham
P. Gruys
H. Steiner
Th. Wildbolz

LIST OF PARTICIPANTS AT IOBC/WPRS MEETINGS CEAS, WYE, 25-28 MARCH 1980.

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ANNEX 1

PROPOSAL FOR A STANDARDIZED EXPERIMENTAL PROCEDURE FOR FIELD TESTS ON BIOLOGICAL CONTROL OF PANONYCHUS ULMI IN INTEGRATED PEST MANAGEMENT IN ORCHARDS.

General considerations

Panonychus ulmi, one of the main pests in orchards, is successfully controlled biologically by phytoseiid mites in some countries but not in others. A standardized experimental procedure for testing the potential of phytoseiids in the different climatic regions is urgently needed. For the sake of comparison it is essential that factors other than climate be as much the same as possible, particularly pesticides. There are, however, differences between countries in the approval of pesticides which have to be considered, and preferences as to the use of certain pesticides which should be considered if possible. The essential point is that only those pesticides definitely known to be non-toxic to the local phytoseiid species should be used. In the proposal, generally acceptable pesticides are mentioned in the text and regional modifications mentioned in notes.

Problems

Primary:

- Is biological control of mites sufficient in the different climatic regions?
- Which species of predators are responsible for biological control of mites?

Secondary:

- Which species of tortrix are important when other pests, particularly codling moth, are controlled selectively?
- Which minor pests tend to increase when selective pesticides are used? Are these outbreaks permanent or transitory?

Orchard

- Apple orchard, 5 years or more old
- minimum acreage 0.5 ha
- sufficiently isolated to prevent spraydrift from adjacent orchards and to minimize immigration of pests
- experiment to be continued for at least five years
- use only pesticides known to be selective
- fertilizers, pruning, and herbicides as in usual practice.

Pesticides

- scab: captan 1);
- mildew: bupirimate, triadimefon, nitrothal-diiso-propyl 2), or ditalimfos (Plondrel)
- storage diseases: captan 3);
- canker (sprays in late autumn or winter): captan or captafol 4);
- DO NOT USE the following fungicides: mancozeb, maneb, zineb, thiram, metiram, dinocap, sulphur, binapacryl, and others if not subjected to field tests prior to use in the experiment;
- codling moth: Laspeyresia pomonella granulosis virus, mating disruption, or diflubenzuron;
- tortrix moths: do not control, or use
  - for Adoxophyes orana: A. orana nuclear polyhedrosis virus, mating disruption, Bacillus thuringiensis on first generation in June-July, or IGR (Ro10-3108/18 or Ro13-5223) on hibernated L5 in May;
  - for other species, including Pandemis: Bacillus thuringiensis, IGR, or diflubenzuron;
- winter moth and noctuids: diflubenzuron;
- mites: white petroleum oil at mouse-ear, benzoximate, tetradifon, or fenbutatinoxide; do not use or be very careful with cyhexatin 5);
- aphids: pirimicarb;
- woolly aphid: pirimicarb 6);
- oystershell scale: white petroleum oil 5% at mouse-ear;
- Lygus pabulinus: white petroleum oil 3% at mouse-ear;
- apple sawfly: diflubenzuron 7);

- apple blossom weevil: diflubenzuron when the weevils have started feeding but before oviposition 8);
- crop thinning: naphthalene acetamide 9);
- phytoseiids: wait for natural colonization or introduce them from unsprayed trees.

Assessments

- mites: Panonychus ulmi eggs on 2 metres of 2-3 year old branches in winter; number of mites (including Aculus: estimate on part of leave when numbers are high) per 100 leaves immediately after blossom, and in June, and August;
- phytoseiids: identify and assess numbers per 100 leaves on same dates as phytophagous mites;

NB: these assessments of mites are a bare minimum; in addition electrophoretic work on preys consumed by mite predators would be useful;

- anthocorids, mirids, Stethorus: number per 100 beats on same dates as mites;
- codling moth attack and numbers in pheromone traps and corrugated paper bands;
- species of tortrix present around bloom (rear on artificial medium), numbers per 100 clusters and parasites 10);
- tortrix per 100 shoots (Adoxophyes), July, and parasites;
- tortrix injury to fruit and species responsible;
- pheromone trap catches of tortrix moths;
- occurrence of minor pests.

Comparison

- The value of the experiment will be enhanced by the availability of a similar plot subjected to the usual broad spectrum sprays as a standard for comparison.

Notes

1) Dodine (pre-blossom) is acceptable but not approved or commonly used in some countries.

Thiophanate-methyl, used incidentally, is acceptable but not approved in some countries.

Folpet and dithianon are used in some countries and possibly acceptable but these fungicides have not yet been put to field tests om toxicity to phytoseiids.

2) In some countries, nitrothal-diisopropyl is only available as a mixture with metiram, sulphur and/or maneb. These mixtures should not be used. Fenarimol has not yet been put to a field test on phytoseiids.

3) Thiophanate-methyl is acceptable nut not approved in some countries.

4) as 3)

5) Cyhexatin proved detrimental to phytoseiids in the Netherlands but, at half strength, was found compatible with biological control in the UK.

6) If woolly aphid is persistent,pirimicarb may prove insufficient, and Thiodan 0.15% or Thiodan in 2% petroleum oil can be used in early spring at the beginning of wax formation (March), when beneficial arthropods are still hidden.

7) Under heavy sawfly pressure thiophanate-methyl at pink bud gives better results; see 3).

8) Eggs laid by diflubenzuron-fed females will fail to hatch.

9) Insufficient in regions with a cool climate. Carbaryl proved acceptable on *Typhlodromus pyri* but should not be used unless its harmlessness to the local species of phytoseiid has been proved.

10) For assessment of the species of tortrix and parasitization, large samples of larvae have to be collected.

EVOLUTION OF PEAR PSYLLA (PSYLLA PYRI (L.) AND BENEFICIAL INSECTS IN PEAR ORCHARDS OF SOUTHEASTERN FRANCE IN 1979

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During the year 1979, in two pear orchards near Orange, populations of pear psylla and various predators were studied by weekly visual counts on 4-10 twigs and by beating fortnightly 60 branches. This last sampling was done using 10 elementary plots in one orchard and 6 rows in the other so as to appreciate ecological relationship on a spatial basis.

Sprays were omitted in one orchard except fungicides and cyhexatin in spring and amitraz on July 7th. In the other orchard an abundant watering was applied with a rain-gun on July 10th to wash off honeydew.

Results show that, for the most part, beneficial insects were linked mainly to mites: this was the case for Orius sp. and an Orthotylus, identified as nassatus (L.), but also for Deraeocoris (Knightocapsus) lutescens (Schil) though its numbers are related partly to psyllids. Araneids clearly responded more to cicadellids.

So the only important predator of P. pyri in these orchards was Anthocoris nemoralis (F.) even if D. lutescens and chrysopids may have sometimes played a role.

Considering P. pyri and A. nemoralis the situation was strongly different in the two orchards. In the non-irrigated one, pear psylla followed a continuously decreasing trend from July onward while the predator regularly increased. In the other, the constant summer increase of the pest seemed related, at least in part, to the lack of second generation A. nemoralis. There is still some question about the reasons for these differences which could have been induced by a poorer growth of the trees (less favourable to psyllids) in the non-irrigated orchard, and by a more depressive effect on predators than on prey by overhead sprinkling in the other orchard.

Nevertheless biological regulation of pear psylla seems easily disturbed by measures directed against other problems.

INTEGRATION OF CHEMICAL AND BIOLOGICAL CONTROL OF PEAR PSYLLA IN KENT

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Pear psylla (*Psylla pyricola* Förster) is the key pest of pears in Kent. From the early 1950s up to the mid 1970s *P. pyricola* was effectively controlled with OP- insecticides such that other control measures were not necessary.
However, in 1976 difficulties were experienced in achieving satisfactory control, and bioassay showed that resistance to OP- insecticides was widespread among psylla populations.
A new approach to control of pear psylla was urgently required.

The possibilities were immediately investigated of utilising natural enemies of pear psylla in integrated control schemes. Of the numerous insect species found preying upon *P. pyricola*, anthocorids particularly *Anthocoris nemoralis* were the most important. It was found that the broad spectrum insecticide permethrin when used at bud-burst, reduced the numbers of overwintered adult psylla (thereby curtailing oviposition), and had little disruptive influence on the later build-up of predators. Amitraz gave effective control of psylla larvae in the post-blossom period without harming predators. Other selective pesticides were identified which controlled the more minor pear pests.

The aims of current research are to clarify reliable pest threshold densities when intervention with pesticides is desirable. In addition the timing of pesticide applications is being investigated in more detail.

ROLE AND EFFECTIVENESS OF PREDATORS IN CONTROLLING APHIDS IN APPLE ORCHARDS

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Predators occurring in apple orchards either prey mainly on aphids (as do Coccinellidae, Syrphidae, Cecidomyiidae, Chamaemyiidae) or they feed on a wider variety of prey (as do Chrysopa carnea, Anthocoris nemorum, Orius minutus and several species of mirids).
Coccinellids play the most important although 'invisible' role in the spring, when it is mainly the adults of Adalia bipunctata, Coccinella septempunctata and Propylea quatuordecimpunctata which kill single mature aphids, newly hatched larvae or small aphid colonies, even when there are few aphids (Rhopalosiphum insertum, Dysaphis plantaginea, Aphis pomi). In some orchards this action destroyed 20-50% of potential aphid colonies. Adult coccinellids were more responsible for this than their larvae.
Syrphidae are associated with high aphid numbers and their larvae appear 8-30 days, according to the year, after aphid colonies establish, when the infested leaves are distinctly or severely damaged.
They can quickly destroy aphid colonies of moderate size.
Predatory cecidomyiid midges, in years when they are abundant, occur in 25-80% of aphid colonies and destroy 30-80% of the aphids in such colonies, in orchards unsprayed with insecticides.
General predators have little effect on large aphid colonies but can prevent the development of very small ones.
The whole complex of predators during June and July reduces the number of aphids in colonies two- to four-fold. In the majority of Polish apple orchards the predators cannot prevent the damage caused by aphids in years when the latter are abundant, but they can greatly reduce it.

AN ELECTROPHORETIC METHOD FOR ANALYSING THE DIET OF PREDATORS

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The traditional methods for detecting prey proteins in the gut of a predator have been based on immunological reactions. They require the preparation of specific prey anti-sera by injecting prey material into a vertebrate, usually a rabbit, and the subsequent testing of predator samples, usually by the precipitin test. Electrophoresis provides a simpler and quicker alternative method for detecting these proteins.

Various electrophoretic techniques have been used extensively by taxonomists for investigating phylogenetic relationships, but the method has evidently not been exploited in the field of prey detection, partly perhaps because of the sensitivity required for detecting possibly small quantities of prey protein in the gut of a predator. Of the various electrophoretic techniques we have investigated, the one that has given the best results with a range of predator and prey species has involved the use of a polyacrylamide concentration gradient gel, with subsequent staining for esterases (Murray & Solomon, 1978). By this technique it is possible to characterise the prey material in the gut of a single predacious insect or mite.

The method relies on each prey species having at least one esterase that is located in a characteristic position on the gel enabling it to be distinguished from esterases arising from the predator or from other possible prey species. Before beginning a field investigation therefore, it is necessary to test some individual predators that have been starved in the laboratory for a few days, and others that have been fed on possible prey species. It is also necessary to test extracts of leaves that might be an alternative food source for the predators, to eliminate the possibility that esterases common to the fed predator and its prey originated from a common food source.

Studies are continuing, to make the method quantitative rather than purely qualitative, and into microelectrophoretic techniques to increase the sensitivity of the method when dealing with small mites.

Murray, R.A. and Solomon, M.G. (1978). A rapid technique for analysing diets of invertebrate predators by electrophoresis. Annals of Applied Biology 90, 7-10.

BARK BUG, ANTHOCORIS NEMORUM L., AS AN EFFECTIVE PREDATOR OF FRUIT TREE RED SPIDER MITE, PANONYCHUS ULMI (KOCH) ON APPLE

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Bark bug, although a general predator in Polish apple orchards, is numerous only when there are large numbers of spider mites, and acts as a density-dependent factor in controlling the latter. The food requirement for anthocorid larvae in the laboratory, was - depending on the instar - from 50-550 immature mites or from 3-75 adult females daily.
On apple trees, when there was a density of one *A. nemorum* per 50 (or less) leaves, the predators were able to reduce the numbers of spider mites to 0.5-3 per leaf and to maintain them at a low level for the rest of the season. In Polish ordhards, the predator is probably very seldom so numerous. In the orchards which were sampled, only some of the trees (20%) had one anthocorid larva per 60-90 leaves; at this density they can probably only prevent mite numbers from increasing.
The presence of an alternative introduced food, such as the eggs of *Sitotroga cerealella* Oliv. kept predators on the trees when all active stages, but not eggs, of the mites had been destroyed, and resulted in a better control. In Polish conditions, *A. nemorum* is considered to be the predator, which together with other predatory insects, can reduce numbers of *P. ulmi* but is unable to regulate them at a low level for long.

THE ROLE OF ANTHOCORIDS AND MIRIDS IN CONTROLLING FRUIT TREE RED SPIDER MITE IN ORCHARDS IN BADEN-WÜRTTEMBERG

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Several Heteroptera species specialise rather strictly on spider mites as prey. In this sense, the most important Anthocoridae species is Orius minutus (L.) in the northern and central part of Europe and Orius vicinus (Rib.) in southern Europe.

Slightly larger than the above mentioned species is Temnostethus pusillus (H.S.); it could be rarely found on apple trees in South Western Germany, in relatively small numbers, and little is known of its way of life.

Though Anthocoris nemorum L. and A. nemoralis (F.) in general are classified as enemies of aphids, they feed partially at least on spider mites also. In certain periods, during the winter, they suck the eggs of Panonychus ulmi when temperatures are high enough. Also the young larvae may feed on spider mites. In the years 1954-56 A. nemoralis was more frequent than A. nemorum which is now dominant. It may be that this fact is dependent on the increasing of the spider mites population during this time.

There are also some mirid species which specialise on spider mites, like Blepharidopterus angulatus (Fall.), Malacocoris chlorizans (Panz.) and Campylomma verbasci (M.D.).

According to our experience, neither the anthocorids nor the mirids are able to prevent a large increase of spider mite populations; they may contribute, however, in a high degree to reduce and stop a gradation. This is the same function as is known of Stethorus punctillum or Oligota flavicornis (Staphilinidae).

Together with gradation-repressing predators (e.g. phytoseiidae) the anthocorids and mirids may build a very effective controlling system against economic losses caused by spider mites on fruit trees. We should be careful with our plant protection measures to avoid any disturbance of this system.

H. Steiner, Landesanstalt für Pflanzenschutz, Stuttgart

HETEROPTERA from Pyrus malus (weitere Umgebung von Stuttgart) 1954-1959

	Anzahl	Monat
Anthocoridae		
Temnostethus pusillus H.S.	6	VIII-X
Anthocoris nemoralis F.	314	IV-X
Anthocoris nemorum L.	159	IV-X
Orius minutus L.	372	IV-X
Miridae		
Phytocoris tiliae F.	82	VIII-IX
Phytocoris longipennis Flor.	5	VIII-IX
Phytocoris dimidiatus Kbm.	143	VI-X
Megacoelum infusum H.S.	17	VIII-IX
Adelphocoris seticornis F.	1	VIII
Adelphocoris lineolatus Gz.	1	VII
Lygus pratensis L.	11	III, V-III
Lygus pubescens Reut.	20	VII-IX
Lygus kalmi L.	4	IV, VIII-IX
Poeciloscytus unifasciatus F.	1	VI
Licocoris tripustulatus F.	1	V
Stenodema calcaratum Fall.	11	VII-X
Stenodema laevigatum L.	1	VIII
Trigonotylus ruficornis Fall.	1	VIII
Deraeocoris lutescens Schill.	153	IV-VI, VIII-X
Deraeocoris ruber L.	19	VIII
Deraeocoris annulipes H.S.	1	VI
Deraeocoris trifasciatus L.	3	VI
Deraeocoris olivaceus F.	13	VI
Campyloneura virgula H.S.	1	VII
Pilophorus perplexus Dgl. + Sc.	329	VIII-X
Cyllocoris histrionicus L.	2	VI
Blepharidopterus angulatus Fall.	283	VI-X
Globiceps flavomaculatus F.	3	VIII
Orthotylus marginalis Reut.	157	VI
Heterotoma meriopterum Scop.	2	VI-VIII

	Anzahl	Monat
Malacocoris chlorizans Pz.	355	VI, VIII-X
Harpocera thoracica Fall.	1	V
Phylus melanocephalus L.	3	VI
Psallus ambiguus Fall.	709	VI-VIII
Psallus variabilis Fall.	13	VI
Psallus varians H.S.	1	VI
Atractotomus mali Mey.D.	67	VI-VIII
Campylomma verbasci H.S.	185	VI-VIII-X

H. Steiner, Landesanstalt für Pflanzenschutz Stuttgart

HETEROPTERA von Apfelbäumen geklopft (Unterheinriet Kr. Heilbronn), geordnet nach der Konstanz

1956

	Konstanz	Monat	Abundanz	Dominanz
Pilophorus perplexus Dgl. + Sc.	66,7	VIII	327	12,9
Psallus ambiguus Fall.	63,3	VI	501	19,8
Orius minutus L.	55,0	IX	213	8,4
Campylomma verbasci H.S.	53,3	VI	166	6,5
Anthocoris nemorum L.	46,7	X	131	5,2
Blepharidopterus angulatus Fall.	46,7	VIII	265	10,4
Malacocoris chlorizans Pz.	45,0	IX	353	13,9
Orthotylus marginalis Reut.	41,7	VI	97	3,8
Phytocoris dimidiatus Kbm.	36,7	IX	123	4,8
Deraeocoris lutescens Schill.	33,3	VIII	82	3,2
Phytocoris tiliae F.	31,7	VIII	55	2,2
Deraeocoris ruber L.	15,0	VIII	19	0,7
Anthocoris nemoralis F.	11,7	IV-X	32	1,3
Piesma maculata Lap.	10,0	V, VIII	17	0,7
Megacoelum infusum H.S.	8,3	-	16	0,6
Phytocoris longipennis Flor.	5,0	VIII	5	0,2
Phylus melanocephalus L.	5,0	VI	3	0,1
Atractotomus mali Mey. D.	5,0	VII	7	0,3
Temnostethus pusillus H.S.	3,3	VIII	4	0,2
Lygus pubescens Reut.	3,3	VII-IX	3	0,1
Deraeocoris olivaceus F.	3,3	VI	2	0,1
Globiceps flavimaculatus F.	3,3	VIII	3	0,1
Palomena prasina L.	3,3	V-VI	2	0,1
Reduviolus rugosus L.	1,7	VI-IX	3	0,1

THE ROLE OF STETHORUS PUNCTILLUM IN THE INTEGRATED CONTROL OF THE EUROPEAN RED MITE IN APPLE ORCHARDS.

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Panonychus ulmi is one of the most common apple pests in the Emilia-Romagna region (about 17.000 hectares in 1976). The chemical treatments to control it are usually 30% of all chemical applications against apple pests.

In our Institute, P. ulmi has been the subject of intensive studies since 1976 and, in particular, our research pointed to the determination of the real possibilities of the Coccinellid Stethorus punctillum in the natural control of the European Red Mite.

We have seen (and applied on a large scale) that if this predator is not troubled by chemicals harmful for it, it is able to control, in a very short time, even widespread outbreaks of P. ulmi (up to 90 motile forms per leaf).

Methomyl (used against leaf-miners larvae) is, at least in our country, one of the products most harmful to S. punctillum.

In 20% of the observed orchards the chemical treatments against P. ulmi are no longer necessary because the European Red Mite is kept at low population density by the predatory coccinellid. This is because in those apple orchards where a supervised control is applied (85 in 1979, about 300 in 1980), methomyl has not been applied for some years.

On the average, compared to traditional control, the use of acaricides in the above-mentioned orchard has dropped from 30 to 17% of the total therefore saving about 50% of acaricide costs.

Our main aim in the next few years will be the full elimination of acaricides. Moreover, recent experiments (1978-79) show that the damage caused by P. ulmi is usually over-estimated.

FIRST EXPERIMENTS WITH PHYTOSEIIDAE IN APPLE ORCHARDS

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From 1973 to 1975, the study of small agricultural orchards (around farmhouses) has enabled us to count the native species of Typhlodromus and to test the different checking methods used in apple orchards. The species most frequently found are T. pyri, A. finlandicus and A. aberrans. Among checking methods, only visual checking (with binocular 10x) guarantees satisfying quantitative results. The study of the method of the percentage of occupied leaves will lead us to a practical use in orchards (in the same way as in vineyards).

In 1979, the study of grass on the ground has shown the precence of T. pyri and A. agrestis (cucumeris) in orchards that had been sprayed in an intensive way.

Releases of T. pyri, A. finlandicus, A. aberrans and A. andersoni have been made in 1973, then in 1978 and 1979 by removing pieces of vine stocks or twigs with leaves (cherry trees,apple trees and vine plants). The releases made between March and June have given no positive results. Later releases (July and August) have given better results. Predator populations develop until autumn but only around the points of release. In all cases, these populations have not been found again the next year (June). These failures could be due to bad hibernation conditions or to a high rate of mortality during spring because of fungicides (described as not dangerous?).

EVOLUTION OF PANONYCHUS ULMI POPULATIONS IN AN APPLE ORCHARD LOCATED NEAR AVIGNON AND RECEIVING NO INSECTICIDE SPRAYS, WITH OBSERVATIONS ON THE POPULATION DYNAMICS OF AMBLYSEIUS (KAMPIMODROMUS) ABERRANS (ACARI = TETRANYCHIDAE, PHYTOSEIIDAE).

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Since 1971 we have been studying the evolution of the acarine fauna in an orchard where only fungicides have been applied and on elmtrees bordering it. Results presented cover the 1975-79 period. We gave a particular attention to the biological regulation of P. ulmi and its relationship to development and abundance of phytoseiids, of which A. aberrans was the main species. Methods used were brushing and washing 100 leaves each time on both host-plants. Water-traps served in 1979 to measure wind transportation of the typhlodromids.

We observed that P. ulmi surpassed the economic threshold in 3 out of 5 years, the only important limiting factor being the activity of predatory insects. Rather surprisingly, numbers of winter eggs seemed to be linked in some way to the number of fungicide sprays, but they showed no relationship to the importance of summer peaks of motile forms.

Phytoseiids increased rather slowly in the first few years and were nearly eliminated in the 4th by repeated fungicide applications due to the humid spring of 1978. Their numbers were not restored before September, 1979, and it seems that elm-trees played a very limited role in the recolonization process in spite of their high populations. On the other hand, a decrease of population was apparent each year in summer on elm as well as on apple trees. This feature, together with their low capabilities to recover from mortality induced by pesticide sprays, may limit strongly their interest for P. ulmi regulation and can explain their scarcity in commercial orchards even when integrated control principles are followed.

EXPERIENCE WITH BIOLOGICAL CONTROL OF FRUIT TREE RED SPIDER MITE BY PHYTOSEIID MITES IN APPLE ORCHARDS IN THE NETHERLANDS

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Most of the data presented in this paper were collected in a spindlebush orchard at Schuilenburg situated near Wageningen in the middle of the country. It was planted in 1965 with James Grieve M7, Cox M9, Beauty of Boskoop M9, Golden Delicious M9 and Jonathan M7. Four one-hectare plots received a selective spray programme. It was expected that in these plots outbreaks of fruit tree red spider mite, Panonychus ulmi, would not develop owing to natural enemies, in particular phytoseiids (Van de Vrie's work). This was expected particularly for the two plots that received a moderate dressing of nitrogen fertilizer (125 kgN/ha/yr), whereas the expectation for the two plots with high N(350 kgN/ha/yr) was uncertain (see Post, 1962).

However, untill 1970 red spider outbreaks did occur and virtually no phytoseiids were found on the trees. In 1970, phytoseiids from a cherry orchard released in these 4 plots gradually brought the spider mite population to, and maintained it on, a very low level. No acaricides were needed once the low level was attained.

In the second year after the introduction, the effect of the phytoseiids on the spider mite population was already very clear, but it took 4 years to achieve the very low spider mite densities characteristic for this prey-predator system. Success was attained quicker on the late than on the early varieties, and slowest on Cox. The population was very stable once the low mite density was attained (Table 1). There was no significant difference between the moderate-N and the high-N plots.

The phytoseiids released were nearly all Amblyseius finlandicus, with some Typhlodromus pyri. Within 4 years, however, the species composition shifted to over 90% T. pyri; with some A. finlandicus. A. finlandicus somewhat recovered from this low level during one year.

Similar results were obtained in a second trial on two one-hectare plots. Although the phytoseiids released in these plots originated from the same source, T. pyri predominated from the beginning.

The red spider-phytoseiid situation in a 0,5 ha, 35 years old bush orchard, also at Schuilenburg, in which selective fungicides and no insecticides were applied since 1967, showed similarity as well as differences to the former 6 plots. Spider mites were also very low on Beauty of Boskoop, but tended to break out on Lombartscalville, a local variety, and the phytoseiid species found were more varied and showed remarkable changes, but were mainly A. finlandicus (Table 2).

Experiments elsewhere in the Netherlands are going on with biological control of red spider mite after artificial release as well as natural colonization of phytoseiids. In the latter experiments, we are particularly interested in the gradual shift of the species composition after the colonization of the orchard by phytoseiids (Table 3).

It has become clear that pesticides, particularly fungicides, must be very carefully chosen because frequent application of several of them eradicates the phytoseiids. One of the factors opposing against natural phytoseiids to become established in the orchard in the early years of the experiment (1967-1970) has been the choice of certain fungicides that, mistakenly, were considered selective (triamiphos and dichlofluanid). A list of recent experiences on the toxicity of pesticides towards T. pyri has been given at the IOBC symposium in Vienna (Gruys, 1980).

References: Gruys, P., 1980. Significance and practical application of selective pesticides. Proc. IOBC-Symp. Vienna, 8-12 October, 1979.

Post, A., 1962. Effect of cultural measures on the population density of the fruit tree red spider mite, Metatetranychus ulmi Koch (Acari, Tetranychidae). Tijdschr. over Plantez. 68: 1-110.

Table 1. Wintereggs per 2m. branch length after release of phytoseiids in August 1970. Economic threshold about 1500 eggs per 2m.

	James Grieve	Cox	Boskoop	G. Delicious	Jonathan
January 1971	6294	4409	*	*	*
2	2096	9852	369	508	603
3	1269	1528	199	1341	232
4	591	1833	264	639	201
5	337	236	220	316	182
6	142	142	142	133	97
7	540	490	352	226	400
8	142	79	106	97	79
9	142	142	160	124	124

* not assessed

Table 2. Winter eggs of fruit tree red spider mite per 2 m. branch length and species of phytoseiids in a 35 years old bush orchard

	wintereggs, January		phytoseiids, summer, %			
	Boskoop	Lombarts	*A. finl.*	*T. pyri*	*T. tiliarum*	others
1971	200	*				
2	178	225				
3	340	1499				
4	135	1082	35	24	41	0
5	537	3787	53	2	44	1
6	192	522	73	17	9	1
7	280	1128	68	28	4	0
8	159	899	54	45	1	0
9	651	2610	68	31	1	0

Table 3. Species of phytoseiids (%) in orchards surrounded by poplars and alders in Ysselmeerpolders. Natural colonization since 1977

	1977	1978	1979
A. potentillae	84	90	56
A. finlandicus	7	3	3
T. tiliarum	4	0.3	2
T. pyri	0	1	6
A. cucumeris	0	4	32
others	5	2	1

PREDATORS OF SPIDER MITE; NATURAL COLONISATION AND ARTIFICIAL INTRODUCTION

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1. Natural colonisation In trials at East Malling, mirids, anthocorids and the phytoseiid mite *Typhlodromus pyri* have colonised experimental plots within the first season of the introduction of a selective pesticide programme, provided that spider mite *P. ulmi* is present as a food supply, though in plots remote from sources of predators the colonisation has been slower. Alder (*Alnus* spp.) windbreaks represent an important source of mirids (*Blepharidopterus angulatus* in particular) and anthocorids.

2. Artificial introduction During the past 5 years, several species of phytoseiid mites, most of them OP-resistant strains, have been artificially reared and released at East Malling.

   Amblyseius finlandicus, a native species, survived into the next year after release but not much beyond that.

   OP-resistant *A. fallacis* and *T. occidentalis* , from U.S.A., did not survive into the year following release.

   OP-resistant *T. pyri* from New Zealand; this strain has now been established for two years in an orchard at East Malling, and was released in a second orchard in 1979.

3. Comparison of these 2 strategies for management of predators i.e. (i) use of selective insecticides, principally pirimicarb and diflubenzuron, allowing natural colonisation by native predators, and (ii) use of OP insecticides, and artificial introduction of OP-resistant *T. pyri*.

These two approaches are being compared on 3 farm sites in Kent in a field trial that began in 1979.

One of the key differences between the 2 strategies is that predacious insects do not survive under the OP regime. This might be an advantage if, as seems possible, predacious insects feed on phytoseiids when *P. ulmi* numbers are low. However, results of a field experiment designed to investigate this possibility suggest that mirids at least do not prey on phytoseiids in this way.

A COMPARATIVE STUDY OF THE EFFECT OF SOME PESTICIDES ON THREE PREDATORY MITE SPECIES: TYPHLODROMUS PYRI, AMBLYSEIUS POTENTILLAE AND A. BIBENS

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Certain phytoseiids, such as Phytoseiulus persimilis and Amblyseius bibens, can be tested for their susceptibility to pesticides on detached bean leaves placed on wet cotton wool contained in small dishes, with the spider mite, Tetranychus urticae, added as prey. When such leaves are sprayed with a pesticide, these phytoseiids will stay on the leaves and produce eggs. Predatory mites from orchards, such as Amblyseius potentillae and Typhlodromus pyri, on the other hand will run off the leaves immediately and become trapped in the cotton wool. These species can only be tested in closed cells for their susceptibility to pesticides. In such cells, however, the predatory mites cannot be treated directly with the pesticide, only the effect of the residue can be determined.

Comparative tests were carried out on A. bibens, A. potentillae and T. pyri in cells with different types of pesticides to see to what extent the responses might differ for the three species. In case no differences would be observed, A. bibens might well replace the orchard species for testing the adverse effects of pesticides.

The LC_{50} for adult females measured after a period of 1 week, the EC_{50} for reproduction, viz. the concentration that causes an effective reproduction over a period of 1 week that is 50% of the reproduction in untreated cells, and the LC_{50} for eggs and juveniles one week after the treatment of eggs were determined. (The effective reproduction is in fact the result of mortality and effected fecundity).

There were no differences found for the responses to Karathane, Zineb, Maneb, Sulphur, Pirimor, Thiodan, Gusathion, Plictran and Torque. At concentrations advised for the use in practice, Karathane was only moderately toxic to younger stages. Zineb was harmless, but Maneb was highly toxic to all stages. Sulphur proved harmful to immature stages. Pirimor was rather toxic to adults and immature stages. Thiodan and Gusathion were highly toxic. Plictran was somewhat toxic to immature stages and Torque

proved harmless to the three species. Based on these results it would seem that A. bibens is a good substitute for orchard mites for testing the adverse effects of pesticides.
However, as to Benlate, differences in response were found: this chemical proved slightly toxic to immature stages of A. bibens, but it was found to be highly toxic to eggs and juveniles of T. pyri and A. potentillae.

TABLE 1

The LC_{50} values for adult females measured after a period of 1 week, the effective concentrations that cause a 50% reduction in the reproduction over a period of 1 week, and LC_{50} values for eggs and juvenile stages after 1 week for various pesticides, given in percentages, for A. bibens, A. potentillae and T. pyri.

pesticide	A.bibens			A. potentillae			T. pyri		
	LC_{50} ♀♀	EC_{50} repr.	LC_{50} e/juv.	LC_{50} ♀♀	EC_{50} repr.	LC_{50} e/juv.	LC_{50} ♀♀	EC_{50} repr.	LC_{50} e/juv.
Karathane	.5	.5	.15	.3	.3	.1	.3	.3	.1
Benlate	1.0	.1	.2	>1.0	.02	.01	>1.0	.02	.02
Zineb	>1.0	>1.0	.7	>1.0	>1.0	.5	>1.0	>1.0	.5
Maneb	.15	.15	.1	.15	.15	<.1	.5	.1	<.1
Sulphur	>4.0	.7	.15	>4.0	.7	.1	>4.0	.7	.1
Pirimor	.05	.05	.05	.05	.05	.05	.05	.03	.03
Thiodan	.1	.05	.05	< .05	< .05	<.05	.1	.05	.05
Gusathion	.003	.003	.01	.01	.01	.007	.01	.01	.007
Plictran	.4	.2	.15	.5	.4	.15	.5	.4	.3
Torque	>1.0	>1.0	>1.0	>1.0	>1.0	>1.0	>1.0	>1.0	>1.0

TABLE II

EC_{50} values for reproduction as measured over a period of 1 week in A. bibens after treatment of mated females on detached bean leaves, and in A. bibens, A. potentillae and T. pyri where mated females were placed on residue in closed cells. Values are given in percentages. The concentrations for the use in practice as advised by the manufacturer are also given for each pesticide.

pesticide	conc. for use in practice	A.bibens EC_{50} leaf spray method	A.bibens EC_{50} cell	A.potentillae EC_{50} cell	T.pyri EC_{50} cell
Karathane	.1%	.2	.5	.3	.3
Benlate	.1%	.1	.1	.02	.02
Zineb	.15%	.8	>1.0	>1.0	>1.0
Maneb	.2%	.15	.15	.15	.1
Sulphur	.3 - .5%	-	.7	.7	.7
Pirimor	.05%	.05	.05	.05	.05
Thiodan	.15%	.05	.05	< .05	.05
Gusathion	.2%	.003	.003	.01	.01
Plictran	.1%	.2	.2	.4	.4
Torque	.05%	.8	>1.0	>1.0	>1.0

VIDEO RECORDING TECHNIQUES FOR STUDYING PREDATORY MITE BEHAVIOUR

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A television camera and video tape deck were used to obtain continuous 24 hour recordings of the activity of the predatory mite *Amblyseius fallacis*. Choice experiments showed the egg stage of *Tetranychus urticae* to be the preferred prey and eggs were therefore used for the recordings and were arranged in a constant pattern on either side of the midrib of a leaf disc. Single adult female predators were placed on each disc and a simultaneously recorded time trace enabled the times of feeding, oviposition, movement starting and movement ending to be noted. 85 - 95% of the predators' day is spent at rest and these stationary periods were divided, on the basis of their frequency distribution, into periods of less than 600 seconds, termed pauses, and periods over 600 seconds, termed rests. Rest periods divide the recordings into blocks of activity characterised by alternating movement periods and pauses.

There is a rather low correlation between the total amount of movement and the number of meals eaten in 24 hours, but a close relationship between feeding and both the number of activity blocks and the frequency of movement within these blocks. The highest level of feeding is associated with shorter rests and long periods of alternating movement and pause, but the duration of the movement periods alone is unrelated to feeding.

Feeding is correlated with oviposition, there being a direct linear relationship between the number of prey eggs consumed and the number of predator eggs laid.

INTEGRATED PEST CONTROL IN SICILIAN ORCHARDS

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In Sicily, further expansion of commercial orchards will aggravate the problems of pest control unless farmers are given better training in this subject; however, some examples of supervised control in apple and pear orchards and of integrated control in lemon orchards have been in progress for a few years.
In apples the most important pest is Laspeyresia pomonella; by monitoring with pheromone traps and visual inspections it has been possible to reduce the 8-10 sprays commonly used by farmers to 4-5, according to the cultivar. Even one application is enough to give control in areas where only light infestations occur. Good control of Dysaphis plantaginea and Panonychus ulmi can be obtained with a single application, even if they exceed the threshold, which will be discussed.

On pears, Psylla pyri is the most important problem and the complex of natural enemies, especially Anthocoris nemoralis, has recently been studied.

Ceratitis capitata is the most serious pest of peaches, and recent findings, especially in relation to the problem of the complex of host plants for this species, will be reported.

ABUNDANCE AND PARASITIZATION OF LEAF ROLLERS IN INTEGRATED CONTROL IN THE NETHERLANDS, IN RELATION TO THE PESTICIDES USED.

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Abundance and parasitization of leaf rollers was studied under 4 variants of an integrated control programme, differing in the insecticides used against caterpillars. The experiments were situated in the middle of the country. The variants, applied to ½-1 hectare plots, were as follows:

- integrated pest control without caterpillar insecticides (IPC-0)
- " , including 2-4 sprays of Dipel (Bac.thur.)
- " , including 1-3 sprays of Dimilin (diflubenzuron)
- " , including 2-4 sprays of Ro10-3108/18 (epofenonane, an insect growth regulator).

In this part of the Netherlands, Adoxophyes orana is the most noxious leaf roller in commercial orchards, but with IPC Adoxophyes was less important and other species predominated. Of the latter, Spilonota ocellana, Pandemis heparana, and Archips podana, in this order, were the most noxious. Hedya nubiferana was also numerous but harmless. When broad-spectrum pesticides were used in the habitual manner, these species were virtually absent. Dipel reduced the numbers present in spring of all species roughly by half, Dimilin reduced all species except Adoxophyes and Pandemis, and epofenonane effectively controlled Adoxophyes under suitable conditions (Table 1).

Average parasitization by a rather large number of ichneumonids and braconids (see Evenhuis, 1974) in spring did not show significant differences between the IPC variants. In the IPC and untreated plots, it varied from 9-46% for Adoxophyes orana and from 7-15% for the other species.

Whereas the other leaf roller species mentioned are mainly univoltine, Adoxophyes has two generations per year. The development of the latter species during summer determines the damage it inflicts. The density of *Adoxophyes* fluctuated considerably during summer, surpassing the economic threshold:

- in 3 out of 5 years in IPC-o,
- in 3 out of 5 years in IPC-Dimilin,
- in 1 out of 5 years in IPC-Dipel,
- in 0 out of 5 years with broad-spectrum pesticides.

Parasitization of *Adoxophyes* during summer ranged from 46 to 89% in 1976-1979. *Colpoclypeus florus*, a gregarious ectoparasitic eulophid, predominated but the percent parasitism by other species (mainly *Teleutaea striata*) increased when (as in 1979, and in the Dimilin plots in all years) the impact of *Colpoclypeus* decreased.

The phenology of *Colpoclypeus* was studied in some detail. Experiments have shown that *Colpoclypeus* goes through 5 generations from April to October and hibernates as a larva. In orchards in The Netherlands, however, it is only abundant in its 3^{rd} and 4^{th} generation, on the half to full-grown larvae of *Adoxophyes* in July and August (Gruys, 1980). It virtually only accepts tortricid larvae of over 1 cm as host and, since *Adoxophyes* and all other tortricids hibernate as smaller (L_2-L_3) larvae, it finds no suitable hosts in September-October and, consequently, is greatly reduced in numbers. Therefore, its numbers in spring are also very low. It is not yet known where and on which hosts it hibernates in the Netherlands, and from what source it builds up its high numbers in summer. Hence, its impact on the different leaf roller species in spring is nil. Moreover, the appearance of *Colpoclypeus* in large numbers in summer is not fully satisfactorily synchronized with the larvae of *Adoxophyes*. *Colpoclypeus* comes in when the first larvae of *Adoxophyes* begin to pupate; hence, a fraction of the latter may escape parasitization.

In order to increase the impact of this parasite, large numbers of it were reared (which is rather easy) and released, in spring (1975-1977) and in summer (1978-1979), respectively. The results were disappointing. Parasitization of all leaf roller species in spring was increased by 15-27%, and of *Adoxophyes* in summer by 20%. Since it was hoped to use *Colpoclypeus* as a biological insecticide, this was not sufficient.

However, because under natural conditions the mortality by *Colpoclypeus* and other parasites of leaf rollers is considerable though not fully sufficient, their impact on the abundance of tortricids and their manipulation require further study. Detailed work on the parasitic behaviour of Colpoclypeus has started in the Netherlands.

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In: Les organismes auxilliaires en verger de pommier. OILB/SROP 1974: 53-59.

Table 1. Average number of leaf rollers per 100 clusters, May 1976-1979.

	integrated pest control				intensive chemical control
	0	Dipel	Dimilin	epofenonane 1)	
Spilonota ocellana	6.5	2.2	0,1	1.3	0.1
Pandemis	3.4	1.6	1.6	1.5	0
Hedya nubiferana	1.6	1.1	0.3	0.4	0.1
Adoxophyes orana	0.5	0.2	0.5	0.2	0.1
Ptycholoma lecheana	0.5	0.2	0.2	0	0
Archips podanus	0.2	0.1	0.1	0	0
Archips rosanus	0.1	0.1	0	0	0

1) Data not fully representative for the potentialities of this insecticide because of insufficient isolation.

Table 2. % Parasitization of Adoxophyes orana in July-August.

	1976		1977		1978		1979	
	C.florus	others	C.florus	others	C.florus	others	C.florus	others
IPC-o	76	1	68	3	66	14	29	33
Dipel	83	2	78	1	81	0	52	16
Dimilin	58	8	43	3	37	22	22	36
epofenon.	89	0	53	2	55	5	37	36

OBSERVATIONS ON THE APPLE LEAF-CURLING MIDGE, DASINEURA MALI KIEFF., AND A NEW CECIDOMYIID ON APPLE, MACROLABIS SP.

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Up till now Dasineura mali was the only gall-midge known to attack the leaves of apple trees. Only within the last 15 years did it become more common in central Europe, simultaneously in several apple growing areas. Especially the attack of young trees may cause serious damage in that it retards normal growth and may then require the application of systemic insecticides which are often ineffective because of the difficulties in the proper timing of the applications which should be carried out during the first generation because of the overlapping generations occurring later in the season.

In the course of our investigations on the natural enemies of Dasineura mali carried out with a view to the biological control of this species in Canada we recorded in 1979 a new gall midge from apple leaves which was identified as a possibly undescribed species of Macrolabis.

In view of the apparently increasing economic importance of gall-midges in commercial apple orchards this new development deserves our particular attention. To date we know next to nothing about this new species, and the purpose of this paper is to obtain as quickly as possible a comprehensive picture about the distribution and relative importance of Macrolabis through your cooperation.

So far we have found Macrolabis in all of our survey areas, that is near Stuttgart in Southwest Germany, St. Gallen in northeastern Switzerland and in the Upper Etsch Valley in South Tyrol. It was particularly common in this latter area where in August and late September of last year it accounted for about 90% of the total population. In some orchards it was the only species present, but more generally it occured in association with Dasineura. Near Stuttgart both species were about equally common and in the area of St. Gallen there were only traces of Macrolabis, less than 1%.

The genus Macrolabis comproses gall-forming species as well as predators. The status of our species is not yet known with certainty, but the fact that we reared only this species from some individual orchards in South Tyrol strongly suggests that Macrolabis is phytophagous and itself induces leaf-galls which are indistinguishable from those of Dasineura mali.

The life history of the two species is very similar. Both leave the galls as mature larvae, spin a fragile silken cocoon with soil particles incrusted close to the soil surface. Their life-cycle is completed within 25-35 days, but Macrolabis develops slightly faster than Dasineura, adults emerging about 5 days earlier. Both hibernate as larvae in the soil and possibly sometimes inside galls on the ground. Adult emergence of Dasineura in the spring reaches a peak at petal-fall, but the appearance of Macrolabis is still unknown.

It is rather easy to distinguish the two species in the adult stage: Macrolabis is orange-coloured whereas Dasineura is much darker, almost blackish brown. A striking morphological difference is in the male antennae: Those of Dasineura are about two thirds of the body length, their flagellum joints are strongly club-shaped with long setae, about 5 times the diameter of the joints. The antennae of Macrolabis reach only about one third of the body length; the joints are sessile ovate, the setae about twice as long as the diameter (Fig. 1).

For some work, for instance for parasitological studies, it is indispensable to distinguish the larvae, preferably under the stereo-microscope. Although full-grown larvae are more difficult to differentiate than adults, there is fortunately a possibility to do so.
The mature larvae of Macrolabis are invariably yellow, those of Dasineura may be yellow, but they may also be orange-coloured which is even more frequently the case. There is a marked difference in the mean body length of the two species, but because of the great intraspecific variability the size cannot be used to identify single individuals, especially in mixed populations. However, a reliable criterion is the relative length of the setae, particularly on the first thoracic segment, visible at about 100-fold magnification in the stereomicroscope. These setae in Dasineura are only half as long as in Macrolabis; absolute measurements in Dasineura are 13 - 15 μ, in Macrolabis 25 - 32 μ(Fig. 2, 3).

While these characteristics are sufficient to seperate the two species it is realized that they are inadequate taxonomically and may fail if in the future we should find that there are more than two species of gall-midges in apple leaves.

Summarizing it may be stated that the occurrence of a new gall-midge on apple leaves is rather disappointing. Our present inadequate knowledge suggests that the species may be more wide-spread in Europe than is known to date and that it may be even more destructive than *Dasineura mali*, for instance in South Tyrol. It is especially disheartening that our studies of the parasites of *Dasineura mali* to date are largely useless because the parasites we recorded, which were very effective in South Tyrol where they caused the collapse of outbreaks, came in fact from two host species. We are certain that the platygasterids, *Inostemma contariniae* Szelényi and *Platygaster marchali* Kieffer as well as the torymid, *Torymus rubi* Schrank, attack the target species, but the pteromalid *Gastrancistrus* sp. near *amaboeus* Walker, sometimes a very important species, might attack only *Macrolabis*.

This rather preliminary but interesting study, which I thought I should let you know about already at this stage, would not have been possible without the generous support of several colleagues. I gratefully acknowledge the kind help of Dr. Z. Boecek, Mr. K.M. Harris and Mr. W. Nijveldt who identified either parasites or hosts, and of Dr. H. Oberhofer, Dr. H. Steiner and Dr. T. Wildbolz who drew my attention to infestation sites of *Dasineura mali*.

FIG.1

DASINEURA MALI MACROLABIS SP.

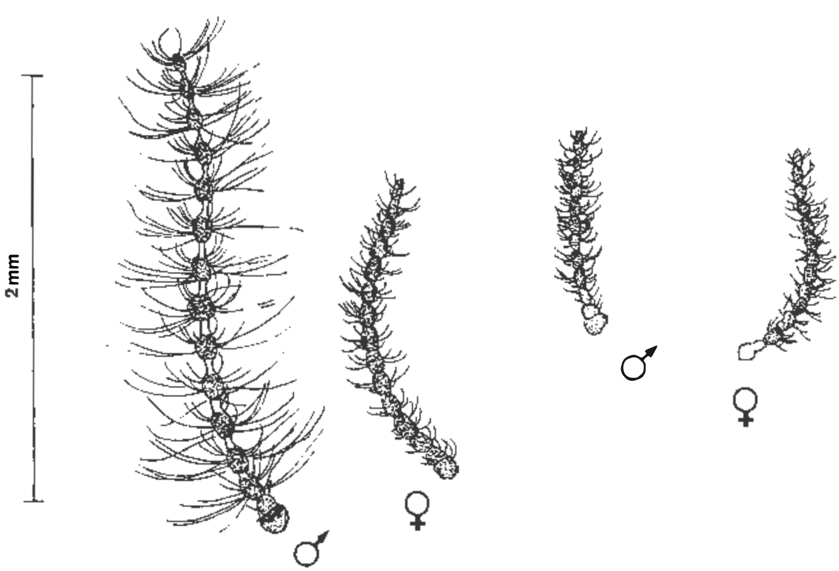


FIG. 2 DASINEURA MALI

DORSAL VIEW

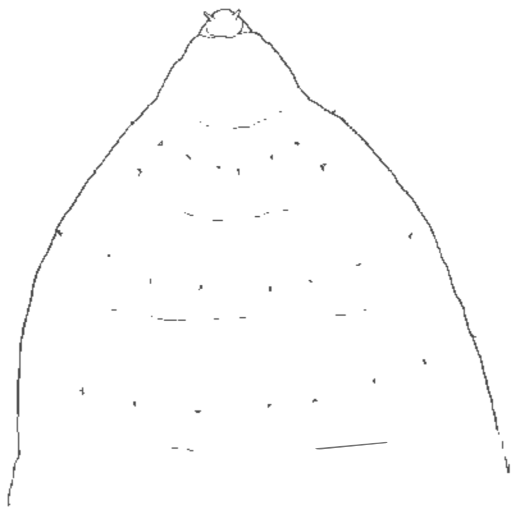
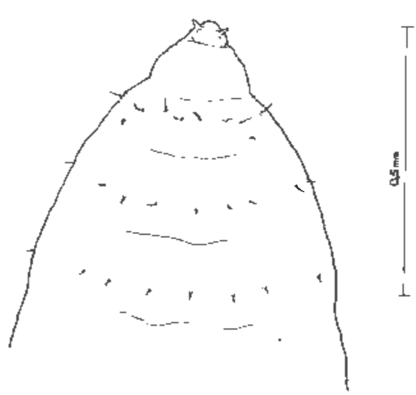


FIG. 3 MACROLABIS SP.

DORSAL VIEW



NATURAL ENEMIES OF APPLE LEAF MIDGE IN THE NETHERLANDS

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Apple leaf midge, Dasineura mali, is one of the minor pests that tend to increase with integrated pest control (IPC).
D. mali hibernates as a larva in the soil. The adults emerge in May. It has 3 generations per year in The Netherlands. The second generation is the most injurious. The adults of the third flight (in September in the cool summer of 1979, and in August in normal years) find decreasing numbers of suitable (i.e. growing) shoots for oviposition at the end of summer, and consequently egg-laying then concentrates on a small fraction of the shoots. In heavily infested orchards, virtually all shoots are attacked at the end of summer.
It is not clear whether outbreaks of this insect in mature orchards inflict any economic damage. They certainly do so in nurseries and young orchards. Presumably, very high densities are tolerable in orchards in the productive phase. There are, however, two reasons to pay attention to this insect. Firstly, because of the conspicuous injury, severe attack by apple leaf midge in any orchard causes psychological nuisance to the fruit grower. Therefore these outbreaks are a negative factor to the appreciation of IPC. Secondly, apple leaf midge is a good object for studying the general phenomenon of minor pest outbreaks in IPC of, besides D. mali , insects like certain species of leaf roller, apple sawfly, apple blossom weevil and brown leaf weevil. Are these outbreaks a permanent characteristic of IPC, or transitory, namely induced by the lack of essential natural enemies when the pressure of broad-spectrum sprays is relieved and will they disappear after these beneficials have re-colonized the orchard? If the latter applies, it is essential for IPC to know, and be able to manipulate, the key beneficials. This paper gives preliminary results on some natural enemies of Dasineura mali.

Parasites

In 1978 and 1979, three Hymenoptera were found to parasitize D. mali in apple orchards in the middle and northwest of the Netherlands:

the egg endoparasite, Platygaster demades (Proctotrupoidea, Platygasteridae), and the larval ectoparasite, Torymus sp. (Chalcidoidea, Torymidae). Another egg endoparasite, Inostemma sp., was very scare.
The degree of parasitization was studied by breeding adult midges and parasites from galls containing full-grown larvae, and comparing the number of hosts and parasites which emerged from these samples. This technique of assessing the rate of parasitization has several shortcomings and needs to be improved or changed. Most of the parasites reared were P. demades: 77 and 98% in 1978 and 1979, respectively; the others were Torymus sp. Inostemma was found only twice in 1979.

In 1979, Platygaster adults synchronized with the presence of the eggs of the first and the second generation, but the parasitization of the second generation was low in most orchards studied because few parasites were present during the first (and greater) part of the egg period of this generation. The effect of Platygaster demades on the population of its host apparently low in 4 out of 5 orchards sampled in 1979, but possibly considerable in one orchard (Table 1).

Table 1. Percent Platygaster demades of total of parasite and apple leaf midge adults emerged from sample of galls.

Orchard	1st generation	2nd generation
Schuilenburg IV	7	2
Thedingsweert I	57	10
Thedingsweert VI	59	8
Ingen	7	2
Andijk	64	88

Predators

Observations in the orchard, suggesting that phytoseiids may consume eggs of apple leaf midge, were corroborated by laboratory experiments Typhlodromus pyri protonymphs, deutonymphs, and females, as well as females of Amblyseius potentillae, ate eggs and young larvae of apple leaf midge. Experiments on the preference of these phytoseiids for mites or midge eggs as food showed that larvae of Panonychus ulmi or eggs of Tetranychus urticae were not preferred over eggs of D. mali. The

effectiveness of phytoseiids in reducing apple leaf midge in the orchard is not yet known. The fact that, habitually, phytoseiids tend to be much less numerous on the leaves at the top than on those on the middle of the shoots may reduce their effectiveness.
Another group of predators - anthocorids - frequently encountered in the galls of D. mali has not yet been studied.

ON SOME CARABIDS OF THE ORCHARD SOIL AND THE EFFECTS ON THEM OF TILLAGE

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The relationships between epigeic and ground-living arthropods are of importance especially in orchards which are itensely cultivated and where refuge sites are scare or lacking altogether.

An interesting relationship is that between predators and two fruit moths such as *Carpocapsa pomonella* and *Cydia molesta* which as mature larvae frequently move to the soil to cocoon. Numerous soil predators may hunt and destroy these Lepidoptera and it would be of interest to find out the effect of certain cultivation practices such as tillage on the soil micro-fauna.

Preliminary studies have been carried out in the Emilia-Romagna region in order to find out which were the soil-living Coleoptera (especially Carabids) in two peach orchards of which one had a regularly mown grass sod, while in the other the soil was kept bare through frequent (every 20-30 days) tillage; this latter is a cultural practice which is gradually spreading throughout Italian orchards.

Traps placed on the ground and inspected periodically for two years have yielded the following results. The dominant species captured in both orchards belong to the Carabidae and in order of importance are: *Harpalus distinguendus*, *H. rufipes*, *H. tardus*, *Pterostichus cupreus*, *Anisodactylus binotatus*.

All species were caught in significantly higher numbers in the orchard with a grass sod.

Predacious species such as *Pterostichus melas* var. *italicus*, *Calathus melanocephalus*, *Bembidion lampros* were caught only in the grass covered ground.

In the second year this orchard was tilled more frequently than before and the number of Carabid **catches** decreased, nearing the levels of the other orchard where the soil had been kept bare for some years.

The samplings and analyses of the soil carried out by the Berlese method have confirmed both orchards a low population density of Carabids and an even lower one of Staphylinids.

POSSIBILITIES OF BIOLOGICAL CONTROL OF PEAR INSECTS

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The problems of integrated pest control in pear orchards in Italy have been studied for only a few years, although this crop is extended over an area of 46,430 ha. of specialized cultivation and of 90,600 ha. in mixed farming. The total production in 1978 was of 1,159,400 tons.

The following varieties are cultivated: J. Guyot, Coscia, B.p. Morettini, William, Conference, Abate Fétel, Decana of Comizio, Kaiser, Passa Crassana. The main pear pests usually controlled with pesticide sprays are the following:
Psylla pyri, Dysaphis pyri, Cydia pomonella, Panonychus ulmi and Endostigma pirina; less frequently Quadraspidiotus perniciosus, Leucoptera scitella, Zeuzera pyrina, Epitrimerus pyri. The P. pyri, actually the most harmful insect, has been considered. The control of P. pyri was started in France by P. Atger, J. Bassino, M. Feron and others, with very satisfactory results.
Research on consistence and dynamics of populations of P. pyri were done in different areas of Piedmont (in northern Italy) by A. Arzone and C. Vidano of the Entomological Institute of the University of Turin since 1977.
The possibility of containing this pest in some areas has suggested a study of natural limiting factors with the main purpose of determining their specific entity and importance. The above-mentioned authors in the years 1977-1978 have considered 8 orchards representative of the changeable fruit-growing of Piedmont, of which 2 had intensive cultivation, 2 others had semi-intensive cultivation and 4 were home orchards. The total numbers of sprays (fungicides, insecticides and acaricides) normally applied, varied from 18 to 23 in the first example, from 9 to 10 in the second and finally from 4 to 5 in the last one.
The antagonists of P. pyri checked during the years 1977 and 1978 in the 8 orchards under consideration, two of which were never sprayed with pesticides, are the following 23 species of predators, 5 species of parasites and 1 species of fungus: Meconema thalassinum, Oecanthus

pellucens, Deraeocoris lutescens, D. ruber, Anthocoris nemoralis, Orius minutus, Aptus myrmecoides, Himacerus apterus, Drepanepteryx phalaenoides, Hemerobius lutescens, H. micans, Chrysopa carnea, C. flavifrons, C. perla, C. 7-punctata, Episyrphus balteatus, Lasiophthicus pyrastri, Platycheirus albimanus, P. sticticus, Sphaerophoria scripta, Adalia bipunctata, Calvia 14-guttata, Coccinella 7-punctata, Pachyneuron concolor, Aphidencyrtus cantabricus, Prionomitus mitratus, P. tiliaris, Trechnites psyllae, Entomophthora sp.

Within these investigated agroecosystems, the biocoenosis related to P. pyri revealed very different composition and incidence.
In the 4 home orchards, the colonies of P. pyri were very effectively controlled by: P. mitratus in two orchards not sprayed; A. nemoralis, C. 14-guttata, P. tiliaris and T. psyllae in one orchars sprayed four times; O. minutus and C. perla in one orchards sprayed five times.
In the two orchards with semi-intensive cultivation P. pyri appeared at intervals, controlled by natural limiting factors, represented mainly by predators coming gradually from the neighbouring land.
The two orchards under intensive cultivation respectively sprayed 18 and 23 times (ten times with insecticides) showed P. pyri not controlled by any natural factor with an irrepressible infestation: the one treated with pesticides 18 times revealed however a set of 11 species of entomophagous insects when the sprays were stopped because considered no more valid. Only one orchard (23 sprays) did not take any advantage from the natural limiting factors of the pest and this was where chemical control eliminated the biological one.

The studies carried out suggest that pesticides alone cannot guarantee an adequate Psylla control, whereas biological control does not ensure the high quality pears requised by the market. It seems, as a consequence, that the exaggerated quality requirements should be reduced and the excellent possibilities offered by the integrated pest management should be applied.

EXPERIENCES WITH INTEGRATED CONTROL IN APPLE ORCHARDS

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Near Mainz, one hectare of apple orchard containing Golden Delicious, Cox's Orange and Boskoop was treated by integrated control. Between the rows of the trees, grass was growing; in their line simazine or paraquat was used against the weeds, or they were removed by mechanical methods. The occurrence of pests was surveyed visually or by the funnel method. Diseases like apple scab and apple mildew were controlled according to the weather conditions; with low rainfall of about 500 mm, an average temperature of 10° C, 75% r.h. and 1700 hours of sunshine per year in this region, apple mildew control is very important. Alltogether, about 8 fungicide applications were necessary each year.
In this apple orchard, the most important insecticide sprays were for caterpillars (*Operophtera brumata, Hedya nubiferana, Orthosia incerta,* etc.) before or after blossom, a partial treatment after blossom against aphids, and suppression or surface-feeding tortrix in July.

The appearance of codling moth in pheromone traps was extremely low; therefore, no control was necessary in the years of the experiment. Nevertheless there were spider mites in large numbers; therefore an acaricide was applied in July and August. At the same time, the leafrollers appeared and caused damage at the shoot tips and fruits. Beneficial insects develop at the end of May/beginning of June, then they decrease, and at the end of August/beginning of September they increase. There are a lot of species: Staphylinidae, Anthocoridae, Chrysopidae, Syrphidae, Coccinellidae, spiders, Hymenoptera and Cantharidae. But only a few individuals of each species were caught by the funnel method. With intensive observation and prognosis, it was possible to save 2 to 3 treatments in comparison with the traditional applications, and to spare the beneficial insects by choosing pesticides like diazinon, trichlorfon, oxydemeton-methyl, cyhexatin, phosphamidon, triadimefon, sulfur and captan. In this way, the number of natural enemies could grow, nevertheless in small steps.

FIELD OBSERVATIONS ON THE LEAFROLLER COMPLEX ON CHEMICAL-, CmGV-, AND UNTREATED APPLE TREES

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In 1974 field experiments were started at Dossenheim, Germany, to study the efficacy of granulosis virus (CmGV) against Laspeyresia pomonella. CmGV was always as effective as organophosphorus insecticides (OPs). CmGV is highly specific to codling moth and omitting OPs led to an increase of fruit damage by leafrollers.
Since 1977 several evaluation techniques were used to analyze the tortricid complex. Corrugated paper bands, shoot samples, and larvae samples were chosen for density studies of caterpillars. Moth activity was observed with pheromone traps and light traps. All field-collected larvae were reared in the laboratory for moth and parasite identification.
In three years of the experiment, chemical insecticides used for Cm-control also suppressed leafroller damage. In plots without chemical insecticides (CmGV and untreated) a high fruit loss was observed. In '77 and '79 a significantly higher leafroller infestation was found in virus plots compared with untreated. Trap bands and shoot samples were found to be not very useful for predicting and monitoring leafroller populations. Nine tortricid and 11 parasite species were reared.
Adoxophyes orana and Pandemis heparana seem to be the species mostly responsible for damage. Finally an integrated programme is discussed which combines codling moth control with CmGV and the control of leafroller by using different selective biological methods especially species-specific viruses.

EFFECTIVENESS OF *TRICHOGRAMMA* AGAINST CODLING MOTH

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The parasitic wasp, *Trichogramma* sp., has been used against codling moth in Russia, U.S.A., Poland, Bulgaria, West Germany, Canada, Australia, Spain, Portugal, Rumania, China and France. Releases of from 125 to 10,000 individuals per tree were made, most often of 1500 to 3000. In some experiments, *Trichogramma* was released only once during the season, in another even ten times. In the majority of cases no correlation was found between the number of introductions and the effectiveness of the parasite.

Results, expressed as percentages of parasitised eggs or numbers of 'wormy' fruits, were very variable and, from an economic viewpoint, usually not satisfactory. In the Soviet Union, of 118 introductions which were analysed, the percentage of wormy fruits decreased to 0-5% in only 11 cases. In most experiments there was 10-20% infested fruit. Similar results were obtained in Poland, U.S.A. and other countries.

In a special experiment established in 1978-79 in Poland, in order to attempt to explain this rather low effectiveness, the parasite was released six times a year using c. 18,000 individuals per tree. In 1978, the parasite halved the number of wormy fruits compared with the check. In 1979 it gave no reduction, and in both years the percentage of infested fruits on trees sprayed with Gusathion was much lower.

PIMPLA TURIONELLAE L. AS A PUPAL PARASITE OF CODLING MOTH IN SWITZERLAND

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In spring 1979 full-grown larvae of codling moth were exposed at 4 localities to examine if *Pimpla turionellae* L. exists in Swiss apple orchards in similar numbers as it does in some English orchards (Glen 1978). Reared codling moth larvae overwintered in an outdoor insectary were induced to spin cocoons in small pieces of bark and in strips of corrugated paper in March. In each locality batches of 90 larvae (15 larvae/tree) were fixed on the trunks of trees in mid April and protected against birds. Three more batches were placed at intervals of 2 weeks. After an exposure of 2 - 4 weeks the batches were taken to the laboratory for emergence of moths and parasites. Parasites were identified by K. Carl, Delémont. In most batches only *P. turionellae* was present. In Grabs *Dibrachys cavus* Walk. emerged from one pupa.

Parasitism by *P. turionellae* is indicated in Tables 1 and 2.

Table 1. Parasitism of Codling Moth pupae by *P. turionellae* L. in 4 localities.

Locality	Number of parasites emerged	% parasitism
Trimmis	82	47
Grabs	25	16
Bad Ragaz	3	2
Wädenswil	0	0

Table 2 Parasitism of Codling Moth pupae by *P. turionellae* L. in relation to the period of exposition

Period of exposition	Number of parasites emerged	% parasitism
1/4. - 8/5.79	0	0
25/4. - 22/5.	34	22
9/5. - 28/5.	42	29
22/5. - 5/6.	34	32

CODLING MOTH CONTROL WITH BEAUVERIA BASSIANA IN ORCHARDS

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A field experiment aimed at measuring the activity of Beauveria bassiana - strain nber 93 - against codling moth, Laspeyresia pomonella, was started in an apple orchard near Avignon in 1978.

The multiplication of the fungus was performed on millet seeds at the La Minière Station. The solution, of which the titre was 1.1×10^8 conidia per ml was completed with powdered skim milk (2.5%) just before use; this was meant to protect the pathogenic agent and serve as a sticker/protectant.

The treatment was aimed at infecting last instar larvae when they start searching for a cocooning site to overwinter. Trunks and the lower parts of main branches were brushed over with a biopesticide containing Beauveria bassiana (40 cc per tree). A single application was performed on 8 August, 1978, on the second generation.

The effect on the future overwintering population was measured. Larvae searching for a shelter were caught in trap-bands placed around the trunks of 20 trees in each of the treated and untreated areas of the orchard. The larvae, collected weekly, were then placed in latticed cages set on the ground between the trees. The next spring, counting of adults in the cages allowed calculation of the mortality.

In 1978, no significant difference was noted between mortality on the treated and on the untreated trees.

But among the larvae in search of a shelter, when mortality was provoked by muscardin during the same month after treatment (avg. 93.9 per 100) it was significantly different from the untreated population (avg. 75.2 per 100).

Moreover, a certain number of adults which emerged from treated trees seemed less vigorous and showed a lack of coordination in their locomotor movements.

These elements led us to intensify the control in 1979 (2 treatments, 96 cc per tree of a solution titrated 5×10^8 conidia/ml).

A considerable mortality rate was observed in the trap bands placed on the treated trees. Effects will be measured in 1980 with the emerged adults, whose reproductive potential will also be examined.

WINTER AND SPRING MORTALITY IN A CODLING MOTH (*Laspeyresia pomonella* L.) POPULATION FOLLOWING A TREATMENT ON APPLE-TREES TRUNKS WITH A BIOPESTICIDE CONTAINING Beauveria bassiana

(TREATMENT ON AUGUST 8th 1978)

CATCHES DATES OF OVERWINTERING LARVAE	DEATH RATES (INITIAL NUMBER OF LARVAE) SPRING 1979 (1)	
	20 TREES TREATED WITH Beauveria	20 NON-TREATED CONTROL TREES
Before treatment		
July		76.3 (38)
1st August	Population added	77.8 (90)
8th August	to the control	58.5 (65)
After treatment		
17th + 24th August	94.7 (57)	72.5 (51)
30th August	96.4 (56)	75.0 (52)
6th September	90.0 (100)	78.0 (100)
	91.6 (71)	
15th September	88.0 (100)	87.0 (100)
25th September	67.0 (100)	78.0 (100)
4th October	79.0 (100)	79.5 (100)
16th + 30th October	64.0 (50)	82.0 (39)
Percentage means after treatment	82.6 (634)a	78.9 (530)a
Percentage means on 17th + 24th, 30th August 6th September	93.9 (284)A	75.2 (203)B

(1) The numbers followed by the same letter do not significantly differ between each other at threshold P = 0.05, for each series of means, to be considered separately (variance analysis on data changed into arc sinus, test F)

FIELD PERSISTENCE OF THE CODLING MOTH GRANULOSIS VIRUS

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In 1979, a trial was carried out to study the persistence of the codling moth GV under field conditions. At the end of July, on the experimental field in Darmstadt, small single apple trees were sprayed with different formulations of the virus. 2 litres of a virus-suspension containing 10^7 virus capsules/ml together with different additives were applied, using a hand-operated pressure sprayer.

The activity of the virus deposits was assessed by collecting leaves from the sprayed trees at intervals after the virus application. In the laboratory, neonate codling moth larvae (72 for each tree) were allowed to feed on pieces from these leaves for 24 hours. Afterwards they were transferred to artificial diet and checked for virus mortality after 2 weeks. For each formulation, the mortality values were subjected to probit analysis, plotting mortality against number of sunshine hours.

The following table shows some calculated values for the standard virus formulation (purified virus with 1% skimmed milk powder):

sunshine hours	mortality in bioassay	virus inactivation
0	98 %	0. %
100 (23 days)	93 %	82. %
200 (40 days)	72 %	99. %
300 (62 days)	51 %	99.7 %
400 (88 days)	36 %	99.95 %

The addition of 0.2 % 2-hydroxy-4-methoxy-benzophenon, a commercial UV-protectant used in cosmetics, prolonged the persistence of the virus by one third. This corresponds to a 5 fold difference in virus concentration. The highest persistence was shown by a preparation of unpurified airdryed virus. Deposits of this formulation, applied at a concentration of 10^8 virus capsules/ml persisted 2.8 times longer on the leaves than the standard formulation at a rate of 10^7 capsules/ml. This difference in time corresponds to a 200 fold difference in concentration. A total bacteria count with the unpurified virus gave a ratio virus: bacteria of 10^3 : 1. The trials will be repeated in 1980.

CODLING MOTH GRANULOSIS VIRUS PRODUCTION AND PRELIMINARY FIELD TRIALS IN THE UNITED KINGDOM

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The granulosis virus (GV) of Cydia pomonella has been produced on a small scale for 2 years in the United Kingdom. The major problems associated with increasing production are a) the need for simplified media to reduce costs; b) the development of mass-rearing methods and their modification for the collection of virus-diseased larvae; and c) methods for improving virus yield per larva.

In our laboratory the labour intensive method of single larval rearing on complex diets is largely being replaced by mass-rearing on the simplified medium used at INRA, Montfavet. Methods are still required for the collection of larvae at an appropriate stage for infection and, later, when fully infected. The incorporation of low concentrations of virus into diet, and behavioural changes (greater surface feeding) of larvae fed on the juvenile hormone analogue, methoprene, may be useful in overcoming such problems.

Larval weights can be increased 1.5-2 fold by incorporating 2 ppm methoprene in the diet from the time of larval hatch. The use of methoprene also extends the time period during which larvae are at their maximum size. Yield of purified virus increased proportionally from 1×10^{10} capsules/larva from normal larvae, to 2×10^{10} capsules from hormone fed larvae.

Purification of the virus is included in the trials clearance for the use of the GV in the UK. Microsporidian spores have been detected in all virus preparations. Although these can be eliminated by centrifugation, it would be ideal if microsporidia-free insect stocks were available. Other aspects of quality control include assessments of infectivity and biochemical comparison of virus batches. Virus infectivity can be measured by bioassay in neonate larvae using virus incorporated into the larval diet. Median lethal concentrations of 1.5×10^6 capsules/ml diet have been obtained for a standard inoculum, equivalent to an LD_{50}

of 15 capsules or less. Electrophoretic analysis of viral proteins and viral DNA should be sufficient to detect strain differences between virus batches.

In preliminary field trials of the virus in 1978, four treatments were applied to an orchard of small bush cider apples cv. Michelin in a 4 x 4 Latin square replicated three times: A, unsprayed; B, two sprays of azinphos-methyl (0.33 g a.i./litre); C, one spray of virus (7×10^{10} capsules/litre); D, two sprays of virus. Sprays were timed from pheromone trap catches. Assessments of apple damage showed that both virus and chemical gave significant reductions in deep damage, with no significant differences between spray treatments. Virus treatment (2 sprays) also reduced the population of larvae collected in trap bands at least as effectively as azinphos-methyl.

EFFECTS OF THE USE OF CODLING MOTH GRANULOSIS VIRUS ON OTHER ORCHARD FAUNA

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In orchard trials, the fauna on trees sprayed with granulosis virus + 1% milk powder was compared with that on unsprayed trees, and on trees sprayed with azinphos-methyl. In 1978, one or two sprays of virus (7×10^{10} capsules/l) were applied, timed against codling moth by pheromone traps. In one trial in 1979, three concentrations of virus (7×10^{9}, 2×10^{10}, 7×10^{10}) were compared. Each treatment was applied twice, timed against codling moth. In another trial in 1979, two sprays of virus (7×10^{10} capsules/l) were applied later than usual, to coincide with attack by larvae of *Archips podana*, the most important tortrix moth in S.W. England.

Tortrix moths (leafrollers)

In 1978, neither azinphos-methyl nor virus significantly affected damage to fruit by tortrix moths. As azinphos-methyl can be effective against tortrix moths, presumably spray timing was wrong. In both trials in 1979, azinphos-methyl significantly reduced tortrix damage, whereas virus had no significant effects.

However, there was an indication that sprays of virus and milk, applied at the time of attack by larvae of *Archips*, could have encouraged increased damage. Tortrix damage to fruit was greater (though not significantly so) on virus-sprayed than on unsprayed trees (5.5 and 3.7% damage respectively). Also, when larvae of *Archips* were reared on leaves from virus-sprayed trees, their survival was not affected, but they grew significantly bigger than larvae on unsprayed trees. Further experiments with leaves from seedling apple trees sprayed with water or 1% milk or virus have shown that milk increases growth of *Archips*, whereas virus alone probably suppresses it.

Sprays timed against *Archips* gave good reductions in codling moth damage, despite their late application.

Pith moth, *Blastodacna atra*

In 1978, we noted an unusual infestation of fruit at harvest. Pith moth larvae differed from young codling larvae because they had dark dorsal sclerites at the tip of the abdomen, and fewer crotchets than codling on abdominal prolegs (a few were reared to adults). Fruit damage was similar to a codling moth sting, but without external frass; it could be definitely attributed to Blastodacna only when the larva was found, or damage was fresh. Some sting damage attributed to codling moth may have been caused by early attack by Blastodacna; this might explain why neither virus nor azinphos-methyl significantly reduced total damage attributed to codling in 1978.

Virus had no significant effect on damage by Blastodacna in 1978, whereas azinphos-methyl reduced damage to 0.3%, compared with 1.5% on unsprayed trees. In 1979, in the same orchard, Blastodacna damaged only 0.1% of fruit on unsprayed trees.

Predators and Panonychus ulmi

Counts of insect and mite predators, and Panonychus ulmi, at 2 wk intervals after spraying in 1978, showed no consistent differences between virus-sprayed and unsprayed trees. There were significantly fewer predatory insects and mites on trees sprayed with azinphos-methyl; P. ulmi increased on these trees to significantly greater numbers than on other trees, presumably due to the lack of predators.

CONTROL OF CODLING MOTH WITH GRANULOSIS VIRUS IN THE FIELD

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Field trials for control of the codling moth with a specific granulosis virus in the Heidelberg area were continued in 1978 and 1979. Virus propagation, study orchards, applications and evaluation procedures have been reported at the Heidelberg meeting of the codling moth group.

In both years Cm - population was very low, reaching 3.3% only in untreated trees in 1979. However, the virus was as effective against Cm as in previous years with 87% and 90.3% reduction by treatment in 1978 and 1979, respectively. In a trial on Golden Delicious in a commercial orchard, trees which had been treated with CmGV plus skimmed milk powder were later sprayed with ethephon about 2 weeks before harvest to hasten fruit ripening; ethephon had no effect on these trees although it hastened ripening on adjacent insecticide-treated trees. The effect appears to be due to skimmed milk.

PHEROMONE TRAP CATCHES OF CODLING MOTH ON A SCALE OF DAY-DEGREES

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Pheromone trap catches provide a convenient way of studying codling moth phenology. At one site the precise situation of the catch curves (one for each brood of moths) along the date line, or along a scale of day-degrees above 10°C, varies somewhat from year to year; but along either scale, mean catch curves can be calculated and drawn.

If we compare catch curves from climatically different places, we can reasonably expect the day-degree scale to be a better basis for comparisons than a time scale (dates). Such an exercise does yield a fairly uniform picture, but as one moves into warmer regions, the catch curves tend to move further along the day-degree scale; thus, the warmer the climate, the more day-degrees elapse before the first catches of the overwintering brood. Possible reasons for this will be discussed. In the following examples, the heat index is a crude average heat sum (above 10°C) for the year.

Place	Approx. lat.	Heat index	First brood d.deg.	First brood date	Second brood d.deg.	Second brood date	Data from
Bristol	51°N	729	35	late May	< 500	late July	Solomon
Michigan	43°N	1366	147	mid May	585	July	Riedl, Croft & Howitt 1976
L. Rhone Valley	44°N	1962	137	late April	750	early July	Audemard 1976
Olney, Ill.	39°N	2110	191	May 5	744	June 26	Glenn 1922
Meknès, Mor.	34°N	2698	190	mid April	700	(June)	El Idrissi 1980

(Glenn's figures are for first emergence of moths, the others for first pheromone trap catches)

With some apparent exceptions, the number of broods increases in step with the warmth of the climate, up to four or five per season.

TIMING THE FIRST SPRAY AGAINST CODLING MOTH

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In England, in seasons with changeable weather in May and June, some male codling moths may be caught in pheromone traps - which catch moths earlier than light traps - for up to a month before much oviposition occurs. Codling occurs at such low numbers that monitoring of oviposition is impracticable. The problem in forecasting is to establish when the flight period effectively 'takes off' and continues to develop, providing indirect evidence that oviposition has begun. At E. Malling, this occured each year (1972-79) when the heat sum was c. 100 day^{o}C and with dusk temperatures on some nights at or above 14^{o}. The reference week is fixed when all of the three following criteria are positive: (1) catches exceed the threshold of 5 moths/trap/week, (2) the heat sum equals or exceeds 100 day^{o}C and (3) dusk temperatures equal or exceed 14^{o}. The advisory service issue a regional warning to apply the first spray 10-14 days after the reference week, to allow for incubation of the eggs. Though there is scope for more precise timing, this system provides good control in commercial orchards, and concurs with the guidance taken previously from light traps.

Both the heat sum and dusk temperatures are very simply estimated from daily maximum and minimum temperatures. For the heat sum, the simple formula $\frac{(\text{max.} + \text{min.})}{2} - 10^{o}C$ was shown to have no disadvantages compared to more complex formulae. The dusk temperature (at sunset + 30 minutes) was approximately equal to the mean night temperature if the latter was 16^{o}C or less, and about 1^{o} lower if the mean was 17^{o} or more. Optimum spray timing in individual orchards may differ appreciably from the regional average and account needs to be taken of local experience and on-site trap catches.

In years with an early reference week and continuing warm weather it is important not to delay the first spray, in order to prevent development of a second generation.

PHEROMONE-TRAP CATCH IN RELATION TO CODLING MOTH PHENOLOGY

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A pheromone trap was operated in the east half of a mature cider-apple orchard from 1975 to 1977, whilst emergence of moths was being recording in emergence traps round trunk and branches in the west half of the orchard. Also larvae were collected each week from a sample of 1000 fruit, and the number of first-instar larvae was determined by counting those with suitable head-capsule widths. With information on the duration of the first-instar, the number of larvae entering apples each week was estimated.

Data for trap-catches and larvae entering fruit were expressed on a scale of day-degrees > 10°C, and curves of numbers against day-degrees were fitted.

Enough male and female moths were trapped when emerging in 1976 to compare their emergence curves: there was no significant difference. In all 3 years, the curves for pheromone-trap catch and emergence of moths were not significantly different, indicating that males were caught in pheromone traps soon after emergence.

For first generation codling moth, the curve for penetration of fruit by larvae lagged 132-164 day-degrees > 10°C behind that for catch of males in the pheromone trap. As egg development takes about 90 day-degrees, the curve for egg-laying lagged about 40-70 day-degrees > 10°C behind that for trap-catch. We combined the curves for pheromone-trap catch with data on the number of eggs laid per day by female moths in the laboratory at 25°C (expressed on a scale of day degrees > 10°C) to predict the egg-laying curve for the population in the orchard. This produced a greater lag between trap-catch and egg-laying than observed in the orchard, indicating either a shorter pre-oviposition period or shorter female life in the orchard, or both.

For second generation codling moth in 1975, the lag between catching moths in the pheromone trap and penetration of fruit by larvae was similar (156 day-degrees > 10°C) to that for the first generation. But in 1976 the lag-time was short (43 day-degrees > 10°C), indicating that eggs were laid before moths were caught in the trap. The reason for this is unknown.

CODLING MOTH ACTIVITY UNDER HIGH INFESTATION POTENTIAL CONDITIONS

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High codling moth infestation potential conditions exist in South Africa due to the relatively warm climate and to trivoltinism.

Moth activity extends over periods of 6-7 months per annum. The first flush of moth emergence in spring reaches a peak before or at full bloom, due to differential response of diapausing larvae and dormant fruit trees to spring change in temperature following the relatively warm winters.

In orchards in which infestation potential was very low due to previous intensive control programmes, complete withholding of spraying resulted in infestation ranging from less than 1% to about 5%. In orchards in which potential was higher due to inadequate previous control or moth influx from extraneous sources, this level of infestation was attained very early in the season already. The combined effects of the ensuing second and third generations added up to infestation of from 25% to more than 50% in the same season. In perperually unsprayed experimental orchards, annual infestation amounts to 80-90%, but this never occurs in commercial orchards.

Significant resurgence of codling moth occured in ensuing seasons when normal spray programmes are withheld completely, even where codling moth had previously been contained to low levels. Reduced spray programmes were only feasible where codling moth activity was monitored continously and adequate prophyllactic action taken to contain codling moth activity within acceptable levels.

A MONITORING SYSTEM FOR CODLING MOTH UNDER HIGH INFESTATION POTENTIAL CONDITIONS

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The high infestation potential of the codling moth in South Africa presents problems in programming control. A basic requirement is that influx of male moths from extraneous sources must be prevented. This was achieved by using a grid system of traps, covering relatively large tracts of orchard or confluent orchards. The component areas within the larger zone were effectively isolated from one another by the surrounding traps each monitoring their own respective areas.

Two hectares per trap was found to be the optimum assignment. Under very low moth population conditions, larger areas could be monitored by single traps. However, the results were often erratic. Under very high moth population conditions the area monitored per trap was often less than half a hectare. Since zones adjoining any such high infestation potential areas should in any case be given adequate prophylactic treatment, the two-hectares trapping area is adequate.

Where no sprays were applied, activity situations reflected by total seasonal catches of 0-10 moths, resulted in infestation of less than 0.5%. Total catches of 25-50 moths represented situation in which 1.5 to 4.0% infestation occurred, too high to be economically acceptable, especially in view of the magnitude of resurgence in ensuing seasons. Seasonal catches of 200-300 moths were related to 50-75% infestation, while 500-700 moths indicated a near saturation infestation level.

In 400 orchards monitored experimentally for two years, as many as 8 spray applications were necessary to achieve economically acceptable control where trap catches were consistently high. In some orchards with very low moth activity, it was possible to withhold spraying altogether, but resurgence inevitably took place in ensuing seasons.

It has been shown to be necessary to apply 3-4 sprays every season, against at least the first generation, to ensure continued low infestation potential. This basic necessity against the key pest must therefore be taken into account in the management of codling moth and other pests occuring at the same time.

EFFECT OF TEMPERATURE ON FECUNDITY AND DEVELOPMENT OF CODLING MOTH (LASPEYRESIA POMONELLA L.) APPLICATION TO FORECASTING METHODS

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A computer simulation model of the biological cycle of Codling moth (Laspeyresia pomonella L.) was formulated by the French Plant Protection Service as a forecasting method, aimed at reproducing both laying and hatching graphs for successive generations.

The initial calculations are based upon the first adult catches by sexual trapping. Then, certain biological parameters are considered as constant (pre-oviposition, number of laying days, fecundity, beginning of diapause). They are directly incorporated in the model. Other parameters - laying pattern, embryonic, larval and pupal development, mean adapted according to daily temperatures and, as for development, mean temperatures are summed (day-degrees).

So as to check certain aspects of the model, studies were undertaken in Avignon both in the laboratory and under semi-natural conditions (shelter, cloth-sleeves on apples-trees).

The goal was to determine the effect of unfavourable evening temperatures on the laying activity and on the total fecundity. The latter was hardly modified by long stays at low temperatures (up to 7 days), since the return to constant temperatures, reaching 20^{o} or above, progressively balanced the number of eggs laid. The same results were recorded under thermoperiodic conditions including 11^{o}C nights. However, a certain decrease of fecundity was noted at 18^{o}C.

It was shown that the laying activity, which stopped at night because of unfavourable temperatures, started again with favourable day temperatures.

These results are very important for the model, which proves unfit for the laying pattern simulation (which consisted of permanently suppressing the eggs that were not laid at unfavourable night temperatures) and for fecundity.

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The results obtained from a cloth-sleeve population were applied to an isolated insect in the model.

Moreover, the maximum day temperature is related to laying, which is direct on days following unfavourable nights, and indirect on favourable days. This can be explained by a correlation between maximum temperature and twilight temperature.

Taking into account the latter factor,and the results of observation on reproduction, led us to conclude that 2 days at a maximum temperature above 18°C were necessary in the orchard to cause laying. This greatly simplifies the use of sexual trapping data for forecasting the risk.

For the Codling moth, the mean incubation time usually corresponds to 90 day-degrees, which seems correct, although the 10°C threshold might vary. In a forecasting goal, it must be mentioned that hatching begins at 80 day-degrees.

The mean larval developmental time on apples, from hatching to pupal stage, under constant and thermoperiodic temperatures, corresponds to 400 day-degrees,with a 10°C development threshold. For the larvae, this duration actually includes two stages: a feeding period of 300 day-degrees and a prospecting stage of 100 day-degrees. The latter, partly corresponding to the prospecting behaviour for a cocooning site, was also observed and quantified in orchards.

Both previous data and the model data give 300 day-degrees for development. The difference from our actual results of 400 day-degrees may be partly explained by the difficulty in classifing the insects of a population in respect of the type of development.

The mean developmental time for pupae, for which the threshold is 11°C, is variable. For pupae which develop from overwintered larvae it corresponds to 170 day-degrees, whereas for non-diapausing larvae 150 day-degrees are obtained. These numbers correspond to the known data, taking into account the pre-pupation time equal to 10 day-degrees.

These various results should greatly contribute to the improvement of certain forecasting methods.

EL IDRISSI AMMARI M.A., 1980. Études biocoenotiques comparées en verger de pommiers au Maroc et influence de la température sur la fécondité et le développement de Carpocapse (Laspeyresia pomonella L.) dans une perspective de protection intégrée. Thèse Doc-ing. Univ. Aix-Marseille Fac.sc., 7 janvier 1980: 246 p.

INTRA-TREE DISTRIBUTION OF CODLING MOTH POPULATIONS

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A trapping design of 17 trees was established in a mixed planting of red and golden cultivars. Four replicates of each of the following trap placements were located within the 17 trees: 1 trap in the canopy 1.5 m from the centre of the tree and 1.5 m above the ground (perimeter); 1 trap in the canopy at the centre of the tree 1.5 m above the ground (ground centre); 1 trap in the canopy at the centre of the tree 3.5 m above the ground (top centre); 1 trap in each of the previous positions in a single tree (poly). One tree served as a check and had an empty trap in each of the above mentioned locations. Rubber sleeve septa treated with 1 μg of synthetic sex pheromone were used to attract males. Within tree trap placement positions were rotated among the trees in the grid every 2 weeks and trap collections were made twice weekly.

Trapping results showed that the population was concentrated in the upper portion of the tree. Ratios of top to bottom catches (bottom catch calculated by averaging the catches of the two bottom traps) ranged from a high of 94.1 to a low of 8.1 with an overall average of 14.5:1. In the polytrap trees, the presence of additional traps did not appear to influence the catches of the individual traps.

INFLUENCE OF TRAP POSITION ON CATCHES OF CODLING MOTH

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Experiments carried out in 1977 and 1978 showed that catches of codling moth in pheromone and female-baited traps were highly influenced by trap position.

When 3 traps were placed in the same apple tree at different heights the trap on the top of the tree caught most moths. Traps in trees (hosts and non hosts) were much more attractive than traps placed on sticks a short distance away. However, catches in traps placed in very small trees were as low as in traps on sticks.

From earlier observations we know that moths are visually attracted to tree silhouettes. By this bahevior they come more easily in contact with pheromone plumes. Moreover pheromone plumes of 'tree traps' may be larger and more compact than plumes of 'stick traps' and are therefore easier to be located by the moths.

THE EFFECT OF CLIMATIC AND NATURALLY-OCCURRING BIOLOGICAL FACTORS ON CODLING MOTH POPULATIONS IN SOUTH POLAND

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In the Nowy Sacz fruit-growing region in the south part of Poland codling moth is a pest of minor importance; in 57% of the unsprayed orchards examined there was only 1% or less of infested fruit (dropped and picked fruit). Infestation was over 2% in only 15% of the orchards. This is due to unfavourable climate and the influence of naturally- occurring biological control agents. Damage to apple fruits is caused only by larvae of a 'first' generation. Night temperatures during May, June and July were frequently below 15°C, so the activity of the moths was limited and one female laid an average of about 20 eggs in the field.
The biological agents affect mainly the diapausing codling larvae: the parasite Trichomma enecator kills about 20%; the micro-organisms - bacteria, Beauveria bassiana, Neoaplectana carpocapsae, fungus - kill c. 10%; and birds, mainly tits, eat about 50%. The proportion of codling eggs destroyed by adverse weather (mainly rain) and by predatory insects (mainly Anthocoris nemorum) ranged from 5-15% according to the year. The total reduction of codling moth population in the Nowy Sacz region due to climatic conditions and biological factors is about 90%.

EFFECTIVENESS OF DIFLUBENZURON IN RELATION TO SPRAY DEPOSITS

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In a combined field and laboratory experiment in 1979, we measured the effects of 5 different spray treatments of diflubenzuron on kill of codling moth eggs and neonate larvae, and how this related to spray deposits.

Treatments were (1) unsprayed; (2) spray by mistblower (275 g a.i./ha) on 20 June; (3) spray by hand-lance (567 g a.i./ha) on 28 June; (4) spray by hand-lance (613 g a.i./ha) on 10 July; (5) ULV spray, by hand-machine, of oil-dispersed concentrate; (6) ULV spray, by hand-machine, of wettable powder in water. (Both ULV sprays applied at a rate of 552 g a.i./ha).

Treatments were applied in a Cox orchard. Treatments 1 to 4 were arranged in a 4 x 4 Latin Square, and damage to fruit was recorded. All spray treatments significantly reduced codling damage, but there were no significant differences between treatments (mean 85% reduction in damage). Damage to fruit by tortrix moths was sparse (0.9% on unsprayed trees), and no spray significantly reduced damage.

Analysis of the percentage of eggs and neonate larvae killed by different spray treatments revealed more about their comparative effectiveness. Spray deposits and their effects on codling eggs and neonate larvae persisted through the season. On trees sprayed by mist-blower (treatment 2), more eggs were killed on the lower than on the upper surfaces of leaves; but in all other spray treatments, egg kill was greater on the upper than the lower surfaces, indicating poorer cover on the undersides of leaves.

ULV spraying by hand-machine did not give better kill of codling moth eggs than either mist-blower or hand-lance,even though ULV sprays gave higher deposits of diflubenzuron than other methods. The oil-based ULV spray gave a slightly, and significantly, better kill than the water-based ULV spray. This was so even though the initial oil-based deposit was only half that of the water-based spray. These results indicate that ULV sprays gave patchy cover; but the oil-based ULV spray gave more even cover than the water-based one.

Larvae hatching from eggs on sprayed leaves were about half as likely to penetrate fruit as those hatching from eggs on unsprayed leaves.

Mortality of eggs and neonate larvae on sprayed leaves, as a percentage of their survival on unsprayed leaves, was similar to the 85% reduction in damage to fruit on sprayed plots. Thus, although kill of eggs laid on fruit was not studied (due to poor fruit set), mortality of eggs and larvae on sprayed leaves seemed to reflect overall mortality of larvae in the orchard.

VARIETAL SUSCEPTIBILITY OF PEARS TO CODLING MOTH (LASPEYRESIA POMONELLA L.) INJURIES: CONSEQUENCES FOR SUPERVISED CONTROL MONITORING

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The varietal susceptibility of pears to larval injuries by the Codling moth (*Laspeyresia pomonella* L.) was first studied by a laboratory method.

The method consists of artificially infesting fruit gathered on the same day (40 pears per variety = 4 x 10) with newly hatched larvae (5 per pear) and examining the results 3 days later. One can observe: visible attacks, their location, larvae found in the fruit, alive or dead. The latter criterion proved to be the most representative one.

Infestation was applied every 10 or 15 days, from the period of the first attacks by the moth until harvest.

The susceptibility of pears to larval injuries by Codling changes with the fruit development and was compared to that of Golden Delicious, which is constantly very susceptible.

On 7 pear varieties examined in 1978 and 1979 in Avignon, the changes in susceptibility were as follows:

- During the last 10 days of May the susceptibility was 20 to 40%.
- In June susceptibility declined somewhat (except for Dr. J. Guyot), and reached the lowest level.
- In July and August, it distinctly increased and reached or exceeded the standard (Golden Delicious) susceptibility before the harvest period.

If susceptibility is less then 15% of that of the standard until the beginning of July, there is no risk of injury higher than 1 per cent in the orchard, supposing the fruit weight of trees is normal.

Observations (4 000 pears counted per variety) made in 1978 and 1979 in pear orchards with a high Codling moth population and not treated during the 1st generation confirmed the very low susceptibility of Passe crassane and Conference (attacks below 1 per cent). The attacks, more important than expected, on Doyenné du Comice were linked to a rather low weight of fruit on the trees. As for the other varieties, the attacks exceeded the economic tolerance threshold.

The regulation of Codling moth populations, when supervised control in pear orchards is applied, must take into acount:

- The incidence of Pear psylla control.
- The differences in varietal susceptibility to larval attacks.
- The risk due to the population level, assessed by sexual trapping, considering the fruit weight of the trees.
- The management of the cultures. The mixing of varieties and the proximity of susceptible apple trees at the beginning of the season.

The Codling moth control management (when the latter is the only pest to be controlled) is being experienced, as shown in the following diagram.

Varietal susceptibility during the 1st generation	Monitoring 1st generation (1) 2nd (2)
1 - Not very susceptible varieties (Passe crassane, Conference, Comice)	No control
2 - Moderately susceptible varieties (Alexandrine Douillard, Beurré Hardy)	Control according to sexual trapping results (apple trees threshold x 3)
3 - Susceptible varieties (Williams)	Control (apple tree threshold x 2)
4 - Very susceptible varieties (Dr. J. Guyot)	Control (apple tree threshold)

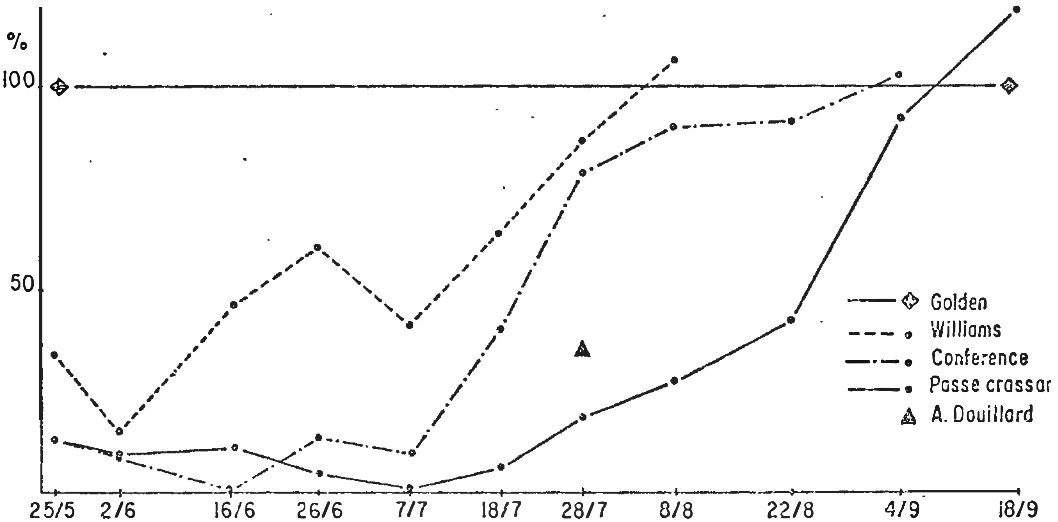
(1) With a normal fruit weight on the trees and presuming the more susceptible pollinating varieties are treated.

(2) Control depending on the sexual trapping threshold adopted in France on apple trees.

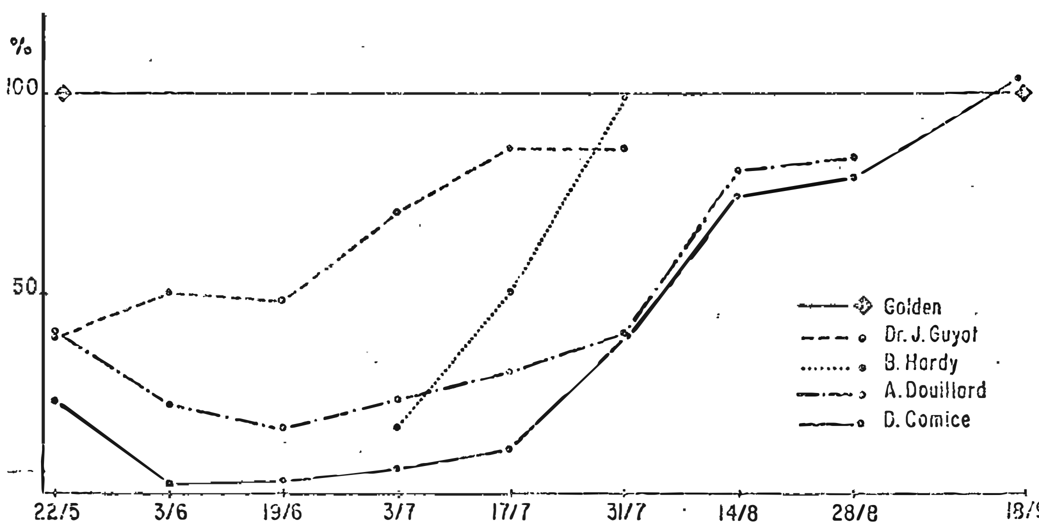
The correlation between the hardness of the pear tissue and the susceptibility to attacks is to be studied, in order to complete the varieties classification more easily.

AUDEMARD H., EL IDRISSI M.A., 1979. Etude de la sensibilité des poires aux attaques de Carpocapse (Laspeyresia pomonella L.): premiers résultats. C.R. Acad. agric. Fr., 65: 427-437.

1978



1979



Percentages of Codling moth larvae entered into pears and alive within 3 days in comparison with Golden Delicious.

FOUR YEARS MATING DISRUPTION CONTROL AGAINST CODLING MOTH (LASPEYRESIA POMONELLA L.)

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From 1976 to 1979 mating disruption control of the codling moth was tried in apple orchards of the Geneva Lake region. The diffusion of the Codlemone (E-8, E-10 dodecadien - 1 - ol) is insured by rubber tubes of 2 mm inner diameter and 1 mm wall thickness. The diffusion rate is about constant until 30 to 40% of the amount of Codlemone remains. In laboratory the half diffusion time is 13.3 days at a constant temperature of 25°C; it is reduced by a factor of 3 at 20°C. A wind of 2m/sec. increases the release rate by a factor of 4. In an orchard, a single deposition of dispensers allows enough attractant to evaporate for all the season and the rubber prevents the oxidation of the Codlemone. The presence of a 100 µg dispenser in a rearing box containing 5 pairs of moths significantly decreased matings. A 100 mg dispenser caused a complete inhibition of copulations. Males and females maintained separately during 4 or 7 days with 1 or 100 mg of Codlemone mate normally during the first night they were together without attractant.

When attractant is released in orchards at rates exceeding 1 mg/ha.h from rubber tubes, males are generally unable to locate traps or tethered females. By maintaining a constant rate of release per unit area it is possible to reduce the number of dispensers up to one per 225 m^2 or even 400 m^2. There is no important difference in disruption when attractant is released from tree crowns at the top or lower down at 1,7 m or even 1 m high. In the presence of codlemone, males are more active and migrate over larger areas. Control trials were conducted with success over 18,1 ha from 1976 to 1979 with 10 to 40 g attractant per ha. The efficiency rate was estimated at 85% or more. The total costs of the mating disruption technique against codling moth are about 160 SF.

A MATING DISRUPTION EXPERIMENT WITH CODLING MOTH; FIRST YEARS RESULTS

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A disruption experiment was started in a 0.9 ha apple orchard in 1979. 270 dispensers (rubber tubes impregnated with 80 mg of Codlemone) were placed in May (1 dispenser/tree at the border and 1 dispenser every second tree within the orchard; 24 gr/ha). The evaporation rate, determined by weighing the dispensers weekly, varied with the temperature (average 8 mg/h, range 0.5 - 17.5).

The moth flight in the orchard and its surroundings, as well as in another apple orchard not sprayed in 1979, was recorded with pheromone- and female baited traps. The larval population was assessed by corrugated paper bands and by inspection of windfall and harvested fruits on 50% of the trees.

Moth catches were almost totally suppressed in the test orchard, they were small in the surroundings and large in the unsprayed orchard. The larval population of the experimental orchard in autumn was 415 fullgrown larvae (1 larva/tree) compared with about 300 in 1978 when codling moth had been controlled with insecticides.

CONTROLLING CODLING MOTH BY COMMUNICATION DISRUPTION METHOD WITH A SYNTHETIC SEX PHEROMONE: TRIALS OF 1978 AND 1979

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The possibility of codling moth control by communication disruption with a synthetic sex pheromone was shown in the U.S.A., France and Switserland.

The purpose of the trials carried on in 1978 and 1979 in Avignon was to obtain a better knowledge of the conditions required for a good efficiency of the method as well as its limitations.

The pheromone (E8 E10 DD-ol) used in these trials was synthesized by the Laboratory of Chemical Mediators (INRA) with the cooperation of Rhone Poulenc Society. An anti-oxidizer, alpha-tocopherol, was added to the pheromone.

The dispenser, identical to the previous type, consists of a tubular rubber (diameters: outside 3 mm, inside 2 mm) filled with pheromone and closed at both ends. It was sheltered by: cardboard tumblers coated with paraffin wax in 1978,and a small board covered with aluminium foil in 1979. Each dispenser was hung in the top of a tree canopy.

The amount of pheromone diffused is established by regular weighing of 30 loaded dispensers and 30 empty ones. Analysis showed the good value of the results provided by weighing.

The checking of results on codling moth population is carried out by:

- trapping of adults by virgin females, pheromone caps or by honey-baited traps (1979)
- checking of mating possibility by the tethered females method (1979)
- visual survey of fruit injuries (4 000 fruits)
- mature larvae and pupae trapping (40 trap-bands).

Codling moth control by disorientation was previously effected by the experimental orchards. It concerned the 2 generations in A1 1976 and 1977 had only the first one in A3 1977 (see table).

Two series of dispensers were set in A1 and only one in A3 (1st generation controlled). In addition, a fence of dispensers was hung in hedges around the orchards for all trials except for A1, 1978.

The mean diffusion rate of 20 mg/ha, effective in prior trials in Avignon was only achieved in A1, 1979. The bad diffusion of 1978 was imputed to low temperatures, frequent rains and to the protection of dispensers by tumblers which limited the diffusion. Nevertheless 15-30mg/ha/h was diffused during the second generation in A1, 1978.

Trapping always gave too disappointing results: A1, 1978: 1 catch in trap baited with pheromone cap, A1 1979: 20 catches with caps and 1 with virgin females from a very high population. Among tethered females (1979):

- in check orchard, 35 mated out of 61 recovered alive (out of 106 initially tethered)
- in A1 controlled orchard 1 mated out of 58 recovered alive (out of 101 initially tethered). Therefore the communication disruption was apparently good in this case.

On the whole the results were bad. The crop protection could not be ensured on a level to conform with the economic damage threshold of 2 per 100 (see table) in spite of saving sprays on the last generations (A1 1978 and A2 1979).

The efficiency on Codling moth dynamics, measured according to trend indexes, previously established in same orchard was: 1978 A1 1st generation = 30 per 100, 2nd generation = 0, A3 = 0 ; 1979 A1 1st generation = 70 per 100.

This is attributed to:

- a deficiency of the amount of pheromone diffused in 1978 during the 1st generation
- the arrival of adults alien to the orchard during the 2nd generation, A1 1978.
- a very large population, facilitating sexes meeting in A1 1979 and the multiplication of the population, the most important increase observed in the region for the last 10 years.

The conditions required for a good efficiency of Codling moth control by communication disruption should be: low population level, relative isolation of the orchard from the infestation source, sufficient and regular diffusion of pheromone.

RESULTS OF THE 1978 AND 1979 TRIALS OF CODLING MOTH (*LASPEYRESIA POMONELLA* L.) CONTROL

THROUGH MALE DISRUPTION METHOD WITH THE SYNTHETIC SEX PHEROMONE

Referring to orchards Year (1)	Generation controlled	Amount of pheromone set/diffused g. hectare / mg/hect/hour (2)	Per cent (3) unmarketable fruits by Codling moth injuries at harvest time	Dynamic of Codling moth population (3): Hibernating larvae before test (5) traps bands / estimated	1st generation larvae + pupae / pupae	2+3 generation larvae + pupae / pupae 2nd	Hibernating larvae after test
A1 1978	1 + 2	124,8/77,8 13,7	5,80	123	177 20	511 (2nd)	668
A3 1978	1	70/23,9 4,2	4,75 (4)	72	250 75	249 (2nd)	499
B1 1978	0	Orchard without control	> 50	1680 100	541 250	2490 (2nd)	3030
A1 1979	1 + 2	270/157,6 46,9	10,00 (4)	668 200	900 563	3300 (2nd + 3rd) 98 (2nd)	3539
B1 1979	0	Orchard without control	> 95	3030 100	1930 1300	7816 (2nd + 3rd) 262 (2nd)	8184

(1) Orchard area in hectare A1 = 0,75 ; A3 = 1; B1 = 0,25
(2) Mean diffused throughout the season
(3) 4 000 fruits examined - 40 trees with trap-bands
(4) A3 1978 in 2nd generation 2 diflubenzuron sprays - A1 1979 from 27th July 3 phosalone sprays
(5) Without trap-bands the population is limited by competition for cocoon sites.

CONTENTS

	Page
Report of the meetings on biological control in orchards, and biology and control of codling moth, at Wye 25-29 March 1980.	1
G. FAUVEL AND P. ATGER Evolution of pear psylla (*Psylla pyri* (L.) and beneficial insects in pear orchards of southeastern France in 1979.	13
C.A.M. CAMPBELL Integration of chemical and biological control of pear psylla in Kent.	14
E. NIEMCZYK, M. PRUSKA AND R. OLSZAK Role and effectiveness of predators in controlling aphids in apple orchards.	15
M.G. SOLOMON An electrophoretic method for analysing the diet of predators.	16
E. NIEMCZYK Bark bug, *Anthocoris nemorum* L., as an effective predator of fruit tree red spider mite, *Panonychus ulmi* (Koch) on apple.	18
H. STEINER The role of anthocorids and mirids in controlling fruit tree red spider mite in orchards in Baden-Württemberg.	19
EDISON PASQUALINI The role of *Stethorus punctillum* in the integrated control of the european red mite in apple orchards.	23
M. BAILLOD First experiments with phytoseiidae in apple orchards.	24
G. FAUVEL Evolution of *Panonychus ulmi* populations in an apple orchard located near Avignon and receiving no insecticide sprays, with observations on the population dynamics of *Amblyseius (Kampimodromus) aberrans* (Acari = Tetranychidae, Phytoseiidae).	25
P. GRUYS Experience with biological control of fruit tree red spider mite by phytoseiid mites in apple orchards in the Netherlands.	26
M.G. SOLOMON Predators of spider mite; natural colonisation and artificial introduction.	30
W.P.J. OVERMEER A comparative study of the effect of some pesticides on three predatory mite species: *Typhlodromus pyri*, *Amblyseius potentillae* and *A. bibens*.	32

	Page
J.B. FORD AND F.M. GIBONEY Video recording techniques for studying predatory mite behaviour.	35
P. GENDUSO Integrated pest control in Sicilian orchards.	36
P. GRUYS Abundance and parasitization of leaf rollers in integrated control in the Netherlands, in relation to the pesticides used.	37
K.P. CARL Observations on the apple leaf-curling midge, *Dasineura mali* Kieff., and a new cecidomyiid on apple, *Macrolabis* sp.	40
F. VAN DER VOOREN, T. THYM AND P. GRUYS Natural enemies of apple leaf midge in the Netherlands.	44
G. DOMENICHINI On some carabids of the orchard soil and the effects on them of tillage.	47
P. GIUNCHI Possibilities of biological control of pear insects.	48
H. WILHELM Experiences with integrated control in apple orchards.	50
E. DICKLER Field observations on the leafroller complex on chemical-, CmGV-, and untreated apple trees.	51
E. NIEMCZYK Effectiveness of *Trichogramma* against codling moth.	52
E. MANI AND TH. WILDBOLZ *Pimpla turionellae* L. as a pupal parasite of codling moth in Switzerland.	53
H. AUDEMARD AND P. FERRON Codling moth control with *Beauveria bassiana* in orchards.	55
JÜRG HUBER Field persistence of the codling moth granulosis virus.	58
C.C. PAYNE AND D.M. GLEN Codling moth granulosis virus production and preliminary field trials in the United Kingdom.	60
D.M. GLEN, C.W. WILTSHIRE & N.F. MILSOM Effects of the use of codling moth granulosis virus on other orchard fauna.	62
E. DICKLER Control of codling moth with granulosis virus in the field.	64
M.E. SOLOMON Pheromone trap catches of codling moth on a scale of day-degrees.	65

	Page
J.E. CRANHAM Timing the first spray against codling moth.	67
D.M. GLEN AND PHILIP BRAIN Pheromone-trap catch in relation to codling moth phenology.	68
A.C. MYBURGH Codling moth activity under high infestation potential conditions.	69
A.C. MYBURGH A monitoring system for codling moth under high infestation potential conditions.	70
M.A. EL IDRISSI AMMARI AND H. AUDEMARD Effect of temperature on fecundity and development of codling moth (Laspeyresia pomonella L.) application to forecasting methods.	71
ROBERT B. HUTT Intra-tree distribution of codling moth populations.	73
E. MANI AND TH. WILDBOLZ Influence of trap position on catches of codling moth.	74
E.NIEMCZYK AND S. PREDKI The effect of climatic and naturally-occurring biological factors on codling moth populations in South Poland.	75
D.M. GLEN, N.F. MILSON, C.W. WILTSHIRE AND J.A. PICKARD Effectiveness of diflubenzuron in relation to spray deposits.	76
H. AUDEMARD Varietal susceptibility of pears to codling moth (Laspeyresia pomonella L.) injuries: consequences for supervised control monitoring.	78
P.J. CHARMILLOT Four years mating disruption control against codling moth (Laspeyresia pomonella L.).	81
E. MANI AND TH. WILDBOLZ A mating disruption experiment with codling moth; first years results.	82
H. AUDEMARD, FRANCOISE BEAUVAIS AND B. SAUPHANOR Controlling codling moth by communication disruption method with a synthetic sex pheromone: trials of 1978 and 1979.	83