ORGANISATION INTERNATIONALE DE LUTTE BIOLOGIQUE CONTRE LES ANIMAUX ET LES PLANTES NUISIBLES (OILB)

INTERNATIONAL ORGANIZATION FOR BIOLOGICAL CONTROL OF NOXIOUS ANIMALS AND PLANTS (IOBC)

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IOBC/WPRS ACTIVITIES

IOBC Working Group on Integrated Pest Control in Orchards

Summary of the meeting on « Fertiliser Use in Integrated Fruit Production », held in Changins, Switzerland, on 2-3 September, 1980. IOBC/WPRS Bulletin (1982) V (1), 64 pp (in French)

This meeting was attended by 35 participants from Western Europe, and the aim was to standardise the techniques of « integrated production » in order to obtain high quality yield while respecting ecological constraints. The themes chosen were : methods for assessing fertility in an orchard (by soil, leaf or other analyses), problems in assessing the analytical results (Ca, N, P, Mg, etc.), possibilities for establishing reference or standard methods (between different institutes), advice on fertilisation to growers, the relationship between fertilisation and plant pests and between fertilisation and fruit quality at harvest. Brief abstracts of papers presented are given below.

J. Catzeflis & J.P. Ryser (CH) : Fertility and rooting profiles in arboriculture, pp 2-6

Analyses performed on soil samples collected from bare and grassed areas between trees in 5 orchards confirmed that soil fertility decreases rapidly with increasing depth. Many roots were found in the upper 10 cm, especially in the weeded area. Root development at a similar distance from the trunk was 1.2 to 1.5 times greater in the weeded than in the grassed area, depending on the orchard. This explains why the way in which the grassed areas are managed has little effect on the orchard.

Secretary-General : G. MATHYS, 1, rue Le Nôtre, *FR-75016 Paris* (France).

Ch. Gysi (CH) : Soil analysis and recommended fertilisation in integrated production in German Switzerland, pp 7-10

Recommended fertilisation is based on both soil analysis and observation of the orchard. An enquiry started in 1978 in 55 commercial orchards revealed that recommended fertilisation procedures are generally well accepted in practice and that there are significant differences between the soils in plots producing fruit with good or poor storage properties.

J.P. Ryser (CH) : Towards the practical use of leaf analyses in viticulture and arboriculture, pp 11-27

Extensive enquiries and leaf analyses in several vineyards and orchards have led to the setting up of a scheme for assessing the nutritional balance of plants based on the nutritional status of the leaves. The information obtained on mineral content of leaf dry matter is analysed using a series of ratios based on the phenomenon of antagonism. A statement on the fertility of the plant can only be made when all the criteria of estimation of an element are similar.

F. Gorini (IT) : Apple bitter pit, means of prevention by treating with calcium salts, pp 28-35

Four experiments from 1976-79 using CaCl on Granny Smith or Golden Delicious apples, and an experiment using $CaPO_4$, are described. Early treatment, 15 days after flowering, did not lead to a reduction in apple bitter pit, and in some cases increased disease incidence. Because of poor adsorption, $CaPO_4$ treatments had no effect. CaCl treatments were only beneficial when applied throughout the growing season. Post-harvest treatments were deleterious.

R. Schumacher (CH) : Possible causes of physiological diseases of apples, pp 36-43

Most physiological diseases of apple are caused by calcium deficiencies. In this study, 50 trees were observed, and at harvest the positions on the tree of all the fruits were recorded. Some trees received 4 CaCl treatments. These treatments reduced the incidence of bitter pit and the K/Ca ratio. % bitter pit was over twice that in fruit at the top of the tree compared with fruit at the bottom. The small fruits from trees with poor growth were less susceptible. Fruit produced on younger wood was more susceptible to bitter pit. The effects of pruning were also investigated. All measures which stimulate growth and decrease fruiting lead to an increase in the susceptibility of fruit to bitter pit.

R. Marcelle & W. Porreye (BE) : Mineral analysis of fruits with regard to their storage properties : report of 6 years practical experience, pp 44-45

An analytical service for fruit mineral composition was started in 1975 at the Gorsem Research Centre, with the aim of 1) establishing a scale of storage values for different batches from a grower in order to plan the harvest, and 2) forecasting the storage properties of fruits from different orchards in order to give some guidance to the persons concerned with storage. Certain facts have emerged over the past 6 years : 1) raised K levels reduce storage time while raised Ca levels improve it, 2) P content needs to be sufficiently raised for fruit to withstand low temperatures and maintain their flavour, 3) N only plays a secondary role in storage, indirectly by its effect on vegetative growth.

A. Staubli (CH) : Relationship between fertilisation and plant pests : effect of tree vigour on population increases of red spider mite (P. ulmi) in apple orchards, pp 46-51

The trial was carried out in 1979 at Bex (Rhône valley) in an area practising integrated control, on an area of 216 ha of Gravenstein planted in 1972. The results showed the following : cutting the trunk to reduce tree vigour reduced the number of *P. ulmi* eggs recorded by 75 % ; there was no migration between cut and adjacent uncut trees, showing that mite population development was directly affected by the physiological state of the tree.

Th. Wildbolz (CH) : Fertilisation and pest and disease occurrence in apple, pp 52-53

This brief review article concludes that measures which prevent excessive and prolonged vegetative growth, including reduced N applications, will reduce the effects of aphids, cecidomyiids and mildew. Well-balanced fertilisation also helps reduce attacks of canker and rots. Similar effects may be obtained for mites.

J. Bosch (DE) : Effect of N fertilisation on multiplication of the red spider mite, P. ulmi, pp 54-55

Three levels of N were investigated : none, 20 mg NH_4 NO_3/plant/week, and 40 mg NH_4NO_3/plant/week. After 4 weeks, 10 *P. ulmi* larvae were placed on each plant, and 4 weeks later the mites on each plant were enumerated and certain leaves analysed. *P. ulmi* numbers increased with increasing N fertilisation (1286-2284/plant). The glucose and total N content of the leaves was also higher in the high N treatment group.

Summary of the meeting on « Influence of Pesticides on the Beneficial Fauna in Fruit Trees », held in Colmar, France, from 31 March to 1 April, 1981. IOBC/WPRS Bulletin (1982) V (2), 90 pp (in French or English)

Thirty-two people attended this meeting, mainly from France, Switzerland, United Kingdom and Fed. Rep. of Germany, with observers from Italy and Portugal. It provided an opportunity to review the state of the art since the last meeting in Colmar on 10-11 April, 1979, and to attempt to establish standard procedures for assessing the short-term effects of chemical pesticides (excluding those with a specific mode of action such as synthetic pyrethroids, likely to manifest a toxic effect in the medium term) on the beneficial fauna. The following contributions were presented :

M. Blanc et al. (FR) : Effects of pesticides on beneficial fauna ; present status of studies on methodology in orchards, pp 16-19

A standard method for assessing the short-term effects (24-48 h) of pesticides on beneficial fauna is described for an orchard in the SE of France. The fauna killed by the initial application of pesticide are collected in containers placed under the treated trees. A subsequent treatment with dichlorvos enables an inventory of the remaining fauna to be made. Alternative sampling methods (rearing, visual inspection, etc.) must be used for certain stages such as eggs, nymphs and some larvae. The mechanical effect of spraying should also be considered, and control trees sprayed only with water included. Experimental design should take into account the distribution of the fauna in an orchard. The appropriate statistical analysis and presentation of results are described.

J.C. Bocquet (FR) : Development of an experimental method to assess the effect of pesticides in orchards, pp 20-22

An experiment was set up in 1980 in the Paris area (Chambourcy) based on the recommendation of the Working Group meeting on beneficial insects held in Colmar, 30 May-1 June, 1978. The method was modified so as to assess the medium-term effects of pesticides and degree of recolonisation : all trees were treated on Day 1, and insects then collected from certain trees 2, 7, 15 and 21 days later (using DDVP).

B. Sechser (CH) : Effect of pesticides for tentative use in pear orchards on Anthocorids and other beneficial insects in the field, pp 23-34

This paper deals with the effects of certain pear orchard pesticides on *Anthocoris nemorum*, in addition to other predators. Amitraz, vamidothion, endosulfan and mancozeb appeared safe for psyllid control and compare favourably with chlordimeform regarding selectivity. Reservations were expressed about acephate and azinphos-type OPs.

A. Staubli et al. (CH) : Secondary effects of various pesticides on the beneficial fauna in pear orchards, pp 35-41

About 13 products were tested in the 4 trials carried out in 1979 and 1980 : amitraz, vamidothion, fenvalerate, powdered sulphur, deltamethrin, diazinon, bupirimate, mevinphos, phosphamidon, endosulfan, acephate, ethiophencarb and X 80.

P. Blaisinger (FR) : Approach to assessing the medium-term effect of pesticides on the beneficial fauna in an orchard, pp 42-45

Population variations were assessed 3, 8 and 21 days after initial treatment. A broad-spectrum pesticide such as permethrin had a great initial impact but recolonisation by certain predators was rapid while an acaricide had a negligible effect on the beneficial fauna 3 days post treatment, but a marked effect at 8 days. Means for improving and using the technique are discussed.

P. Blaisinger (FR) : Longterm effect of pesticides on winter egg production in P. ulmi, pp 46-47

Intervention treatments (dichlorvos at 100 g a.i./hl) were applied 3, 8 and 21 days post initial treatment. There were a number of anomalies in the residual population levels of *P. ulmi* : they were affected both by the pesticide used and by the date of the intervention treatment. In the absence of the latter, the phosalon and cyhexatin treated trees had lower levels than the control, while the permethrin treated plots had very many more *P. ulmi* winter eggs.

J.E. Cranham (UK) : Field trials to assess the effects of pesticides on Typhlodromus pyri, pp 48-50

Trials at EMRS in 1979-80 have involved 3 strains of *T. pyri* established in 3 different orchards and, also, for comparison of the effects of pesticides, in different blocks of the same orchard. About 33 pesticides were investigated, and those which were so far shown to be virtually harmless to *T. pyri* include : pirimicarb, diflubenzuron, tetradifon, bupirimate, triadimefon, fenarimol, captan, dodine, dithianon, urea, ethephon and MB25-105.

M.A. Easterbrook (UK) : Effect of pesticides on apple rust mite, Aculus schlechtendali, pp 51-53

Although high population levels of *A. schlechtendali* can cause damage, it is particularly important as an alternative food source for the predacious mite *T. pyri* early in the season before *P. ulmi* hatches and also later in the season if *P. ulmi* numbers are low. The toxicity of 9 insecticides, 4 acaricides and 8 fungicides to *A. schlechtendali* was investigated. Carbaryl and amitraz showed high toxicity both pre- and post-blossom.

W. Wilkinson & J.F.H. Cole (UK) : A field study to show the effects of permethrin and azinphos-methyl on the arthropod fauna of apple trees, pp 56-58

The aim of this trial was to test the suitability of several sampling methods for assessing the effects of permethrin and azinphos-methyl on arthropods in an apple orchard. The methods used were suitable but time-consuming. Both permethrin and azinphos-methyl caused an increase of *P. ulmi*. This spider mite increase can be linked to a reduction of predators, but possible stimulation of *P. ulmi* fecundity might also contribute.

J. Coulon (FR) : Laboratory results on the application of fungicides to Phytoseiulus persimilis, pp 59-62

Thirty fungicides were assessed, more than half of which proved to have a more or less marked effect on multiplication of the predator. Studies on mortality of *P. persimilis* adults, eggs or larvae could not alone explain the population reduction effects observed for certain treatments. Compounds showing no or very little toxicity included captafol, chlorothalonil, ethirimol, fenarimol, folpet, iprodione, oxycarboxine, thiram, triadimefon and triforin.

P.W. Carden (UK) : Trials of integrated control on apples in south-east England 1980, pp 63-67

An integrated control program of the type used in these trials appeared to be effective in preventing serious economic losses from pests and diseases of apple while having less serious side-effects on the environment than those from a conventional spray program. However, it had slight economic disadvantages in that spray chemicals may cost very slightly more and pests may damage up to 2 % more fruit. If it became necessary to adopt an integrated control program, the cost to growers would not be great but there is no great economic incentive for them to change to such a system at present.

M.A. Easterbrook et al. (UK) : Integrated pest management trials in English apple orchards, pp 68-71

Two strategies for the integration of biological control of *P. ulmi* with chemical control of other pests and diseases are described : a) use of selective insecticides, allowing natural colonisation by native predators ; b) use of OP insecticides for insect pests, with artificial introduction of an OP-resistant strain of the predacious mite, *T. pyri*.

S.A. Hassan (DE) : Tests on the side-effects of pesticides carried out by the Working Group « Pesticides and Beneficial Arthropods », pp 72-73

Pesticides are first tested in the laboratory on as many beneficial arthropods as possible. If the pesticide is found to be harmless or only slightly harmful to several important natural enemies, further investigations on its suitability for integrated control are recommended. Semi-field or field tests

may be carried out to confirm the laboratory results. Field experiments are best carried out by experts in other IOBC Working Groups specialised in integrated control.

Summary of the meeting on « Integrated Production of Apples », held in Wädenswil, Switzerland, on 15-16 June, 1982. IOBC/WPRS Bulletin (1982) V (1) : 60-64 (in English)

This meeting of pomologists from 7 European countries was held at the suggestion of the Working Group with the aim of establishing cooperation between research workers concerned with fruit quality. There were 13 participants who presented papers on the concept of and prevailing approaches in integrated production of apples, and on the factors influencing fruit quality. The following conclusions were made by the meeting :

1) that it is difficult to achieve consistent production of apples of high intrinsic quality and that certain modern methods of production may increase the occurrence of physiological disorders and reduce eating quality,
2) that the criteria to describe quality should be defined more clearly and measured objectively for both scientific and commercial purposes,
3) that the methods of prognosis of fruit quality before and at harvest must be developed further for the main varieties and tested in different growing regions,
4) that apple production systems should be acceptable in both ecological and economical terms and suitable for use over periods of several decades,
5) that residues on fruit must be minimized as far as possible and that agrochemicals should be used in ways which protect the ecosystem,
6) that such efforts are in accordance with consumers' demands for a « good apple », particularly in terms of safety and eating quality,
7) that such an objective can only be realized by comprehensive integrated fruit production (i.e. the production of good quality apples by economically and ecologically acceptable methods),
8) that research, grower and marketing organizations should give high priority to integrated fruit production.

A workshop on fruit production methods and apple quality should be held in autumn 1984 at Bonn/FRG.

IOBC Working Group on Use of Models in Integrated Crop Protection : Report of the Fifth Meeting, held from 22-24 February, 1982 in Stuttgart-Hohenheim (Fed. Rep. of Germany)

This meeting was attended by 22 participants from Western Europe. Brief abstracts of some of the contributions are given below, following a summary of the recommendations made :

1. Activities of the Group to continue, and cooperation between participants increased. Investigations to be made regarding EEC funds.
2. An inventory of models in different phases of development should be published in the IOBC Bulletin in 1982.
3. The IOBC Bulletin on use and development of models in integrated crop protection should be finished in 1983.
4. Subgroups dealing with specific topics to be set up, such as the *Septoria* Group.
5. More attention should be given to the practical application of knowledge and to an insight of epidemiology and damage assessment.

B. Hau & J. Krantz : Approaches to the modelling of interactions in the wheat agroecosystem

The experiments were carried out in commercial wheat fields in which 20 observation plots remained untreated. The following constraints were the most important : *diseases* (glume blotch, powdery mildew, seedling blight), *pests* (cereal leaf beetle, rose grain aphid, grain aphid), *weeds* (scented mayweed, cleavers). By means of two-dimensional frequency distributions, the interactions of some constraints were investigated ; for instance, competition between *Lema melanopus* and *Macrosiphum avenae*. The single tiller approach enabled culms to be grouped according to the constraints present. A comparison of disease progress curves, observed for the different groups of culms, also showed interactions, for instance the antagonistic effect between mildew and *Septoria*. In addition to the total losses due to the constraints, their relative importance was assessed by means of loss profiles.

I. V. Leeuwen-Pannekoek : Recent results with EPIPRE in different countries

No abstract.

D. Obst & D. Royle : Aims, methods and results of the Septoria Working Group

Losses due to *S. nodorum* range from 8-12-15 %, with local losses up to 30 % reported in 1980. A series of 12 experiments was started in 1978, scattered over Bavaria. Initially, application of captafol gave good yield increases. In 1981, however, yield increases were poor or nil because of different weather conditions. *S. nodorum* usually develops slowly, with typical lesions appearing on successive leaves. The situation in Bavaria differed in that, at a certain point, the *Septoria* epidemic exploded, several levels of leaves being colonised at one time. The central questions of the Working Group are : 1) can disease development be observed sufficiently in advance to give a warning for chemical control ? 2) are there simple meteorological data to which to relate disease progress ?

M.J. Jaeger : Damage assessment in wheat diseases

No abstract.

N. Carter : Forecast and prediction of cereal aphids

No abstract.

J.S. Pierre : Analysis of 6 years' data on cereal aphid populations in Brittany. Possible application to forecasting population increases

No abstract.

R.A. Daamen : Damage assessment and epidemiology of powdery mildew

In 1980, 3 field experiments were done to determine the relationship between disease severity and yield loss, before and at flowering. The mildew attack was comparable to that in commercial fields, 0-5 % on the 3rd leaf, and yields were high (7-8 t/ha). Under these circumstances, mildew had a great impact on yield : 200 kg/ha/ % mildew on the 3rd leaf at GS 31-60, and 140 kg/ha/ % mildew on the 3rd leaf at GS 60-75. A disease yield-loss function was derived from the data obtained. In the supervised control system, EPIPRE, mildew incidence in the field is assessed by the farmers, and data transformed to severity on the computer. An expectation of disease progression is computed, taking into account various factors. Where disease yield loss exceeds the expected cost of treatment, the farmer is advised to spray.

M. Strizyk : Models for potential status of infection in some plant diseases

No abstract.

D.J. Butt : Decision-based management of orchard diseases in England

No abstract.

S.P. Eisensmith : Development of a model to detect environmental periods favourable for infection of sour cherry by Coccomyces hiemalis

Cherry leaf spot, caused by *Coccomyces hiemalis*, is a major problem for sour cherry in New York and Michigan. A regression model was developed from historical data by Keitt *et al.* in Wisconsin. They inoculated sour cherry trees with conidial suspensions and incubated them in a moist chamber for 4 to 70 hours at temperatures of 4-28°C. The model is :

$$EFI = (-11.0 + 0.2858W + 1.4639T - 0.0019W^2 - 0.0389T^2 - 0.0030WT)^2$$

where T = temperature °C, W = hours of leaf wetness, and EFI = environmental favourability index from 0 to 100. An EFI of 14 was selected to delineate the minimum conditions for infection under field conditions. The model was used in 1978 and 1980 to time fungicide applications. Infection periods were identified and classified as LOW, MODERATE and HIGH, based on EFI values of over 14, 28 and 42, respectively. In both years, chemicals provided good leaf spot control when applied after low or moderate infection periods. Secondary infection was prevented with eradicant sprays applied against conidial inoculum available during infection periods. Use of the EFI model for timing eradicant fungicide sprays for leaf spot is a promising alternative to fixed time interval spray schedules.

W. Müller : Biometeorological crop conditions

Variations in meteorological field data with time (during one growing season, between different seasons/years) and with space (in 3 dimensions of a plot, from one site to another) were studied at an experimental station close to Stuttgart, from 1977. The same weather conditions at different sites can provoke quite different losses, depending on the exposure and, therefore, the shifting phenophases of pests and diseases. The influence of vegetation on total radiation within the crop canopy, the influence of vegetation on leaf wetness (duration and kind), and the interception of rain by the canopy are considered.

R.H. de Reede & C. Flukiger : Quantitative phenology of leaf rollers in apple orchards

A model to simulate the population development of the summerfruit tortrix, *Adoxophyes orana*, is described. It consists of a system of differential equations with temperature as the only driving variable. The simulated data correspond well with those observed in the field, except in warm years, when the end of the second flight could not be simulated very precisely. Introduction of photoperiod into the model would probably solve this problem because, in warm years, there may be a third flight. At present, the model is used for optimisation of strategies and techniques to control *A. orana* with baculoviruses.

A model has been developed in which the age composition and numbers of *A. orana* can be calculated backwards. This model is used to investigate the synchronisation between crop development and population development of the apple leaf roller in order to determine critical periods for sampling and pesticides application.

U. Jonsson : Swedish trials with Blitecaster, an instrument used for potato late blight forecasting

With BLITECAST, the grower collects weather information from his own potato field, and phones this weekly to the University for processing by a computer, and obtaining a recommendation. As an alternative to BLITECAST, an on-site microcomputer named Blitecaster has been developed. The instrument is installed between the rows at the time of emergence and collects data on temperature, relative humidity and precipitation every 10 minutes. Every 24 hours, the microcomputer makes a recommendation which can be read by pressing a button on the front of the instrument. Results to-date have indicated that Blitecaster could be useful in Sweden, but more work is needed, however, to adapt its use to cultivars of differing blight resistance.

H. Steiner : Development of an integrated production system in arable crops

No abstract.

R. Rabbinge : Development of an integrated production system in arable crops in the Netherlands

No abstract.

Inventory on Models in Integrated Crop Protection

Dr D. Butt is anxious to know whether there have been any new developments in this field, so that an updated inventory may be published in the IOBC Bulletin. Those who have any appropriate information are kindly requested to contact Dr D. Butt at E.M.R.S., Maidstone, Kent, ME19 6BJ, UK.

IOBC Working Group on Quality Control : Workshop held in Gainesville from 22 August-3 September, 1982

The program centred on the state of the art of quality control in the world's major sterile release programs and on their needs for research and development, including : Caribfly model, Lepidoptera model, Oriental fruit fly – Taiwan, Melon fly – Japan, Medfly – Australia, Medfly – CA/HI/USDA, Medfly – USA/Mexico/Guatemala, Mexican fruit fly, Tsetse fly, *Anopheles*, Screwworm fly, Pink bollworm, Gypsy moth, *Heliothis*, Boll weevil Following the Workshop, there was a visit to Mexico to tour the screwworm and medfly facilities and review the programs.

REPORTS OF CONFERENCES

International Workshop on Heliothis Management, Hyderabad, India, November 1981. Trop. Pest Manage. 28 (1) : 92-98

This workshop was convened by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) during 15-20 November, 1981 to bring together experienced and active scientists from both developed and developing countries to review current information on different aspects of the managment of *Heliothis* spp., and to determine priorities for future action. The topics for consideration were grouped under seven main headings, with a review paper and several more specific papers presented in each session. More than 50 scientists from some 35 research groups in 11 countries (Australia, Germany, India, Mexico, Nigeria,

Sudan, Syria, Tanzania, UK, USA and Zimbabwe) attended the sessions and contributed to the discussions.

E.G. King (USA) reviewed the topic of « Natural and biological control elements ». The relative advantages and disadvantages of control using NPVs were evaluated by D.J. McKinley (UK). M.R. Bell (USA) extended the review to the potential uses of all microbials in *Heliothis* management. The possibilities for natural enemies were reviewed by D.J. Greathead (UK) and D.J. Girling. S. Nagarkatti (India) reported on the progress of a project involving the introduction of exotic species, including the tachinid *Eucelatoria*. The session on novel methods of management began with a review by A.N. Sparks (USA) of more than 20 years of pheromone research. F.I. Proshold's (USA) paper reported on a 4-year experiment to control field populations of *Heliothis* by releases of hybridised *H. subflexa* and *H. virescens*. The final group of papers, entitled « Integration of management », described recent and current field experience and practice in widely dispersed countries outside the Americas, including Australia, Africa and South-West Asia.

Symposium « Insect Control of Tomorrow », 15 September, 1981. Ent. exp. appl. 31 : 1-131

This Symposium was organised to mark the occasion of the 65th birthday and subsequent retirement of Professor J. de Wilde, Head of the Department of Entomology, Agricultural University, Wageningen, the Netherlands. The texts of the following nine papers are included :

W.S. Bowers : Endocrine strategies for insect control, pp 3-14

Analogs of juvenile hormone III have been successfully applied to the control of several adult insect pests. Since these hormones are ineffective for the control of immature insects which are most important in agriculture through their feeding damage to crops, we searched for and discovered hormone antagonists as natural constituents of plants in the genus *Ageratum*. These anti-hormones (Precocenes) induce lethal precocious metamorphosis in immature stages and sterilize adult insects. Mode of action and metabolism studies have revealed that the precocenes undergo a lethal activation within the endocrine gland which secretes juvenile hormone, resulting in destruction of the gland.

G.B. Staal : Insect control with growth regulators interfering with the endocrine system, pp 15-23

Out of a field of many thousands of analogs of the insect juvenile hormones (JHA), only a few have found practical utility in the control of a variety of insect species. Their mode of action and the lack of foliar stability in all but the most recently discovered juvenoids have so far precluded their use against pests of field crops. A possible more efficacious mode of action is present in anti-juvenile hormone agents (AJH), which can induce premature metamorphosis, but of which none of the present prototypes has yet been developed into a cost effective control agent. These AJH prototypes represent a number of very different action mechanisms and degrees of selectivity for different insect taxa. In an even more contemporary approach, the interference with neurohormonal pathways presents significant perspectives for insect control.

G.M. Chippendale : Insect diapause, the seasonal synchronisation of life cycles, and management strategies, pp 24-35

Diapause permits insect survival under adverse climatic conditions and synchronizes the life cycles of individual insects within a population as well as with their food supply. The question is addressed about how the state of diapause might be more fully exploited for insect control than it is at present. Methods currently used and new approaches that might be developed to disrupt the seasonal synchronization and diapause of plant-feeding insects are discussed. For example, the agronomic practices of carefully timed planting dates, use of early maturing varieties, and the destruction of crop residues are well-established methods for suppressing populations of pest insects on many crops. In contrast, the possibility of disrupting insect diapause through, for example, the use of non-diapausing strains, seasonally inappropriate environmental cues, or hormones or antihormones requires much additional research. Although the ecological, physiological, and endocrinological aspects of insect diapause have received much study, practical methods have yet to be developed to interfere with the programming of diapause. Using the larval diapause of the southwestern corn borer, *Diatraea grandiosella*, and the adult diapause of the Colorado potato beetle, *Leptinotarsa decemlineata*, as examples, some aspects of research into diapause are reviewed. Included is a discussion of the role of temperature cycles, the titre and function of juvenile hormone, and the role of amino acids present in high titre in the haemolymph. Several areas requiring further research are suggested.

H. Dingle : Function of migration in the seasonal synchronisation of insects, pp 36-48

Seasonal migrations of insects can be roughly divided into those within the temperate zone, those within the tropics, and those between the tropics and temperate areas. Temperate migrations often involve movements to and from diapause sites with correlated seasonal cycles in reproductive physiology. Many temperate migrants have apterous or brachypterous generations whose adaptive significance is not always clear, diapause may also be involved in tropical migrations, but the cue is likely to be food or moisture limitation rather than photoperiod. Interestingly, the capacity to diapause may be a prerequisite for migration into the temperate zone by tropical species : the two behaviours occur together in several migrants. An interesting subclass of tropical-temperate migrants are « pied-piper » species which apparently have no return movement : the action of natural selection in these cases is unclear. In all cases, migration and diapause are intimately involved with other aspects of life histories because they allow choices of where and when to breed. The elucidation of the contributions of genetic and environmental variance to insect migration strategies is an important problem for entomologists.

V.G. Dethier : Mechanism of host-plant recognition, pp 49-56

Recognition and preference of host plants involve the integration of a complex of neural and metabolic events. These include : the sensing and encoding characteristics of the sense organs, decoding mechanisms in the central nervous system, assessment of across-fiber patterns and deterrent/stimulant ratios, pre- and post-ingestion factors such as level of satiety, nutritional balance, and experiential factors such as induction and aversion-learning.

L.M. Schoohoven : Biological aspects of antifeedants, pp 57-69

Certain chemicals of plant origin may inhibit food intake in phytophagous insects. Such antifeedants act at low concentrations and are perceived by specialized deterrent receptors or by their modifying effect on normal chemosensory input. In some cases, habituation to the presence of

antifeedants occurs. When we want to find more chemicals which fulfil all requirements of true and effective antifeedants, more research on plant chemistry and insect behaviour is needed. Large scale application only becomes feasible when a number of biological as well as technical problems will be solved.

P. Gruys : Hits and misses, the ecological approach to pest control in orchards, pp 70-87

Experiments in the Netherlands have shown that over half of the 24 species of arthropod noxious to apple orchards can be controlled fully or substantially by biological or cultural methods. *Typhlodromus pyri* proved the agent responsible for biological spider mite control. Contrary to the results of earlier experiments in the Netherlands, biological control of spider mites was successful in intensively managed orchards. Modern management of orchards suppresses several other insect pests. An undergrowth of wild flowering plants did not prove helpful to control. Ecological control of tortricids, a leaf miner and woolly aphid is discussed, and a survey is given of ecological and other controls that can be combined in an IPM programme. Present constraints to the adoption of truly integrated programmes are primarily attitudinal. Large-scale demonstration projects of these programmes should be initiated by the government to overcome resistance against their application.

B.A. Croft : Arthropod resistance to insecticides : a key to pest control failures and successes in North American apple orchards, pp 88-110

Cases of developed resistance in apple arthropods in North America, including pests and natural enemies, are reviewed with emphasis on the past 20 years since organophosphate (O-P) insecticides were first widely employed. During the period, no key pest, including the codling moth, *Laspeyresia pomonella*, has developed resistance to the O-P compound, azinphosmethyl, while a variety of secondary pests including mites, aphids, leafhopper and leafminers, have done so as well as several important natural enemies of these species. The extensive features of DDT, O-P, carbamate and pyrethroid resistance in the predatory mites *Typhlodromus occidentalis* and *Amblyseius fallacis* are described. Also discussed is the impact of long-term O-P use and resistance in relation to pest problems, insecticide selectivity and IPM, increased biological control, changing requirements for new chemical insecticides and possibilities for « resistance management » within the entire arthropod pest natural enemy complex associated with this crop.

L. Brader : Recent trends of insect control in the tropics, pp 111-120

Efforts to increase agricultural production in the tropics must be oriented in the first place towards the small farmers' food crops. However, by tradition virtually all research efforts have been oriented to the so-called cash crops, and consequently current knowledge on pest control in food crops in the tropics is very limited. Moreover entomologists are trained on the basis of intensive agricultural production systems. From a selected number of examples it is evident that insects can cause significant losses in major food crops such as rice, maize, cassava, sorghum, millet, pulses and vegetables. However the history of insect control in cotton growing, for example, shows that in tropical ecosystems insect populations can be maintained at comparatively low levels when properly managed. Insect control in the tropics will lead to the further development and application of integrated pest control, and this will be the surest way to achieve real improvement in the plant health situation.

The issue ends with a review by J. de Wilde entitled « Insect control in retrospect and in prospect », pp 121-131

FORTHCOMING CONFERENCES AND MEETINGS

XV Pacific Science Congress

This Congress wil be held in Dunedin, New Zealand, from 1-11 February, 1983. The theme is Conservation, Development and Utilisation of the Resources of the Pacific. The Entomology program includes a plenary session entitled « Entomology in the Development of the Pacific ». The keynote addresses are as follows :

Ethics of pest control : B.P. Beirne (Canada) ;
Chemical pesticides, present and future : J.F. Copplestone (WHO) ;
Microbial pesticides, present and future : H.D. Burges (UK) ;
Biological control in the development of the Pacific : C.B. Huffaker (USA).

There are seven Symposia topics :

1) Insect vectors of human and animal diseases in the Pacific Basin.
2) Agricultural and forest pests in the Pacific Basin.
3) Evolution and distribution of insects in the Pacific Basin.
4) Rice pest management.
5) Pest management systems for the Pacific Basin.
6) Biological control of insects of economic importance.
7) Accidental introduction of insects through human agency.

For further details, write to the Convenor of the Entomology program : Dr J.S. Pillai, Department of Microbiology, University of Otago, P.O. Box 56, Dunedin, New Zealand.

IOBC Working Group on Use of Models in Integrated Crop Protection

The next meeting of this Group will be held from 28 February to 2 March, 1983 in Leuven, Belgium. The general theme will be « The use and implementation of models in integrated crop protection ». Those who would like to contribute or attend are invited to contact the convenor, R. Rabbinge, Department of Theoretical Production Ecology, Agricultural University, Bornsesteeg 65, 6708 PD Wageningen, The Netherlands. Tel. 08370 82141.

MISCELLANEOUS

Visit to the Institute of Nutrition of Central America and Panama (INCAP), Guatemala, February 1982. Summary of the report by B. Leroi

This visit was made possible by IOBC. INCAP is a scientific institute directly supported by WHO : its aim is to promote the development of nutrition science and its practical applications in the countries of Central America : Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama. The main research centre is in Guatemala City. The Institute has both a training and research function, with

students taken principally from Central America. The research is grouped into 4 departments : Agriculture and Food Sciences, Human Biology, Growth and Development, Applied Nutrition. Agriculture and Food Sciences is further subdivided into 4 sections : staple foods, food technology, new food sources, animal nutrition, and about 15 programs are underway in this department. Dr P. Bressani heads the staple foods section. He and Dr Elias are world-renowned for their work on the nutritional evaluation of beans and other legumes, particularly with regard to the physiochemical factors which cause the nutritional problems associated with beans : seed coat hardness, cooking difficulties, protein quality, nutritional value, etc. Although the biochemical studies are somewhat fundamental, they are a step towards improving nutrition in Central America.

With regard to Bruchidae/*Phaseolus* spp. interactions, there are some common areas of research at INCAP and IBEAS (Institut de Biocénotique Expérimentale des Agrosystèmes, Université François Rabelais, Tours, France) : similarity of plants (bean seeds), mechanical importance of the seed coat (a barrier against Bruchid larvae ; cause of nutritional problems for man), role of toxic chemical factors in the seedcoat (for larvae which penetrate it, for human nutrition), etc. There could be a fruitful exchange of results enabling better understanding of Bruchid/bean relationships, i.e. the knowledge of Bruchid physiology gained at IBEAS is useful to INCAP and the biochemical studies on seeds carried out at INCAP are of value to IBEAS researchers. It is for this reason that the possibility of future collaboration is proposed :

- either by initiating parallel research on the physiochemical barrier of the seedcoat, which may lead subsequently to greater cooperation necessitating the setting up of a program and locating appropriate funds,
- or by allowing a student, preferably from Central America, to work successively in both institutes.

It would be invaluable to include INCAP researchers in any further research on Bruchid/*Phaseolus* relationships, especially in view of their expertise in bean seed physiochemistry. The collaboration of these workers in a study of the physiology of Bruchid nutrition is fundamental.

BOOKS

1) Biological Control by Augmentation of Natural Enemies. Insect and Mite Control with Parasites and Predators. Proc. 15th Int. Congr. Ent. Washington, D.C., Aug. 1976. Environmental Science Research Volume 11. Eds. A. Hollaender *et al.* Plenum Press, New York, USA (1977) 480 pp.

2) Blackflies : The Future for Biological Methods in Integrated Control. Ed. M. Laird. Academic Press, London (1981), 399 pp.

3) Biocontrol of Medical and Veterinary Pests. Ed. M. Laird. Praeger, New York, USA (1981) ; based on a symposium held during the 16th Int. Congr. Ent., Kyoto, Japan, Aug. 1980.

4) Environmental Protection and Biological Forms of Control of Pest Organisms. Eds. B. Lundholm & M. Stackerud. Ecological Bulletins No. 31, 171 pp. Proc. Int. Workshop, Stockholm, 14-17 May, 1979. Swedish Natural Science Research Council (Stockholm) (1980).

ABSTRACTS

a) Plant Protection

1. INSECT AND MITE CONTROL

i) Entomopathogens

T.B. Johnson & L.C. Lewis (1982). Evaluation of Rachiplusia ou and Autographa californica nuclear polyhedrosis viruses in suppressing black cutworm damage to seedling corn in greenhouse and field. J. econ. Ent. 75 (3) : 401-404

Nuclear polyhedrosis viruses isolated from the alfalfa looper, *Autographa californica*, and a mint looper, *Rachiplusia ou*, were formulated as virus baits on wheat bran and tested in greenhouse and field plots for suppressing black cutworm, *Agrotis ipsilon*, damage to seedling corn. Both viruses reduced plant damage and the number of cut plants in the greenhouse and field when applied at 7×10^{11} polyhedral inclusion bodies per ha.

P.J. McLeod et al. (1982). Application of a baculovirus of Pseudoplusia includens to soybean : efficacy and seasonal persistence. Environ. Ent. 11 (2) : 412-416

A baculovirus of the soybean looper, *Pseudoplusia includens*, was applied at a rate of 247 LE/ha to soybean. Larval population levels, virus induced larval mortality and viral concentration in the soil and on the foliage were monitored from August 1975 until August 1977. Viral applications resulted in epizootics in soybean looper populations reducing larval numbers. A significant reduction in larval numbers did not occur until 12 to 13 days after treatment. The virus persisted at high concentrations in soil from 2 weeks posttreatment through the fall. Viral concentration in the soil was reduced by November 1975. In 1976-1977, viral concentration in soil remained high (1.13×10^{14} PIB/ha) through May, after which it declined. Viral concentration in soil was not sufficient to initiate an epizootic in *P. includens* the following summer. By 72 h after treatment, viral concentration on foliage was low when compared with concentration immediately after virus application. After a substantial proportion of larvae had died, 6 to 7 days after treatment, high viral concentrations were detected on the foliage.

T.B. Johnson & L.C. Lewis (1982). Pathogenicity of two nuclear polyhedrosis viruses in the black cutworm, Agrotis ipsilon. Can. Ent. 114 (4) : 311-316

LC_{50} and LT_{50} values for two multicapsid nuclear polyhedrosis viruses isolated from the alfalfa looper, *Autographa californica*, and a mint looper, *Rachiplusia ou*, were determined against black cutworm, *Agrotis ipsilon*, neonate larvae. 1-day-old larvae reared at 15°C before testing, and 1-day-old larvae reared at 27°C before testing. The results showed that black cutworm larvae have low to moderate susceptibility to these viruses. As the larvae developed, their susceptibility to the viruses rapidly declined. Initial growth of larvae surviving sublethal dosages of these viruses was reduced, but pupal weights of these larvae were not significantly different from untreated controls.

J.J. Hamm (1982). Relative susceptibility of several noctuid species to a nuclear polyhedrosis virus from Heliothis armigera. J. Invert. Path. 39 (2) : 255-256

A multicapsid NPV of *H. armigera* (HaMNPV) was tested against *H. zea* and *Spodoptera frugiperda*, *H. virescens* and

S. exigua H. zea was most susceptible, with the LC_{50} in the range of low 10^3 polyhedra/ml diet. *H. virescens* and *S. exigua* had LC_{50}s in the low 10^4 range, and *S. frugiperda* was much less susceptible, with LC_{50}s in the upper 10^5 and lower 10^6 polyhedra/ml range. The requirement of about 420 times as many polyhedra to produce 50 % mortality in *S. frugiperda* as in *H. zea* makes it unlikely that this virus will be useful in controlling *S. frugiperda*.

D.W. Pritchett et al. (1982). Dissolution of Autographa californica NPV polyhedra by the digestive fluid of Trichoplusia ni larvae. J. Invert. Path. 39 (3) : 354-361

The dissolution of polyhedra of *Autographa californica* NPV by digestive fluid collected from 5th stage *Trichoplusia ni* larvae was studied *in vitro*. Observations were made at timed intervals using phase contrast microscopy, and scanning and transmission electron microscopy. Dissolution occurred rapidly and in a detectable sequence. Under phase contrast, most polyhedra lost their refringence by 0.5 min. The polyhedra became rounded in appearance with small protuberances on the surface and Brownian movement was observed within. After 1 min, the envelope of most polyhedra had ruptured, releasing the enclosed virions. The protuberances were also observed under the scanning electron microscope after digestion for 0.5 min. Many shell fragments devoid of internal contents were seen after more lengthy digestion. Internal structural changes were revealed by electron microscopy. After 1 min of exposure, polyhedra were observed in all stages of dissolution. By 3 min, only virions, scattered about in heterogeneous material, could be distinguished.

K.S. Ritter et al. (1982). Eclipse period of Baculovirus infection in larvae of the armyworm, Pseudaletia unipuncta. J. Invert. Path. 39 (2) : 203-209

Two strains of a nuclear polyhedrosis virus (baculovirus) infect larvae of the armyworm, *Pseudaletia unipuncta*. The hypertrophy strain (HNPV) produces a gradient of infected epithelial cells along the tracheae indicating the movement of infectious material to adjacent cells. Cytopathology of the eclipse period up to the appearance of the virogenic stroma has been separated into three phases during which the chromatin disappears and is replaced by dense interconnected strands of fibrils and dense punctate bodies. Cellular hypertrophy occurs in phase 1 and the virogenic stroma appears in phase 3. The typical strain (TNPV) does not produce structures comparable to those of HNPV infection.

R.R. Gettig & W.J. McCarthy (1982). Genotypic variation among wild isolates of Heliothis spp. NPVs from different geographical regions. Virology 117 (1). 245-252

Ten nuclear polyhedrosis viruses infecting insect hosts in the genus *Heliothis* and isolated in different geographical regions of the world were characterized using restriction endonuclease analysis. Digestion of the dsDNA genomes with *Bam*HI, *Eco*RI, and *Hind*III resulted in fragmentation profiles which separated the wild-type isolates into two major genotypes, corresponding with the morphology of the virion (multiply embedded vs singly embedded). Isolates within each major genotype have similar fragmentation profiles, showing only slight differences in the number and size of several fragments, and thus represent variants of the major genotype. Submolar fragments present in a number of the digests suggest that these wild-type isolates might themselves consist of two or more genotypic variants. The significance of this genotypic heterogeneity is discussed.

N. Kislev & M. Edelman (1982). DNA restriction-pattern differences from geographic isolates of Spodoptera littoralis NPV. Virology 119 (1) : 219-222

Two nuclear polyhedrosis viruses were isolated from *Spodoptera littoralis* larvae collected from several areas in Israel. The two viruses were characterised and compared by restriction endonuclease cleavage of their DNA and Southern blot hybridization. The two viruses have no detectable sequence homology. A variant, homologous to the more common virus isolate, was also found.

K.J. Marschall & I. Ioane (1982). The effect of re-release of Oryctes rhinoceros baculovirus in the biological control of rhinoceros beetles in Western Samoa. J. Invert. Path. 39 (2) : 267-276

The Rhinoceros Beetle Project in Western Samoa has developed and successfully applied biological methods to control the rhinoceros beetle, a serious pest of coconut palms, by using two specific pathogens, a baculovirus, and an entomopathogenic fungus, *Metarhizium anisopliae*. The application of virus particularly has markedly suppressed the beetle population and helped revive the copra industry. The virus disease had established itself in the wild beetle population several years after its introduction at a level between 30 and 50 %. At the same time, an increase in beetle numbers and damage to palm trees was experienced. Therefore, a continuous release of virus into beetle-infested areas was proposed. It was argued that, considering the relatively high level of « natural » virus incidence, further releases of virus into the population would be futile. In a combined research and control program, virus was again re-released into the wild beetle population which was already virus infected. The results show that through re-release the virus level can be raised and the number of beetles and consequently the damage can be reduced. The techniques of the control methods are described. The virus release is very easy and cheap ; it requires no chemicals, no special equipment, and it is particularly recommended in situations where breeding places are inaccessible or other methods such as plantation sanitation are either impossible or economically impractical. Above all, the methods are absolutely safe from the standpoint of environmental protection.

J.F. Fuxa (1982). Prevalence of viral infections in populations of fall armyworm, Spodoptera frugiperda, in southeastern Louisiana. Environ. Ent. 11 (1) : 239-242

Prevalence of the nuclear polyhedrosis virus (NPV) and granulosis virus (GV) was determined in populations of fall armyworm, *Spodoptera frugiperda*, in southeastern Louisiana. Both diseases reached their peak mean infection rates in mid-August in fall armyworms infesting pastures, the NPV at 50.8 % and the GV at 2.8 %. NPV prevalence in some pastures peaked at 60 to 68 %. Infection rates by NPV in fall armyworms infesting corn and sorghum were initially lower than in pastures but were similar after mid-July (corn) or late July (sorghum). Infections by a mermithid nematode, an entomogenous fungus, and a microsporidium were rare.

J.J. Hamm (1982). Extension of the host range for a granulosis virus from Heliothis armigera from South Africa. Environ. Ent. 11 (1) : 159-160

A granulosis virus of *Heliothis armigera* from South Africa was shown to be pathogenic to *Heliothis zea*, *Spodoptera frugiperda*, *S. exigua* and *Trichoplusia ni*, all Lepidoptera: Noctuidae.

D.T. Briese (1982). Genetic basis for resistance to a granulosis virus in the potato moth, Phthorimaea operculella. J. Invert. Path. 39 (2) : 215-218

Evidence is presented to show that the resistance to a granulosis virus in a laboratory strain of potato moth, *Phthorimaea operculella*, is controlled by a single dominant autosomal gene which segregates according to simple Mendelian ratios. This may be only one of a number of genes which influence the phenotypic expression of resistance and contribute to the wide variability in response to the virus shown by field populations of the moth.

R.C. Reardon et al. (1982). Efficacy of two formulations of Bacillus thuringiensis on populations of spruce budworm on balsam fir in Wisconsin. J. econ. Ent. 75 (3) : 509-514

The efficacy of Thuricide 16B and Dipel 4L formulations of *Bacillus thuringiensis* var. *kurstaki* was determined on *Choristoneura fumiferana* infestations on balsam fir, *Abies balsamea* in northern Wisconsin. Both formulations reduced budworm populations and protected foliage sufficiently to warrant further field testing with different dosages and gallonage. The *B. thuringiensis* did not adversely affect parasitism, as determined by laboratory rearing of field-collected larvae.

G.E. Cantwell & W.W. Camelo (1982). Potential of Bacillus thuringiensis as a microbial agent against the Mexican bean beetle. J. econ. Ent. 75 (2) : 348-350

A preparation of *Bacillus thuringiensis*, which contained a heat-stable-exotoxin, was effective in controlling larvae of *Epilachna varivestis* in both laboratory and field trials. At a dilution of 10^{-2}, nearly 100 % kill was attained in 6 days, and over 60 % kill was obtained with a dilution of 10^{-3}. In field tests, a dilution of 5×10^{-2} provided adequate protection to bean plants, resulting in significant increases in plant yield.

L. Szalay-Marzso et al. (1981). Microbial control experiment against Stilpnotia salicis, a pest of poplar stands in northwest Hungary. Acta Phytopath. Acad. Sci. Hung. 16 (1-2) : 189-197

In northwest Hungary, *S. salicis* has only one generation and overwinters in the L_2 stage. A spring treatment was applied, using a chemical pesticide (Fekama AT-25) together with the biological preparations Thuricide HP, Entobakterin, Dendrobacillin and Gomelin, on an area of over 800 ha. Although Fekama AT-25 was more economical, the authors still recommend the use of selective *B. thuringiensis* preparations in the future.

D.R. Johnson (1982). Suppression of Heliothis spp. on cotton by using Bacillus thuringiensis, Baculovirus heliothis and two feeding adjuvants. J. econ. Ent. 75 (2) : 207-210

The application of *Bacillus thuringiensis* and *Baculovirus heliothis* to cotton suppressed *Heliothis* spp. populations an average of 28 % compared with the untreated check during field tests in 1980. The addition of the feeding adjuvants Coax ® and Gustol ® to the microbial insecticides increased the control by reducing the number of laryae by 46 % in 1979 and 54 % in 1980. The two feeding adjuvants Gustol ® and Coax ® improved efficacy of the microbial insecticides, but neither proved better than the other. In addition, spray combinations of *B. heliothis* + *B. thuringiensis* + feeding adjuvants did not prove to be superior to either pathogen alone + feeding adjuvants. For full-season use, the *Heliothis* spp. control in cotton using the microbials plus feeding adjuvants was not adequate compared with the insecticide standard permethrin. Significantly higher yields and lower *Heliothis* spp. populations were found with permethrin.

C.M. Ignoffo et al. (1982). Susceptibility of the Colorado beetle, Leptinotarsa decemlineata, to Bacillus thuringiensis. J. Invert. Path. 39 (2) : 244-246

A spray-dried, unformulated, technical powder of *B. thuringiensis kurstaki* was used, which was devoid of ß-exotoxin, and contained 35,550 IU/mg and 3.4×10^6 viable spores/mg. Although *L. decemlineata* is susceptible to the ß-exotoxin, this is the first report of its susceptibility to the γ-endotoxin. In addition to larval mortality, var. *kurstaki* treatments also reduced larval feeding and bodyweight gain.

H.S. Salama & M.S. Foda (1982). A strain of Bacillus thuringiensis var. entomocidus with high potential activity on Spodoptera littoralis. J. Invert. Path. 39 (1) : 110-111

Seventeen varieties of *B. thuringiensis* were screened for activity against *S. littoralis*. Only *B.t.* var. *entomocidus* showed high potential activity, with a potency of 65,520 IU/mg for the first instar.

M.B. Mohd-Salleh & L.C. Lewis (1982). Toxic effects of spore/crystal ratios of B. thuringiensis on European corn borer larvae. J. Invert. Path. 39 (2) : 290-297

Bioassays to determine LC_{50} values of spores and crystals of four varieties of *B. thuringiensis* grown on nutrient agar plates were carried out against neonate and 6-day-old European corn borer, *Ostrinia nubilalis*, larvae. The four bacterial varieties were equally toxic against the neonate, but only *B. thuringiensis* var. *kenyae*, var. *galleriae*, and var. *kurstaki* were toxic to 6-day-old larvae. *B. thuringiensis* var. *tolworthi* was inactive against 6-day-old larvae. Different ratios of pure spores and crystals of the bacteria also were tested against neonate and 6-day-old larvae. Pure spores are not pathogenic to neonates or 6-day-old larvae. Pure crystals were toxic to both ages of the larvae, but a combination of spores and crystals was necessary for maximum larval mortality.

P. Jarrett & H.D. Burges (1982). Effect of bacterial varieties on the susceptibility of the greater wax moth, Galleria mellonella to B. thuringiensis and its significance in classification of the bacterium. Ent. exp. appl. 31 : 346-352

The activities (inactive, moderate or active) of 308 isolates of *B. thuringiensis* in 12 H-serotypes against *Galleria mellonella* revealed important, unique relationships between pathogenicity and serotype. With few exceptions, all active isolates belonged to types 5 and 7. Although a few type 5 and 7 isolates were inactive or moderately active, all 64 H-type 5a5b isolates with crystal serotype *gal* were active as were 25/28 H-type 7 isolates with the crystal serotype *aiz*. The work supports the varietal status given to these two H-types and enables each to be divided into two subgroups on the basis of activity. H-types 1, 3a3b and 3a, and crystal types *thu*, *k-1*, *k-73* and *ale* tended to be moderately active, while 4a4b and 4a4c, and *den* and *ken* tended to be inactive. No consistent correlation between activities in *G. mellonella* and those in other host species were observed. This suggests the presence of a number of factors, those in H-types 5 and 7

and crystal types *gal* and *aiz* inducing high activity in *G. mellonella*, others inducing moderate or low activity in *G. mellonella* but high activity in some other species. No isolate was more active than the 5a5b organism once used in Thuricide, but type 7 isolates are better for fermentation since they are less susceptible to bacteriophage.

M.B. Mohd-Salleh & L.C. Lewis (1982). Feeding deterrent response of corn insects to ß-exotoxin of B. thuringiensis. J. Invert. Path. 39 (2) : 323-328

Exotoxins produced by three varieties of *B. thuringiensis* were added at different concentrations to the diets of the black cutworm, the fall armyworm, the European corn borer, and the house fly. By day 7 of treatment, mortality of the three lepidopterans was higher at the lower concentrations of exotoxin than at the higher concentrations tested ; by day 14 of treatment, mortality was 90 % or greater at all the exotoxin concentrations tested. In the house fly tests, mortality increased with increasing exotoxin concentration. Additional lepidopteran tests were run to study both the anomalous effect of toxin concentration on mortality and the effect of feeding inhibition evident by day 7 but not day 14 in treatments with high concentrations of the toxins. The tests, run with the European corn borer and with ß-exotoxin calcium salt, shown that both effects could be attributed to a « feeding deterrent » associated with the toxin, and that the deterrent was not odoriforous and did not degrade over time. Apparently, the insects ate very little of the diets high in exotoxin, stopping quickly upon receiving a high dosage of the deterrent but, nevertheless, having consumed enough toxin to be killed over time (between 7 and 14 days).

C.M. Ignoffo et al. (1982). High-temperature sensitivity of formulations of B. thuringiensis var. israelensis. Environ. Ent. 11 (2) : 409-411

Formulations of the bacterium *B. thuringiensis* var. *israelensis*, but not *Bacillus thuringiensis* var. *kurstaki*, lost most of their insecticidal activities during 28 days of exposure at 50°C. The half-lives of one liquid-flowable and two wettable-powder formulations of *B. thuringiensis* var. *israelensis* were 18.0, 7.2, and 6.0 days, respectively. No loss in activity was detected for the wettable-powder formulation of *B. thuringiensis* var. *kurstaki*. On the basis of viable spore counts, half-lives were 6.0 days for the liquid-flowable formulation, and 18.5 and 10.5 days for the two wettable-powder formulations, of *B. thuringiensis* var. *israelensis*. Differences in thermal sensitivity were attributed to relative differences in the ultrastructure of endocrystals of *B. thuringiensis* var. *israelenesis* and *B. thuringiensis* var. *kurstaki*.

C.C. Beegle et al. (1982). Relationships between laboratory bioassay-derived potencies and field efficacies of B. thuringiensis isolates with different spectral activities. J. Invert. Path. 39 (2) : 138-148

B. thuringiensis isolates with different spectral activities were not equally efficacious when applied to cabbage at the same number of IUs/ha for protection against larvae of the cabbage looper, *Trichoplusia ni*. Preparations of the isolates were standardized against *T. ni* larvae. Variety *galleriae* isolates (HD-196 and HD-153) were the most efficacious per applied IU, and a K-73 type variety *kurstaki* (HD-73) was the least efficacious per applied IU. A variety *thuringiensis* (HD-264) and a K-1 type variety *kurstaki* (HD-1) were intermediate in efficacy per applied IU. Speed of kill and, to some extent, differences in the amount of food consumed appear to be responsible for the differences in efficacy per applied IU. When more potent *B. thuringiensis* isolates are discovered and developed, the recommended field dosages for the new isolates must be determined by actual field experimentation rather than by extrapolation from existing HD-1 data.

A.J. Delucca et al. (1982). Bacillus thuringiensis in grain elevator dusts. Can. J. Microbiol. 28 (4) : 452-456

Grain dust from four large elevators along the Mississippi River near New Orleans, Louisiana, was analyzed for the presence of *B. thuringiensis*, a pathogen of lepidopterous insects. Both settled grain dust and respirable grain dust samples were taken. A total of 20 settled and 53 respirable dust samples were assayed. No insects, alive or dead, insect parts, webbing, or feces were observed. Of the settled dust samples, 55.0 % contained *B. thuringiensis*, while 16.9 % of the respirable dust samples were positive for this organism. Two hundred and fifty-five *Bacillus* colonies were studied, with 30.9 % being *B. thuringiensis*. Serological and biochemical tests showed 94.9 % of them to be variety *aizawai*. Other varieties present were *morrisoni*, *canadensis*, *indiana*, and *kurstaki*.

V.I. Miteva et al. (1981). Transformation of B. thuringiensis protoplasts by plasmid DNA. FEMS Microbiol. Letters 12 : 253-256

The recent discovery of plasmids in *B. thuringiensis* opens up new prospects for the investigation of the genetic mechanisms of crystal synthesis and for the establishment, by genetic engineering, of strains with a higher toxicity and wider host range against insect pests. This brief communication describes the successful transformation of *B.t.* var. *galleriae* protoplasts by pUB110 plasmid DNA, with a frequency of 10^{-6}.

B.A. Federici (1982). A new type of insect pathogen in larvae of the clover cutworm, Scotogramma trifolii. J. Invert. Path. 40 (1) : 41-54

A unique type of microorganism has been found causing an unusual disease in larvae of the clover cutworm, *Scotogramma trifolii*. The organism contains DNA and reproduces exclusively by self-assembly forming enveloped reniform/bacilliform particles which measure 170 × 450 nm in negatively stained preparations. During initial stages of development, the organism apparently reproduces primarily within vesicles in the cytoplasm of a variety of cell types including hemocytes, and epidermal, fat body, and tracheal matrix cells. Most reproduction, however, occurs in vesicles that circulate in the haemolymph. These vesicles, most of which are derived from host cells, measure 2-10 µm in diameter, are highly refractile, reach populations as high as 10^8/ml of haemolymph, and are diagnostic for the disease. The pathology caused by this organism, its shape and ultrastructure, and reproduction within vesicles indicate it is either a peculiar type of rickettsia, possibly related to those of the genus *Rickettsiella*, or a new type of invertebrate virus. Among its unusual features are its ability to induce the formation of reproductive vesicles from host cell components, and its apparent control of de novo ribosome and membrane synthesis within these vesicles as it develops. The possible relationship of this organism to baculoviruses and rickettsia is discussed.

H.W. Browning et al. (1982). Occurrence of a disease caused by a rickettsia-like organism in a larval population of the cabbage looper, Trichoplusia ni, in southern California. Environ. Ent. 11 (3) : 550-554

A study of natural mortality in larvae of the cabbage looper, *Trichoplusia ni*, feeding on experimental broccoli

plantings in Riverside, Calif., revealed that ca. 10 % of the larvae collected from July through October 1979 had a disease caused by a rickettsia-like organism. The disease occurred most commonly in 2nd- and 3rd-instars, where the rates of incidence were 12.8 and 15.2 %, respectively. All larvae that developed patent infections died from the disease. The disease was most easily recognized in larvae which were reared individually in the laboratory on artificial diet. Disease signs included an opaque yellow-white discoloration on the body, incomplete shedding of the molted cuticle, reduced feeding activity, and a retarded growth rate with concomitantly increased larval longevity. At the histological level, the haemolymph of diseased larvae was milky white and contained numerous refractile vesicles that were diagnostic for the disease. Electron microscopy demonstrated slightly curved bacilliform particles, 160 by 420 nm, developing within these vesicles. Vesicles and particles also were found in the cytoplasm of epidermal, tracheal matrix, and fat body cells. The disease was transmitted to healthy *T. ni* larvae by injecting them with diluted haemolymph from diseased larvae. About 50 % of the treated larvae developed typical signs of disease and subsequently died.

R.J. Milner et al. (1982). Field release of an Israeli strain of the fungus Zoophthora radicans for biological control of Therioaphis trifolii f. maculata. J. Aust. Ent. Soc. 21 (2) : 113-118

An exotic pathogen, *Zoophthora radicans* was released into lucerne crops for the biological control of *Therioaphis trifolis* f. *maculata*. At one site an epizootic was initiated, with up to 88 % infection being recorded within 3 m of the point of release. No rain was recorded during the epizootic and disease transmission could be correlated with prolonged periods of high humidity at night. Data from 4 other sites are summarised. The disease did not occur on other aphids but has persisted, probably as resting spores, at one site for many months in the apparent absence of the host. Initial levels of field infection have been usually low despite the use of a high humidity field cage. A method which is expected to improve this initial infection rate is described.

J.N. McNeil & D.M. MacLeod (1982). Two species of fungus infecting the European skipper, Thymelicus lineola in Quebec. Can. Ent. 114 (1) : 87-88

T. lineola has been found attacking timothy grass throughout much of eastern Canada and the United States, reaching pest status in Ontario and Quebec. The two species of fungi isolated and described are *Zoophthora radicans (= Entomophthora sphaerosperma)* and *Entomophthora egressa*. This is the first record of an entomopathogenic fungus affecting the European skipper or any other hesperiid.

P.Y.K. Cheung & E.A. Grula (1982). In vivo events associated with entomopathology of Beauveria bassiana for the corn earworm (Heliothis zea). J. Invert. Path. 39 (2) : 303-313

When conidia of *Beauveria bassiana* are injected into the haemocoel of corn earworm larvae, it appears that a positive correlation exists between exocellular proteolytic activity of the fungus and entomopathological manifestations. Once inside the haemolymph, defense mechanisms (including phagocytosis) are incapable of overcoming the fungus and one important event in a terminal mycocidal cascade involves preferential invasion of the gut wall. Such invasion helps explain the observed inhibition of feeding by infected larvae. Although histopathological changes seen in gut tissues suggest that a gut toxin is produced, evidence for such a toxin could not be obtained in preliminary tests. Biochemical changes are seen in hemolymph components ; however, these are viewed as being due to general starvation rather than to specific activities of the fungus, at least up to the time that a general mycosis is established. With the host larva under physiological stress (starvation, nutrient depletion, and, possibly, toxin production in gut tissues) and failure of defense mechanisms, the infection spreads quickly and a terminal mycosis results.

C.M. Ignoffo et al. (1982). Use of larvae of Trichoplusia ni to bioassay conidia of Beauveria bassiana. J. econ. Ent. 75 (2) : 275-276

A procedure is described that can be effectively used to measure the activity of conidial preparations of the entomopathogenic fungus *Beauveria bassiana*. 1st instars of the cabbage looper are exposed to a leaf disc surface-treated with viable conidia. After 48 h, larvae are transferred to an untreated, semisynthetic diet (at 25 ± 1°C), and the bioassay is terminated 5 days later. The dosage-mortality regression equation for this bioassay was $Y = 2.1420 + 1.3352X$. The calculated LC_{20}, LC_{50}, and LC_{80} were 32, 139, and 590 total conidia per mm^2, respectively.

R.A. Clark et al. (1982). Influence of pesticides on Beauveria bassiana, a pathogen of the Colorado potato beetle. Environ. Entomol. 11 (1) : 67-70

The effect of pesticides on development of *Beauveria bassiana* was examined both in liquid culture and in the field. The commonly recommended late blight fungicides and insecticides inhibited growth of *B. bassiana*. The experimental fungicide CGA 48988 and the insecticide permethrin showed the least inhibition of the fungus. Field experiments with the Colorado potato beetle, *Leptinotarsa decemlineata*, supported laboratory findings.

R.J. Smith & E.A. Grula (1982). Toxic components on the larval surface of the corn earworm (Heliothis zea) and their effects on germination and growth of Beauveria bassiana. J. Invert. Path. 39 (1) : 15-22

Caprylic acid is present on the surface of corn earworm, *Heliothis zea*, and fall armyworm, *Spodoptera frugiperda*, larvae. Because caprylic acid inhibits germination of *Beauveria bassiana*, presence of this compound will be detrimental to the establishment of an infection of larvae by this fungus. Other free fatty acids present on the surface of *H. zea* and *S. frugiperda* are tentatively identified as valeric and nonanoic acids ; these also possess mycostatic activity towards *B. bassiana*. Depending on concentration, caprylic acid inhibits germination of conidia for different amounts of time. We now further report that inhibition and/or growth is also related to the source of carbon, nitrogen, and energy present in the growth medium. This observation of selective toxicity in the presence of different nutrients was also observed using nonanoic acid. Our data therefore make it necessary to interpret the effects of certain fatty acids on germination and growth of *B. bassiana* (and probably other fungi as well) in terms of nutrients for the germination process.

R.A. Samson & H.C. Evans (1982). Two new Beauveria spp. from South America. J. Invert. Path. 39 (1) : 93-97

Beauveria velata sp. nov. was found on Lepidoptera larvae in Ecuador and is characterized by ellipsoid conidia covered with a distinct mucilaginous layer. Another

Beauveria species, commonly encountered on Coleoptera in Brazil proved to be identical with *Isaria amorpha*, originally described from a cicada in Indonesia. The new combination *Beauveria amorpha* is proposed. Details of the occurrence and ecology of both species are described.

M.S. Shields et al. (1981). Identification of a Penicillium urticae metabolite which inhibits Beauveria bassiana. J. Invert. Path. 38 (3) : 374-377

A metabolite of a common soil fungus, *Penicillium urticae*, which inhibits conidia germination and growth of *Beauveria bassiana*, was identified. The production, extraction from the culture, and purification of the metabolite is described. Two-dimension thin-layer chromatography, reverse-phase chromatography, mass spectrophotometer and bioassay data indicate that the metabolite is patulin. The implication of patulin inhibition of *B. bassiana* and its subsequent effect on the potential role of *B. bassiana* as a control agent of soil-inhabiting insects are discussed.

G. St. Julian et al. (1982). Infectivity of Nomuraea rileyi conidia to Popillia japonica larvae. J. Invert. Path. 39 (2) : 253-254

N. rileyi NRRL-5885A was used in these studies, and was shown to cause larval death. Although it was difficult to determine the route of fungal infection, the authors assumed that fungal growth in the larval gut with no apparent fungal growth on the larval integument indicated infection via ingestion of conidia. Most fungal infection was probably through the larval integument.

D.G. Boucias et al. (1982). The relative susceptibility of six noctuid species to infection by Nomuraea rileyi isolated from Anticarsia gemmatalis. J. Invert. Path. 39 (2) : 238-240

The noctuid species tested included *A. gemmatalis*, *Pseudoplusia includens*, *Spodoptera frugiperda*, *S. exigua*, *Heliothis zea* and *Trichoplusia ni*. Two Florida *N. rileyi* isolates, FI 74 and FI 78, were used. The results of the comparative assays demonstrated unique differences in the susceptibility of some noctuids to these two *N. rileyi* isolates, thus providing a format for the selection of specific strains against defined pest complexes.

C.M. Ignoffo et al. (1982). Susceptibility of larvae of Trichoplusia ni and Anticarsia gemmatalis to intrahaemocoelic injections of conidia and blastospores of Nomuraea rileyi. J. Invert. Path. 39 (2) : 198-202

The LD_{50} for larvae of *Trichoplusia ni* injected with blastospores of *Nomuraea rileyi* was 4.30 ± 1.16 hyphal bodies/larva ; the LD_{50} for injected conidia was ca. 25,000 conidia/larva. The dose-mortality regression line for blastospores was $Y = 4.6504 + 0.5487\ X$. Larval mortalities of *Anticarsia gemmatalis* and *T. ni* at 100 blastospores/larva were 0.4 ± 0.5 % and 96.7 ± 1.9 %, respectively. At a dosage of 25,000 conidia/larva, larval mortalities for *A. gemmatalis* and *T. ni* were 0.4 ± 0.5 % and 43.1 ± 8.7 %, respectively. Thus, larvae of *A. gemmatalis* were >100 times and >200 times more resistant to injected conidia and blastospores, respectively, than were larvae of *T. ni*. Resistance of *A. gemmatalis* to *N. rileyi* may not be solely at the integumental barrier, as is often believed, but may also be a function of an internal physiological response.

D.G. Boucias & J.C. Pendland (1982). Ultrastructural studies on the fungus Nomuraea rileyi infecting the velvetbean caterpillar, Anticarsia gemmatalis. J. Invert. Path. 39 (3) : 338-345

Combined scanning and transmission electron microscopy was used to study the fine structure of the developmental stages of *Nomuraea rileyi* infecting host larvae of *Anticarsia gemmatalis*. Larvae were dusted with large numbers of fungal conidia, which germinated and penetrated the cuticle within 6 hr post-treatment. Within 24 hr, penetration hyphae had reached the cuticular epidermis and, via a budding process, initiated the hyphal body stage in the haemocoel. The hyphal bodies, suspended in haemolymph, multiplied and spread throughout the host larvae. By 6-7 days post-treatment, the majority of larvae were mummified. Within 12 hr postmortem, numerous conidiophores emerged, producing a confluent mycelial mat over the entire cuticular surface. Numerous hydrophobic conidia were formed on phialides present on the aerial conidiophores.

G. Zimmermann (1982). Effect of high temperatures and artificial sunlight on the viability of conidia of Metarhizium anisopliae. J. Invert. Path. 40 (1) : 36-40

Studies on the heat resistance of the conidia of *Metarhizium anisopliae* showed a clear correlation to the actual moisture conditions. The medium lethal temperature for 30 min of exposure in a suspension was 42°C, but 50.5°C at 100 % RH, 57.5°C at 76 % RH, and 68.8°C at 33 % RH. The experiments on the effect of artificial sunlight indicated an extrapolated half-life of the conidia under field conditions of 1 hr, 40 min for 24 hr incubation at 25°C in the dark following exposure and about 2 hr, 45 min for 48 hr incubation.

K.R. Kramm & D.F. West (1982). Termite pathogens : effects of ingested Metarhizium, Beauveria and Gliocladium conidia on worker termites (Reticulitermes sp.). J. Invert. Path. 40 (1) : 7-11

Separate groups of subterranean termites (*Reticulitermes* sp.) were exposed to whole cultures of *Beauveria bassiana*, *Gliocladium virens*, or *Metarhizium anisopliae*. Individuals were removed after varying time intervals and hindgut contents were plated onto potato dextrose agar. Viable spores first appeared in the hindguts within 8 hr of exposure. Fungi reisolated from the hindguts of diseased termites were pathogenic of healthy termites. Histological examination showed that invasion of the hemocoel by *M. anisopliae* occurred exclusively through direct invasion of the integument ca. 24 hr after death. *B. bassiana* invaded, primarily through the alimentary tract, ca. 12 hr prior to termite death.

K.R. Kramm et al. (1982). Termite pathogens : transfer of the entomopathogen Metarhizium anisopliae between Recitulitermes sp. termites. J. Invert. Path. 40 (1) : 1-6

Subterranean termites (*Reticulitermes* sp.) exposed to whole cultures of *Metarhizium anisopliae* for 4, 8, 12, or 48 h transfer disease to previously healthy termites. Healthy termites concentrate grooming activity on diseased individuals and thereby become infected. Termites which have been killed by the fungus are avoided by healthy individuals and are less effective in spreading disease than are exposed living termites.

P.Y. Lai et al. (1982). Pathogenicity of six strains of entomogenous fungi to Coptotermes formosanus. J. Invert. Path. 39 (1) : 1-5

One strain (2A3) of *Beauveria bassiana*, two strains (N-22 ; T-27) of *Beauveria* sp., and three strains (Tonga ; 10B, MM-773) of *Metarhizium anisopliae* were tested for their pathogenicity to workers from a colony of *Coptotermes formosanus*. A microsyringe method for estimating and applying the inoculum was employed in these tests. On the basis of LD_{50} and fiducial limits, the pathogenicity, in descending order, was MM-773 > 10B = N – 22 = 2A3 = T-27. Because of heterogeneity, the fiducial limits of the Tonga strain overlapped all of the other isolates except for MM-773. Except for the Tonga strains, *M. anisopliae* appeared to be more pathogenic than *Beauveria*. LD_{95} and LT_{50} of these fungi were also determined.

D.G. Boucias et al. (1982). Isozyme differentiation among 17 geographical isolates of Hirsutella thompsonii. J. Invert. Path. 39 (3) : 329-337

Electrophoretic analysis of mycelial preparations of 17 isolates of *Hirsutella thompsonii* demonstrated extensive variability in isozyme content. Many isolates possessed distinct electromorphs used to group or separate individual isolates. Coefficients of similarity based on isozyme patterns closely followed the morphological scheme used to separate *H. thompsonii* into three varieties. One exception, the nonsynnematous vinacious variety was very close to the nonsynnematous grayish-green variety biochemically. The electrophoretic data demonstrate that extensive differentiation among the *H. thompsonii* isolates is occurring at the subcellular level without attendant morphological changes.

R.J. Milner (1982). On the occurrence of pea aphids, Acyrthosiphon pisum, resistant to isolates of the fungal pathogen Erynia neoaphidis. Ent. expl appl. 32 (1) - 23-27

A laboratory colony of *Acyrthosiphon pisum* has been found to consist of 2 biotypes distinct in their susceptibility to an isolate of the fungal pathogen *Erynia neoaphidis*. Dosages which killed an average of 94 % of the « susceptible » biotype did not kill a single « resistant » aphid. Clones were established and have bred true for over 25 generations on broad beans and over 16 generations on lucerne. Seven of 8 field populations tested contained the « resistant » biotype. Eleven isolates of *E. neoaphidis* were tested against the 2 clones and 2 were found to attack the « resistant » biotype as readily as they attacked the « susceptible ». This is the first time that field populations of aphids have been reported to contain a biotype resistant to a fungus disease and also the first time strains of a pathogen have been found capable of attacking an otherwise resistant biotype.

W.A. Gardner (1982). Occurrence of Erynia sp. in Hypera postica in central Georgia. J. Invert. Path. 40 (1) : 146-147

This entomogenous fungus has become established as a natural biological control agent of *H. postica* in Pike and Spalding counties in central Georgia. Its occurrence could play a vital role in the resurgence of alfalfa in the state. Comparisons of chlamydospores and zygospores with those from midwestern *H. postica* cadavers suggest that the fungus is *E. phytonomi*.

R.J. Milner (1981). Patterns of primary spore discharge of Entomophthora spp. from the blue green aphid, Acyrthosiphon kondoi. J. Invert. Path. 38 (3) : 419-425

Experiments were conducted to study the effects of time, temperature, and light regime on primary spore formation at 100 % RH for the three major pathogens of *Acyrthosiphon kondoi*. Only small differences were detected between the continuous light and continuous dark regimes. *Entomophthora obscura* produced between 6 and 10×10^3 primary spores mostly during the first 48 hr. Total primary spore production was similar at the five temperatures tested from 5 to 25°C. *Entomophthora planchoniana* produced large numbers of primary spores (about 5×10^4 per aphid) only at temperatures between 10 and 20°C. The majority of primary spores were formed during the first 24 hr. Primary spore production with *Entomophthora* nr. *exitialis* ranged from about 10^3 per aphid at 5 and 10°C to 3 or 4×10^5 at 15 to 25°C, with most spores being formed during the first 48 hr. It is suggested that rainfall is more likely to be important for transmission of *E. obscura* and *E.* nr. *exitialis* than for transmission of *E. planchoniana*, and that *E. obscura* is likely to be the most important pathogen during cool or cold weather.

T.G. Andreadis (1982). Impact of Nosema pyrausta on field populations of Macrocentrus grandii, an introduced parasite of the European corn borer, Ostrinia nubilalis. J. Invert. Path. 39 (2) : 298-302

In field populations of the European corn borer, *Ostrinia nubilalis*, there is a significant inverse correlation between the prevalence of corn borer infection with the microsporidian *Nosema pyrausta* and the prevalence of parasitism by the introduced braconid *Macrocentrus grandii* where infections with *N. pyrausta* exceed 45 %. This relationship occurs geographically and from year to year. Corn borer infection with *N. pyrausta*, the source of infection for *M. grandii*, is significantly related to corn borer density in the cornfield. These findings strongly suggest that *N. pyrausta* has a significant adverse effect on field populations of *M. grandii* and may help explain the diminishing role of this and other introduced parasites as natural controls of the corn borer in the United States.

J.E. Henry & J.A. Onsager (1982). Large-scale test of control of grasshoppers on rangeland with Nosema locustae. J. econ. Ent. 75 (1) : 31-35

Nosema locustae was applied to rangeland by aircraft at dosage rates of 2.1×10^9 and 2.1×10^8 spores per ha when the major grasshopper species, *Melanoplus sanguinipes*, were mostly 3rd instars. These treatments were compared with a standard rangeland insecticide treatment with 560 ml of 95 % technical malathion per ha, and compared with no treatment. Each plot was 2,332 ha, and each treatment was replicated four times. The high level of *N. locustae* caused significant reductions in grasshopper densities during the season of treatment (1975). A panzootic among grasshoppers caused by the fungus *Entomophthora grylli* occurred early in the second season and reduced the potential for expression of subsequent effects by *N. locustae*. Nevertheless, the high level caused significant reductions, and the low level appeared to cause slight but not significant reductions in grasshopper densities during the two subsequent seasons (1976 and 1977). Parasitism of grasshoppers by entomophagous flies and nematodes decreased sharply in malathion plots, but tended to increase in *N. locustae* and untreated plots.

G.G. Wilson (1982). Effects of Pleistophora schubergi (Microsporida) on the spruce budworm, Choristoneura fumiferana. Can. Ent. 114 (1) : 81-83

Spores of the microsporidium *Pleistophora schubergi* were fed to second- and fifth-instar larvae of the spruce budworm, *Choristoneura fumiferana*. A treatment of 2×10^5 spores applied to the surface of the host's diet resulted in 100 % mortality to second- and 60 % to fifth-instar larvae. Susceptibility of the host to the parasite decreased as the larvae became older. Other effects on host development were not significant at the dosages tested.

J. Percy et al. (1982). Development and ultrastructure of a microsporidian parasite in midgut cells of the larch sawfly, Pristiphora erichsonii. J. Invert. Path. 39 (1) : 49-59

The developmental stages of a microsporidium from larvae of *Pristiphora erichsonii* were investigated. Meronts appeared to be the only stage containing a diplokaryon. Nuclei of sporonts in a parasitophorous vesicle underwent at least three divisions and uninucleate sporoblasts developed from these multinucleate sporonts. As many as 38 spores were observed with a vesicle. A thin pansporoblastic membrane limited the vesicle and was derived from rough endoplasmic reticulum of the host cell. The microsporidium was tentatively identified as *Pleistophora* sp. Infection levels of the microsporidium in natural populations of *P. erichsonii* reached 25 %.

ii) Parasites and Predators

H. Kajita (1981). Native parasites of the greenhouse whitefly, Trialeurodes vaporariorum, in Japan and results of first use as biological control agents. Z. ang. Ent. 92 : 457-464

Six species of hymenopterous parasites have emerged from greenhouse whitefly pupae collected in Japan during 1975-1978 : *Encarsia* sp.A, *Encarsia* sp.B, *Eretmocerus haldemani*, *Eretmocerus* sp., *Prospaltella lutea* and *Prospaltella* sp. *Encarsia* sp.A and *Prospaltella* sp. were relatively common species, whereas *Encarsia* sp.B, *Eretmocerus haldemani*, *Eretmocerus* sp. and *Prospaltella lutea* were rare ones. Although *Prospaltella* sp. occurred most frequently in the field, the number of hosts attacked in greenhouse experiments by adult parasites of this species was significantly lower than that attacked by *Encarsia* sp.A. The ability of these native parasites in controlling whiteflies was examined in laboratory and greenhouse experiments. It was concluded that they were inferior to the introduced *Encarsia formosa*.

L.S. Osborne (1981). Utility of physiological time in integrating chemical and biological control of greenhouse whitefly. Environ. Ent. 10 (6) : 885-888

Encarsia formosa, a parasite of greenhouse whitefly, *Trialeurodes vaporariorum*, became established following release in 90 % of the cages where the only whitefly scales present were ca. 265 D°>8.3°C old. In laboratory studies, there was no significant reduction in parasite emergence when black-parasitized scales (ca. 125 D°>12.7°C old) were treated with resmethrin (0.25 lb. AI/100 gal.). In greenhouse studies, there was a significant reduction in parasite emergence when black scales (ca. 125 D°>12.7°C old) were treated with either resmethrin (0.25 lb. AI/100 gal.) plus a spreader sticker or with resmethrin (0.25 lb. AI/100 gal.) alone. In the greenhouse study where only resmethrin was applied, the mean percent whitefly emergence was reduced by 71 %, whereas the mean percent parasite emergence was reduced by only 27 %. The parasites which emerged in the latter experiment were able to reproduce and thus continue the host-parasite interaction.

L.S. Osborne (1982). Temperature-dependent development of greenhouse whitefly and its parasite Encarsia formosa. Environ. Ent. 11 (2) : 483-485

The thermal threshold for greenhouse whitefly, *Trialeurodes vaporariorum*, was 8.3°C, and the developmental times, in day-degrees above 8.3°C, for the egg, 1st-, 2nd-, 3rd-, and 4th- instar nymphs were 122.9, 63.9, 38.4, 40.1 and 115.4, respectively. The thermal threshold for the parasite, *Encarsia formosa*, was 12.7°C, and the developmental times, in day-degrees above 12.7°C, for the periods from oviposition to the black scale stage ; from the black-scale stage to adult eclosion and from oviposition to adult eclosion were 86.9, 101.7 and 188.9, respectively. These data should enable growers to predict when to release *E. formosa* and when to apply pesticides with minimal effects to the parasite population.

M.H. Eggenkamp-Rotteveel Mansveld et al. (1982). The parasite-host relationship between Encarsia formosa and Trialeurodes vaporariorum. XII. Population dynamics of parasite and host in a large, commercial glasshouse and test of the parasite-introduction method used in the Netherlands (first part). Z. ang. Ent. 93 (2) : 113-130

This research project was initiated in order to find a quick and reliable sampling method, both for growers and suppliers of parasites ; to test the effectiveness of the Dutch method of introducing *E. formosa* ; to explain why inferior results were obtained in small glasshouses compared with large houses ; to test Huffakers 1958 hypothesis that coexistence of predator and prey is possible only if special requirements of space and dispersal capacity of both predator and prey are fulfilled. The introduction scheme used in the Netherlands proved successful : parasites are introduced 1-4 weeks after the pest is seen ; 4 parasite introductions were made, with an interval of two weeks and a planned total of 6 parasites per plant.

R. Arakawa (1982). Reproductive capacity and amount of host feeding of Encarsia formosa. Z. ang. Ent. 93 (2) : 175-182

The reproductive capacity and the amount of host-feeding of *Encarsia formosa*, a parasitoid of the greenhouse whitefly *Trialeurodes vaporariorum*, were studied in two experimental series. Firstly, to measure the percentage survival and the developmental period from egg to adult emergence of the wasp, hosts of the 1st, 2nd, 3rd, early 4th, middle 4th and late 4th instar on tobacco leaves, were exposed to female wasps. Those hosts in which eggs of the wasp were deposited, were reared in a leaf cage attached to a tobacco leaf until adult wasps emerged. Secondly, to measure the fecundity and the total number of hosts killed by host-feeding during the life span of female wasps, 36 whitefly larvae in the 4th instar were presented daily to wasps from emergence to death. These experiments were conducted under a photoperiod of 16L8D at 25 ± 1°C. The percentage survival of the wasps scarcely varied with the host stages parasitized, but the developmental period from egg to adult emergence of the wasps was significantly affected by the host stage parasitized. When eggs were deposited in young hosts (1st, 2nd and 3rd larval instars), the period from egg to adult emergence took a longer time than when hosts of the 4th larval instar were parasitized. The

average life span of adult female wasps was 36.8 days and during this period wasps deposited about 442 eggs and killed about 101 hosts by host-feeding. From these results the intrinsic rate of natural increase was calculated to be about 0.2/female/day.

G.D. Propp (1982). Functional response of Nabis americoferus to two of its prey, Spodoptera exigua and Lygus hesperus. Environ. Ent. 11 (3) : 670-674

The maximum rate of prey consumption and the functional responses of 4th- and 5th-instar nymphs, prereproductive, unmated adults, and reproductively mature females of *Nabis americoferus* were determined. Consumption increased with nymphal instar and was greatest for reproductive females. Attack rates were highest and handling times lowest for reproductively mature females, whereas prereproductive adults had the lowest attack rates and highest handling times of the stages tested. Attack rates were shown to vary with prey type and structural complexity of the universe.

S.D. Pair et al. (1982). Parasitoids of Heliothis spp. larvae in Mississippi associated with sesame interplantings in cotton, 1971-1974 : implications of host-habitat interaction. Environ. Ent. 11 (2) : 509-512

The parasitoids of the cotton bollworm, *Heliothis zea*, and tobacco budworm, *H. virescens*, larvae collected from cotton and interplanted sesame were determined from 1971 through 1974 in the Mississippi delta. Greater numbers of *Heliothis* larvae (especially *H. virescens)* were found on sesame than on cotton and were more often parasitized. *Apanteles marginiventris* and *Campoletis sonorensis* were the most abundant parasitoid species reared from *Heliothis* larvae on cotton (41.7 %) and sesame (54.8 %), respectively. Although *A. marginiventris* frequently attacked larvae on both crops, only one *C. sonorensis* was recovered from *Heliothis* larvae infesting cotton during the entire study.

P.L. Versoi & W.G. Yendol (1982). Discrimination by the parasite, Apanteles melanoscelus, between healthy and virus-infected gypsy moth larvae. Environ. Ent. 11 (1) : 42-45

Lymantria dispar larvae infected with the gypsy moth nuclear polyhedrosis virus were exposed to *Apanteles melanoscelus* females, separately and in combination with noninfected larvae. Significant differences established among the number of parasite-host contacts and percent ovipositional attempts observed under various treatments indicated that the parasites preferred noninfected larvae, making fewer efforts to parasitize virus-infected individuals. Since the noninfected and virus-infected larvae were different in a number of ways, several factors may have contributed to the behavioral discrimination evidenced.

S.G. McDaniel & W.L. Sterling (1982). Predation of Heliothis virescens eggs on cotton in East Texas. Environ. Ent. 11 (1) : 60-66

Heliothis virescens eggs labeled with radioactive phosphorus were placed in an east Texas cotton field, and 777 radioactive arthropods were later captured. These captures consisted of 12 species and 3 arthropods identified only to family. Singularly placed *H. virescens* eggs exposed to predation after the onset of pinhead squaring averaged 77 % predation in 24 h. When all nonflying predators were excluded from plants, egg predation averaged 46 %, and on plants where nonflying predators and alate predators were unable to penetrate the 42-cm² mesh, egg predation averaged 34 %. The seasonal cumulative percent predation on *H. virescens* eggs averaged 77.6 and 86.6 for 24 h and 48 h, respectively. D-Vac® sampling of predator numbers and whole-plant sampling of the *Heliothis* spp. egg numbers revealed a seasonal mean of 137:1 (predator-to-egg ratio). The equation $Y = 71.449\ (X)^{0.194}$, $X>0$ with an r value of 0.60 predicts the expected percent *Heliothis* spp. egg predation, using the log predator-to-egg ratio as the predictor. Predator efficiency values were calculated for several species or groups of species and presented as number of eggs individually consumed per 24 h. Eggs consumed per individual per day ranged from 14.2 eggs for *Chiracanthium inclusum* to 0.3 eggs consumed by *Solenopsis invicta*.

N.E. Stamp (1982). Behavioural interactions of parasitoids and Baltimore checkerspot caterpillars (Euphydryas phaeton). Environ. Ent. 11 (1) : 100-104

Braconid wasps, *Apanteles euphydryidis*, attended webs of their lepidopteran hosts, *Euphydryas phaeton*, for hours, with one-third of each hour spent searching for caterpillars. Encounters with larvae on the outside of webs were frequent and usually resulted in parasitoids turning away. Head-jerking exhibited by caterpillars was effective in knocking parasitoids away. Ichneumonid wasps, *Benjaminia euphydryadis*, travelled from web to web, spending less than 1 min per web. Overall, the defensive mechanisms exhibited by the caterpillars and their distribution on and in webs were effective in deterring parasitoids.

R.W. Campbell & T.R. Torgersen (1982). Some effects of predaceous ants on western spruce budworm pupae in North Central Washington. Environ. Ent. 11 (1) : 111-114

Predators killed about 95 % of the western spruce budworm, *Choristoneura occidentalis*, pupae placed in one site in north central Washington. We infer that most of this mortality was caused by foraging ants.

C.D. Basarkar & P.K. Nikam (1982). Longevity, fecundity and sex-ratio of Goryphus nursei, a solitary parasitoid of Earias vittella. Z. ang. Ent. 93 (2) : 213-216

The longevity, fecundity and sex-ratio of *Goryphus nursei*, a pupal parasitoid of *Earias vittella*, were determined under laboratory conditions (22 ± 1°C and 50-55 % RH). Longevity, ovipositional period, progeny production and sex-ratio averaged 24.6 days, 21.5 days, 82.4 indiv. and 1.62 males : 1 female respectively. A significant correlation was obtained between the age of female parasitoid and her progeny production capacity ($P<0.005$).

D.T. Briese (1981). The incidence of parasitism and disease in field populations of the potato moth, Phthorimaea operculella in Australia. J. Aust. ent. Soc. 20 : 319-326

The incidence of parasitism and disease was recorded during a survey of *Phthorimaea operculella* populations from the major Australian potato growing areas. High levels of parasitism were found in most regions, though the contribution of each of the three major species showed marked geographic variation. There were also differences in the parasitism of larvae in leaves and in tubers. In some locations larvae were infected by a granulosis virus, which appeared to be endemic at a low frequency throughout the potato moth's range in Australia.

J.E. Laing & J.M. Heraty (1981). Establishment in Canada of the parasite Apanteles pedias on the spotted tentiform leafminer, Phyllonorycter blancardella. Environ. Ent. 10 (6) : 933-935

In May 1978, two females of *Apanteles pedias* introduced from New Zealand were released in an apple orchard at the University of Guelph, Guelph, Ontario, for the control of the spotted tentiform leafminer, *Phyllonorycter blancardella*. In the fall of 1978, *A. pedias* was recovered from 2.4 % of the overwintering or third-generation leafmines of *P. blancardella*. In the fall of 1979, the rate of parasitism by *A. pedias* had increased to 25.7 % in the original release orchard. *A. pedias* is firmly established in the Guelph area, and recoveries have been made from as far away as Ancaster, Ontario, 43 km south of the original release site.

G.P. Watterson & J.D. Stone (1982). Parasites of blackmargined aphids and their effect on aphid populations in far-west Texas. Environ. Ent. 11 (3) : 667-669

One primary parasite, *Aphelinus perpallidus*, and five previously unreported secondary (suspected) parasites, *Alloxysta schlingeri*, *Aphidencyrtus* spp., *Chartocerus* spp., *Dendrocerus* spp., and *Pachyneuron* spp., were identified from black margined aphids, *Monellia caryella*, in far-west Texas pecan orchards. *Aphelinus perpallidus* was found in significant numbers, but populations varied greatly among orchards. During most of the growing season, less than 6 % of collected *M. caryella* specimens were parasitized by *A. perpallidus*, but up to 52 % were parasitized in one orchard in October. Other species parasitized <1 % of *M. caryella* populations.

A.M. Harper & C.E. Lilly (1982). Aggregations and winter survival in southern Alberta of Hippodamia quinquesignata, a predator of the pea aphid. Can. Ent. 114 (4) : 303-309

Aggregations of the ladybird beetle *Hippodamia quinquesignata* were found at several sites on the eastern edge of the Rocky Mountains in southern Alberta at altitudes of 1250-2439 m, and also in the Porcupine Hills (1780 m), just east of the Rockies. The beetles apparently migrate from the prairie region where they feed on pea and grain aphids to the aggregation sites in fall, and return to the prairie in spring. *H. quinquesignata* can survive southern Alberta winters, but some protection is needed as high mortality sometimes occurs in localized areas of the aggregation sites. Supercooling data indicate that the greatest protection against cold occurs during mid-winter but a considerable amount of cold hardening occurs during the fall. The most critical period for survival appears to be April and May when the beetles have lost much of their cold resistance, and a late spring cold period could cause high mortality.

E.J. Wright & J.E. Laing (1982). Stage-specific mortality of Coleomegilla maculata lengi on corn in southern Ontario. Environ. Ent. 11 (1) : 32-37

Factors affecting the mortality of *Coleomegilla maculata lengi* were investigated at Guelph, Ontario from 1976 through 1978. It was found that most of the overwintering mortality of caged beetles occurred at the end of the winter. Parasitism by *Perilitus coccinellae* reduced survivorship of overwintering beetles. There was no significant difference found in overwintering mortality of beetles caged at three different densities. Predation of eggs of *C. m. lengi* was 44.8 and 48.6 % in 1976 and 1977, respectively. Stage-specific mortality for the coccinellids of the first generation in corn (primarily *C. m. lengi*) at Guelph calculated for the period from egg to pupa was 93.8 % in 1977. In 1978, mortality from egg to pupa of *C. m. lengi* was 95.4 %. *C. m. lengi* displays a type IV survivorship curve of Slobodkin.

T.P. Mack & Z. Smilowitz (1982). Using temperature-mediated functional response models to predict the impact of Coleomegilla maculata adults and 3rd-instar larvae on green peach aphids. Environ. Ent. 11 (1) : 46-52

The effects of temperature and prey density on *Coleomegilla maculata* feeding on *Myzus persicae* were determined to quantify their impact on the *C. maculata-M. persicae* interaction. Seven temperatures ranging from 15.6 to 32.2°C were employed in the study. Nine prey densities per temperature and two predator and prey age classes per prey density were also used. An enzyme kinetic equation was used to describe the change with temperature in the green peach aphid intrinsic rates of increase and the *C. maculata* larval and adult search rates. The larval and adult handling rates were determined to be linearly related to temperature over the range studied. The short-term impact of *C. maculata* adults and 3rd-instar larvae on green peach aphids was simulated by substituting these equations into two aphid growth rate models. Both models predicted that *C. maculata* 3rd-instar larvae and adults would be most effective in reducing the aphid population in temperatures above 29°C.

R.K. Pandey et al. (1982). Bionomics of Trioxys (Binodoxys) indicus, an aphidiid parasitoid of Aphis craccivora. Z. ang. Ent. 93 (2) : 164-175

The present paper elucidates the functional response of *Trioxys (Binodoxys) indicus* showing sigmoid type of relationship between the number of eggs laid or host (*Aphis craccivora*) parasitised and their density. This relationship is described using an exponential equation $Y = k(10)\frac{x}{x+1}$ which indicates that within 15 min of exposure period, in an area of ca 80 cm^2, the number of eggs laid by the parasitoid cannot exceed 51.4. This type of functional response is considered to be the most stabilising one. At low host densities ($\leqslant 10$) the parasitoid is unable to locate the host in ca 50 % cases. At high host densities ($\geqslant 20$) the parasitoid approaches the host quicker and stays on the leaf (of the host plant) longer than at low densities ($\leqslant 20$). The number of antennal encounter and pricking by the parasitoid increases with the increase of host numbers. The wasp tends to emigrate from an area where it parasitised most of the hosts, which is initiated by antennal encounter with parasitised hosts. Different behavioural activities in relation to functional response are explained and discussed.

C.G. Wilson et al. (1982). The introduction of Trioxys complanatus, an internal parasite of the spotted alfalfa aphid, into South Australia. J. Aust. ent. Soc. 21 : 13-27

Trioxys complanatus was introduced into South Australia in August 1977 as a parasite of the spotted alfalfa aphid *Therioaphis trifolii* f. *maculata*. A mass rearing technique was devised whereby approximately 2000 *T. complanatus* could be released at each of 14 fields, as primary release sites every week. A total of 39 primary release sites and 629 secondary release sites, inoculated from these with the help of farmers, were established. By the end of April 1978 *T. complanatus* was being recovered every week in samples

from all 15 primary release sites and from most of the secondary release sites that had been visited. *T. complanatus* was capable of dispersing relatively long distances (at least 30 km) from release sites. By the end of November 1979 when the last releases were made, the parasite was considered permanently established throughout the region to the east of Spencer Gulf and in some areas to the west. *T. complanatus* displays all the qualities of an effective biological control agent.

K. Purrini & R. Ormieres (1982). Gregarina hylobii and Ophryocystis hylobii n.sp. parasitising Hylobius abietis. J. Invert. Path. 39 (2) : 164-173

Two sporozoan parasites, *Gregarina hylobii* and *Ophryocystis hylobii* n. sp., parasitizing the adults of natural populations of *Hylobius abietis* are described. The gregarine *G. hylobii*, a parasite of the gut of *H. abietis*, has been reexamined and its complete life cycle, including the solitary gamonts, gametocysts, and sporoducts is described. The life cycle of the neogregarine *O. hylobii* infecting the Malpighian tubules of host animals examined at light and electron microscope levels is discussed. Some data on the prevalence of infections and host-parasite relationships are also discussed.

V.M. Kirk (1982). Carabids : minimal role in pest management of corn rootworms. Environ. Ent. 11 (1) : 5-8

By reputation, ground beetles are known to be predators. However, neither carabid adults nor larvae come in contact with corn rootworms. Also, the rootworms have become adept in all stages at avoiding ground-dwelling predators. Carabids and rootworms have different habits, and they seldom come together. It is more accurate to call these carabids « opportunists » than predators.

R.F. Mizell & T.E. Nebeker (1982). Preference and oviposition rates of adult Thanasimus dubius on three prey species. Environ. Ent. 11 (1) : 139-143

The relative preference of adult *Thanasimus dubius* for two natural prey, the southern pine beetle, *Dendroctonus frontalis*, and the small (four-spined) southern pine engraver, *Ips avulsus*, and for a laboratory prey, the cowpea weevil, *Callosobruchus maculatus*, was determined. Newly emerged, hungry *T. dubius* preferred the two natural prey over *C. maculatus*, but consumed *I. avulsus* and *D. frontalis* as encountered. A 7-day conditioning period did not affect the preference ; all predators, when offered a choice of three prey species, preferred *I. avulsus*. Egg production was significantly lower for *T. dubius* fed *C. maculatus*, and egg viability was significantly lower for *T. dubius* reared on *D. frontalis*.

V.E. Harris & J.W. Todd (1982). Longevity and reproduction of the southern green stink bug, Nezara viridula, as affected by parasitisation by Trichopoda pennipes. Ent. exp. appl. 31 : 409-412

A comparative study of 618 field-collected *Nezara viridula* showed that parasitization by *Trichopoda pennipes* caused a 49 % reduction in the longevity of male and female *N. viridula*. Egg fertility and egg-mass size were not reduced by parasitization. Fecundity of parasitized females was not reduced relative to that of unparasitized females during a time period equal to the lifetime of parasitized females. However, lifetime fecundity of unparasitized females was 3.8 times the lifetime fecundity of parasitized females. Since *N. viridula* mate and oviposit throughout their lives, parasitization by *T. pennipes* can cause significant reductions in population levels of this pest.

A.C. Cohen (1982). Water and temperature relations of two Hemipteran members of a predator-prey complex. Environ. Ent. 11 (3) : 715-719

Certain aspects of temperature and water relations were investigated in individuals of two hemipteran species that live in arid habitats. Thermal tolerance, measured as critical thermal maximum (CTM) was considerably higher in *Geocoris punctipes* (CTM = 47.8) than in *Lygus hesperus* (CTM = 42.4). *L. hesperus* had higher resistance to water loss at high temperatures than *G. punctipes*, whereas both species had rates of water loss that were generally higher than other arthropods that inhabit arid zones. Fecal water loss was higher in *L. hesperus* than it was in *G. punctipes* (5.5 %.day^{-1} compared with 2.7 %.day^{-1}). *L. hesperus* had a significantly lesser amount of cuticular lipid per cm^2 ; $\bar{x}$ = 33.2 mg.cm^{-2} (SD = 8.4) than did *G. punctipes* ; $\bar{x}$ = 53.4 (SD = 16.2). Older adults had lower rates of water loss than did newly emerged adults ($P<0.001$).

A.M. Gol'berg (1982). Influence of temperature and relative humidity on survival and fecundity of Pauridia peregrina, a parasite of mealybugs and its interactions with Planococcus citri. Ent. exp. appl. 32 (1) : 86-90

Some biological aspects of the encyrtid parasite *Pauridia peregrina* were studied. Non-ovipositing females lived longer than ovipositing females. Parasite survival was strongly affected by relative humidity. Females survived best at 21.5° and 92 % r.h. ; 41.0° and 45 % r.h. caused 96.7 % mortality within 3 hr. Total number of eggs laid was not influenced by 49-71 % r.h. at 26.5°. Lowering of the r.h. increased the proportion of the eggs laid on the first day to 91.1, 65.9 and 59.1 %, respectively, at 49, 57, and 71 % r.h. The parasite could complete development in mealybugs *(Planococcus citri)* growing on young twigs of grapefruit. Grapefruit sepals provided good protection to mealybugs against *P. peregrina*.

G.A. Pak & E.R. Oatman (1982). Comparative life table, behaviour and competition studies of Trichogramma brevicapillum and T. pretiosum. Ent. exp. appl. 32 (1) : 68-74

Life-table studies of *Trichogramma brevicapillum* and *Trichogramma pretiosum* were conducted at various fluctuating temperatures (means ± 5°C), from 15 to 35°C. The intrinsic rate of natural increase (r) was higher for *T. brevicapillum* than that for *T. pretiosum* at 30 and 35°C, and was higher for *T. pretiosum* between 15 and 25°C, due to differences between the 2 spp. in development, longevity, fecundity, sex ratio, and number of progeny per host egg. *T. brevicapillum* had a higher fecundity than *T. pretiosum*, but its development was slower (ca. 10 %), and was retarded facultatively at temperatures of 20°C and below, probably due to diapause. Ovipositional behaviour of *T. brevicapillum* and *T. pretiosum* was similar, but differed in the duration of the different ovipositional activities. Superparasitization occurred by both species when the host egg supply was limited and exposed to more than 1 female simultaneously. *T. pretiosum* laid more eggs per host egg than *T. brevicapillum* at various parasite densities. When eggs were exposed to both species simultaneously, oviposition was intermediate between the number of eggs laid by each species separately. From such eggs, 24 and 76 % of the emerged progeny was *T. brevicapillum* and *T. pretiosum*, respectively, and these percentages were independent of parasite density. The results may explain the distribution of *T. brevicapillum* and *T. pretiosum* in California, and may assess their fitness for mass-release and establishment attempts.

G.A. Pak & E.R. Oatman (1982). Biology of Trichogramma brevicapillum. Ent. exp. appl. 32 (1) : 61-67

The biology of *Trichogramma brevicapillum* reared on eggs of *Trichoplusia ni*, and the influence of some abiotic and biotic conditions on the parasitization strategy of the adults were studied. Egg, larva, prepupa, and pupa are described. Development of these stages lasted ca. 1, 3, 1, and 5 days, respectively, at 25°C. Reproduction is biparental, arrhenotokous. The preoviposition period lasts ca. 3 hr, and oviposition activity was maximal in the 3rd and 4th hr of the photophase and was minimal in the scotophase. The suitability of *T. ni* eggs as a host was maximal in the blastula stage of the embryo, decreased sharply in the early stages of differentiation, and increased rapidly in the later stages of embryological differentiation. A single female reared from a host egg was larger and more fecund than females from eggs yielding 2 or 3 parasites. Oviposition by individual females was restrained when the host egg density was limited, thus preventing superparasitization. The number of progeny per host egg and the male proportion of the sex ratio were inversely related to the host egg density over a range of limited host densities.

D.G. Martinez & R.L. Pienkowski (1982). Laboratory studies on insect predators of potato leafhopper eggs, nymphs and adults. Environ. Ent. 11 (2) : 361-362

Laboratory tests showed that *Orius insidiosus* and the common damsel bug, *Reduviolus americoferus*, were able to locate and destroy eggs of the potato leafhopper, *Empoasca fabae*. *O. insidiosus* appeared to be the more efficient egg predator. The average daily mortality of leafhopper adults and nymphs attributed to the feeding of the coccinellids, *Hippodamia convergens* and *Coccinella novemnotata*, the common green lacewing, *Chrysopa carnea* and *R. americoferus* ranged from 1.9 to 3.2, with the exception of *C. carnea* adults, which averaged 0.4 nymphs.

H.A. Dean & D.E. Meyerdirk (1982). Ceroplastes cirripediformis parasite complex on Texas citrus. Environ. Ent. 11 (1) : 177-180

Barnacle scale, *Ceroplastes cirripediformis*, reached damaging levels in several groves in the Lower Rio Grande Valley of Texas during 1975. *Metaphycus eruptor* was the most numerous primary parasite, although *Coccophagus ochraceus*, *Ammonoencyrtus californicus*, and an unknown encyrtid were also recovered. Effectiveness of the primary parasites was apparently reduced by the hyperparasites *Marietta pulchella*, *Tetrasticus minutus*, and *Cheiloneurus inimicus*. Parasitism by primaries varied from 4 to 31 %, and that by hyperparasites 0.0 to 56 %. Individuals per host varied from 1 to 22 for primaries and 1 to 9 for hyperparasites. A single incident was found in research plots of a possible association between increase in barnacle scale and use of dicofol. Because of the effective biological control, barnacle scale was scarce on Texas citrus during 1977.

J.P. Roth et al. (1982). Plant, host and parasite interactions in the host selection sequence of the tachinid Lixophaga diatraeae. Environ. Ent. 11 (2) : 273-277

Tests conducted in a large field cage demonstrated that the tachinid, *Lixophaga diatraeae*, were attracted to sections of the cage containing sugarcane infested with the larvae of the parasites' host, the sugarcane borer, *Diatraea saccharalis*. Within sections of the cage, the parasites were able to distinguish between adjacent infested and uninfested plants. Further testing indicated that interactions between the host and its food plant are the source of attraction to larvipositing females. Larviposition by *L. diatraeae* on sugarcane stalks was significantly reduced at host feeding sites where larviposition and subsequent parasitization had occurred 24 h previously. This may prevent multiple parasitization of unsuitable hosts, thus conserving maggots.

P.K. Nikam & C.D. Basarkar (1981). Life tables and intrinsic rate of natural increase of Xanthopimpla stemmator population on Chilo partellus pupae. Insect Sci. Applic. 2 (4) : 209-212

The pupal parasitoid *Xanthopimpla stemmator* oviposits in the pupae of the spotted stalk borer (or sorghum stem borer) *Chilo partellus*. The adult parasitoid emerges from the pupal case, killing it in the process. Ten mated females of the parasitoid had an average longevity of 30 days (maximum 37 days and minimum 22 days). The number of progeny produced ranged from 71 to 115, with an average of 84.5. The male:female sex-ratio of their progeny averaged 1.14:1. The maximum mean progeny production per day (m_x) was 1.9. The innate capacity for increase was 0.131 per female per day ; and the population multiplied 43.43 times in the generation time of 28.78 days.

N.E. Rees & J.A. Onsager (1982). Influence of predators on the efficiency of the Blaesoxipha spp. parasites of the migratory grasshopper. Environ. Ent. 11 (2) : 426-428

The average longevity of adult females of three species of *Blaesoxipha* grasshopper parasites was estimated at 3.0 to 4.8 days under field conditions. Circumstantial evidence suggested predation as a major cause of mortality. When parasites and grasshoppers were isolated in large cages, average survival of parasites increased about fourfold and the level of parasitism among grasshoppers increased about fivefold over field levels. In identical cage tests that included robber fly predators, all parasites were destroyed, parasitism essentially was eliminated, and the survival rate of grasshoppers increased.

S.A. Hassan (1982). Comparison of three different strains of Phytoseiulus persimilis to control Tetranychus urticae on cucumber in glasshouses. Z. ang. Ent. 93 (2) : 131-140

The effectiveness of three different strains of *Phytoseiulus persimilis* to control the two-spotted spider mite *Tetranychus urticae* as well as their susceptibility to pesticides were compared under practical glasshouse cultural procedures in the Federal Republic of Germany. Despite large differences in rearing techniques, no marked differences in the ability of the predator to control the pest in the glasshouses were observed. *P. persimilis* obtained from the University of Stuttgart-« Hohenheim », that were kept in laboratory rearings for at least 28 years using detached bean leaves, performed as good as predators in commercial use obtained from the Dutch company « Koppert » & Sohn, Berkel en Rodenrijs or from the Glasshouse Crops Research Institute « Littlehampton », England. While the « Koppert » strain of *P. persimilis* was found to be resistant to the fungicide Afugan WP30 (pyrazophos), total mortality of the strain « Hohenheim » was recorded following sprays of this chemical. The use of the resistant « Koppert » strain of *P. persimilis* allowed the integration of the predator together with Afugan to control *T. urticae* and *Thrips tabaci*, taking advantage of the side effect of this preparation on *T. tabaci*. Spray treatments with Frutogard (ditalimfos), Saprol

(triforine), Bayleton spezial (triadimefon), drenches with Du Pont Benomyl (benomyl) to control mildew disease, sprays with Euparen (dichlofluanid) against *Botrytis* disease as well as Pirimor (pirimicarb) against aphids, did not notably affect the populations of the predator in the experiments with all the three strains of *P. persimilis* and successful control of *T. urticae* was repeatedly obtained.

M.A. Hoy & K.A. Standow (1982). Inheritance of resistance to sulphur in the spider mite predator Metaseiulus occidentalis. Ent. exp. appl. 31 : 316-323

Metaseiulus (= *Typhlodromus* or *Galendromus*) *occidentalis* colonies collected from California vineyards are resistant to all formulations of sulphur tested. Colonies collected from apple, pear, or almond orchards are susceptible to sulphur. Resistant larvae survive to adulthood on treated leaves whereas susceptible larvae rarely survive to become protonymphs. In contrast, fecundity and longevity of resistant and susceptible adult females on sulphur-treated leaves are not significantly different. Survival rates of reciprocal F_1, F_2, and backcross larvae fit a model in which sulphur resistance is determined by a major semidominant gene. Sons inherit their resistance genes from their mothers, supporting the parahaploidy model for *M. occidentalis*. An acquired resistance to sulphur has never before been demonstrated in a phytoseiid, or any other biological control agent.

R.M. McPherson et al. (1982). Incidence of arthropod predators in different soybean cropping systems. Environ. Ent. 11 (3) : 685-689

The seasonal incidence of nabids, *Nabis* spp., big-eyed bugs, *Geocoris* spp., minute pirate bugs, *Orius* spp., and spiders was examined in conventional, drill-, and double-crop-planted soybean in two localities in eastern Virginia during 1979 and 1980. Population densities of these predators were not sufficiently abundant during the sampling period in 1979 to make statistical comparisons. During 1980, *Nabis* spp., primarily *N. roseipennis*, were significantly more numerous in conventional and drill-planted fields. *Geocoris* spp., primarily *G. punctipes* were significantly higher in conventionally planted fields in Westmoreland County and in drill-planted fields in Richmond County. At both locations, *Geocoris* were most abundant in the earliest planted fields and were not commonly encountered in double-cropped fields. There were significantly more spiders in the drill-planted fields in Richmond County, and a similar trend was apparent at the other sampling location. Other Arthropod predators commonly encountered in soybean fields included : *Podisus maculiventris, Stiretrus anchorago, Hippodamia tredecimpunctata tibialis, Hippodamia convergens, Zelus* spp., *Sinea* spp., *Arilus* spp., *Chrysopa* spp., and mantids. No comparisons between population densities in different soybean cropping systems were determined for these species. Population densities of predators in untreated soybean fields were significantly higher during the first six weekly sampling periods than densities in fields treated with disulfoton (1.2 kg of a.i./ha) in the furrow at planting.

C.T. Maier (1982). Parasitism of the apple blotch leafminer, Phyllonorycter crataegella, on sprayed and unsprayed apple trees in Connecticut. Environ. Ent. 11 (3) : 603-610

Parasitism of the apple blotch leafminer, *Phyllonorycter crataegella*, was investigated over nine generations (3 years) at two sites in Connecticut. Twelve species of parasitoids, three of them recorded for the first time, attacked *P. crataegella* immatures, their primary parasitoids, or both in commercial apple orchards. Eulophid *Sympiesis marylandensis*, a primary ectoparasitoid, dominated in 14/16 (87.5 %) of samples reared from different areas or generations. Emergence of *S. marylandensis* and *P. crataegella* adults was synchronous ; however, that of *S. marylandensis* preceded the appearance of hosts, 4th- and 5th-instar larvae of *P. crataegella*, by ca. one month. Number of species and abundance of adult parasitoids varied considerably between leafminer generations, although they usually rose sharply from second to third generation in sprayed orchards. In 1978 and 1979 percent parasitism was lowest in the second and highest in the third (last) generation during each year. In the third generation of 1977 and 1979, percent parasitism was higher on unsprayed than sprayed trees at Southington during the first generation of 1978-1980 and during the second generation of 1978-1979. Overall percent parasitism may have been influenced negatively by insecticides and positively by immigration of parasitoids and increased developmental period of hosts (i.e. longer exposure to parasitoids).

M. Page et al. (1982). Comparative toxicity of acephate, diflubenzuron and malathion to larvae of the larch casebearer, Coleophora laricella, and adults of its parasites, Chrysocharis laricinellae and Dicladocerus nearcticus. Environ. Ent. 11 (3) : 730-732

Fourth-instar larch casebearer, *Coleophora laricella*, was significantly less susceptible to acephate and malathion than were adults of its parasites, *Chrysocharis laricinellae* and *Dicladocerus nearcticus* ($P<0.01$). The parasites were more tolerant ($P<0.01$) than the hosts to diflubenzuron. Malathion was equally toxic to both parasite species. *D. nearcticus* appeared to be the more tolerant of the parasites to both acephate and diflubenzuron.

M.I. Haverty (1982). Sensitivity of selected nontarget insects to the carrier of Dipel 4L in the laboratory. Environ. Ent. 11 (2) : 337-338

A mixture of water and the carrier of Dipel 4L® (3:1) was applied to selected insect predators and a parasite in a controlled laboratory environment. Corrected mortality from the 9.4-liter/ha application never exceeded 2.1 % for any species. The 18.7-liter/ha rate resulted in a statistically significant increase in mortality for *Chrysopa carnea* and *Hippodamia convergens* adults 3 and 7 days after treatment, but not for *C. carnea* larvae or *Aphytis melinus* adults. Corrected mortality for the higher application rate never exceeded 13.4 % for any species.

L.A. Warner & B.A. Croft (1982). Toxicities of azinphosmethyl and selected orchard pesticides to an aphid predator, Aphidoletes aphidimyza. J. econ. Ent. 75 (3) : 410-415

Toxicities of azinphosmethyl and 27 other pesticides to *Aphidoletes aphidimyza*, a predator of apple aphids, were evaluated by using contact and residue methods. Among life stages, there was a six fold difference in susceptibility to azinphosmethyl ; 1st instars were most susceptible, and eggs were least susceptible. Egg mortality was greatest in embryos exposed just before eclosion. Mortalities to azinphosmethyl in eggs from 14 field sites revealed significantly higher LC_{50} values in populations from commercial vs. unsprayed orchards. The largest resistance level found was 12.2-fold between a laboratory-reared vs. a

field-collected strain. In eggs and 3rd instars, mortalities to pesticides revealed three classes of compounds, i.e. those causing : high mortality (>50 %) in both stages (diazinon, methomyl, carbaryl, demeton, dimethoate, azinphosmethyl) ; high mortality in one stage (oxythioquinox, phosmet, permethrin, fenvalerate, oxamyl) ; and low mortality (<30 %) in both stages (phosalone, phosphamidon, carbophenthion, pirimicarb, plus several fungicides and miticides).

K. Strickler & B.A. Croft (1982). Selection for permethrin resistance in the predatory mite Amblyseius fallacis. Ent. exp. appl. 31 : 339-345

In selections of two greenhouse populations of the predatory mite, *Amblyseius fallacis*, a 64-fold increase in resistance to permethrin was achieved after about 12 permethrin applications. The initial populations were established by mixing a variety of laboratory colonies, and adding a few individuals from recently collected field colonies. One population was treated alternately with azinphosmethyl and permethrin ; it developed permethrin resistance more slowly than did the population receiving only permethrin treatments. A third population, established from the laboratory colony with the highest initial resistance level, showed little increase in resistance. After selection all three populations showed reasonable survivorship in the greenhouse on plants sprayed at recommended field rates of permethrin. All three populations also maintained resistance to azinphosmethyl, whether or not they received selection with this compound. These permethrin-resistant predatory mites may provide biological control of pest mites on crops where synthetic pyrethroids are used to control other pests.

R.T. Roush & F.W. Plapp, Jr (1982). Biochemical genetics of resistance to aryl carbamate insecticides in the predaceous mite, Metaseiulus occidentalis. J. econ. Ent. 75 (2) : 304-307

The mechanism of insecticide resistance, the inheritance of resistance, and cross-resistance to different insecticides were investigated in a carbaryl-resistant strain of the predaceous mite, *Metaseiulus occidentalis*. Resistance extends to the aryl carbamate insecticide propoxur and the benzimidazolecarbamate fungicide benomyl, but not to the oxime carbamate insecticide methomyl or to noncarbamate insecticides. Resistance appears to be related to high levels of oxidative detoxification, which seems to be present even in the egg stage. Genetic analyses showed that the resistance is primarily due to a single, incompletely dominant gene. Carbamate resistance in *M. occidentalis* seems very similar to that observed previously in insects.

M.E. Whalon & E.A. Elsner (1982). Impact of insecticides on Illinoia pepperi and its predators. J. econ. Ent. 75 (2) : 356-358

Impact of five insecticides against *Illinoia pepperi*, the aphid vector of blueberry shoestring virus, and its predators from ground and air applications are reported. Pirimicarb and acephate demonstrated the greatest reduction in aphid numbers yet had the least impact on predators. No predators were found in the plots receiving other treatments 7 days post-application. Malathion and methomyl offered intermediate control from the ground but were not as effective in air application plots. Diazinon was the least effective insecticide tested. Blueberry aphid predators included *Orius* sp., *Aphidoletes aphidimyza*, *Chrysopa carnea*, *Coleomegilla maculata lengi*, *Hippodamia convergens*, and *Syrphus* sp.

D.E. Meyerdirk et al. (1982). Effect of pesticide residues on the natural enemies of citrus mealybug. Environ. Ent. 11 (1) : 134-136

The toxic residual activities of four pesticides, phosmet, carbaryl, diazinon and dimethoate, were tested against natural enemies of the citrus mealybug, *Planococcus citri*. Species tested included four parasites, *Pauridia peregrina*, *Leptomastidea abnormis*, *Leptomastix dactylopii* and *Anagyrus pseudococci* and two predators, *Cryptolaemus montrouzieri* and *Sympherobius barberi*. These natural enemies were exposed 24 h to pesticide residues on leaves of commercially treated citrus at intervals of 1, 9, 16, 23, and 30 days posttreatment to determine their susceptibility to and the persistence of toxic residues. Phosmet and carbaryl had significantly high toxic residual activity up to 30 days posttreatment against the majority of natural enemies tested. Diazinon and dimethoate toxic residue activity decreased significantly in 9 days against the majority of species tested.

B.A. Croft et al. (1982). Multiple- and cross-resistance to insecticides in pyrethroid-resistant strains of the predatory mite, Amblyseius fallacis. Environ. Ent. 11 (1) : 161-164

Strains of the predatory mite, *Amblyseius fallacis*, which were variably resistant to a synthetic pyrethroid permethrin, showed multiple-resistances to DDT and to azinphosmethyl. In a resistant strain selected with permethrin, cross-resistances to a variety of pyrethroid types, including natural crude pyrethrins and several synthetic pyrethroid compounds, were demonstrated. Mechanisms of resistance relative to field insecticide use patterns and possible uses of these mites in future integrated pest management programs are discussed.

W.H. Reissig et al. (1982). Effects of insecticides on Nilaparvata lugens and its predators : spiders, Microvelia atrolineata and Cyrtorhinus lividipennis. Environ. Ent. 11 (1) : 193-199

Thirty-five insecticides used on rice in Asia were tested in the field against *Nilaparvata lugens*. The most important predators of the pest, *Cyrtorhinus lividipennis*, *Microvelia atrolineata*, and predacious spiders, *Lycosa pseudoannulata*, *Tetragnatha* and *Araneus* species, were also monitored in the test plots. Ten insecticides significantly reduced numbers of *N. lugens*, but propoxur and ethylan gave the most consistent and effective control. Most insecticides did not significantly reduce populations of spiders and *M. atrolineata* compared with untreated checks, but they did reduce numbers of *C. lividipennis*. Fifteen treatments caused resurgence of *N. lugens*, resulting in significantly higher numbers in the treated plots than in untreated checks. Resurgence was apparently not caused by the toxicity of the materials against predators. Eleven of the insecticides had no effect on *N. lugens*.

P.W. Schaeffer & K. Ikebe (1982). Recovery of Hexamermis sp. (Nematoda : Mermithidae), parasitising gypsy moth, Lymantria dispar, in Hokkaido, Japan. Environ. Ent. 11 (3) : 675-680

Hexamermis sp. were recovered from natural populations of gypsy moth, *Lymantria dispar* in Hokkaido, Japan. This parasite has spotty distribution, and it appears to favor moist, deciduous forest areas and not *Larix leptolepis* plantations where gypsy moth outbreaks usually occur. *Hexamermis* sp. emerged from host larvae but not pupae, and superparasitism occurred frequently. In 1979, experimental field exposure of laboratory-reared gypsy moth larvae confirmed an extended period of parasite attack

(26 May to 19 July), during which a maximum of ca. 84 % parasitism occurred at a maximum rate of 683 mermithids produced per 100 recaptured hosts. Infection was highest during periods of rainfall. Under natural conditions, maxima of 61, 77, and 86 per 100 hosts were recorded. Other Lepidoptera attacked include *Lymantria mathura aurora*, *Rhagastis mongoliana*, and an unidentified arctiid species.

C.M. MacVean et al. (1982). Field tests of antidesiccants to extend the infection period of an entomogenous nematode, Neoaplectana carpocapsae, against the Colorado potato beetle. J. econ. Ent. 75 (1) : 97-101

Field tests were conducted in Fort Collins, Colo., to determine the value of various commercially available antidesiccants for protection of infectious dauerlarvae of an entomogenous nematode, *Neoaplectana carpocapsae*, after application. The aqueous formulations containing inert thickeners and surfactants were sprayed on potato foliage infested with larvae of *Leptinotarsa decemlineata*. The formulations tested included various concentrations and mixtures of Methocel(TM), Folicote(TM), Norbak(TM), and Nalcotrol(TM). All formulations tested retarded desiccation and increased retention of nematodes on leaf surfaces, yielding infection rates of 30 to 60 %. Nematodes sprayed in water suspensions under similar conditions produced infection rates of 10 %. Also, comparison of morning and evening nematode applications demonstrated that applications made during the evening hours produce higher infection levels than those made during the morning.

H.K. Kaya & B.J. Grieve (1982). The nematode Neoaplectana carpocapsae and the beet armyworm, Spodoptera exigua : infectivity of prepupae and pupae in soil and of adults during emergence from soil. J. Invert. Path. 39 (2) : 192-197

The nematode, *Neoaplectana carpocapsae*, infected >90 % of the prepupae of *Spodoptera exigua* in soil even at concentrations as low as five nematodes/cm² of soil surface. Pupae were less susceptible to nematode infection in soil than prepupae, with mortality ranging from 10 to 24 % and 10 to 83 % for pupae exposed 3-5 days and 6-8 days to the nematode, respectively. Longer exposure (6-8 days) of the pupae to the nematode resulted in higher mortality with a positive relationship with increasing concentrations. Adults of *S. exigua* were susceptible to nematode infections as they emerged from the soil. The higher nematode concentrations (25 and 50 nematodes/cm²) resulted in higher adult mortality. The majority of nematode-induced mortality occurred within 24 hr after emergence. The susceptibility of emerging *S. exigua* adults to *N. carpocapsae* offers a new dimension for insect control.

R.A. Bedding & L.A. Miller (1981). Use of a nematode, Heterorhabditis heliothidis, to control black vine weevil, Otiorhynchus sulcatus, in potted plants. Ann. appl. Biol. 99 : 211-216

Application of aqueous suspensions of infective juvenile *Heterorhabditis heliothidis*, isolate T327, to the soil resulted in up to 100 % parasitisation of larvae of the black vine weevil, *Otiorhynchus sulcatus*, in potted yew, raspberries and grapes in nurseries, and over 87 % parasitisation on potted cyclamens and strawberries. Pupae and newly emerged adults on grapevines were also parasitised. Another isolate, T310, produced 92.5 to 98.5 % parasitism of *O. sulcatus* larvae on potted cyclamens in glasshouse, but was less effective on strawberries. *Neoaplectana bibionis* was found to be less effective than *H. heliothidis* T327 strain. The use of these nematodes provides an economical and effective method for controlling *O. sulcatus* on potted plants in glasshouses and nurseries.

W.R. Simons (1981). Biological control of Otiorhynchus sulcatus with heterorhabditid nematodes in the glasshouse. Neth. J. Pl. Path. 87 : 149-158

A *Heterohabditis* species, found in dead larvae of *Otiorhynchus sulcatus*, was tested for its efficacy as a biological control agent of this insect in glasshouse experiments. In a preliminary test, all weevil larvae were killed in pots with primula, 88 % in strawberry and 50 % in cyclamen. In a second test with strawberry plants, good results were obtained when the nematodes were applied about the hatching time of the weevil eggs. At a dosage of 100 nematodes per cm² of soil area, 90-97 % of the larvae were killed and 90 % of the plants remained undamaged. A dosage of 50 nematodes per cm² produced roughly the same level of larval mortality, but left 30 % of the plants damaged. Both early and late application of nematodes protected the plants insufficiently, because too many larvae survived. In a third test with strawberry, cyclamen and primula, soil treatment with 50 and 100 nematodes per cm² gave comparable results at both application times, i.e. one and three weeks after hatching of the weevil eggs. In strawberry 100 % of the larvae were killed and all plants remained in good condition. Also in cyclamen, nearly all larvae were killed and all plants remained in good condition, although the root systems had less fine roots in comparison with control plants without insects. In primula, 4-12 % of the weevil larvae survived, whereas up to 20 % of the plants died, indicating that soil structure, soil moisture and condition of the plants have an important impact on the control results. A dosage of 25 nematodes per cm² appeared to be too low in all cases. The results of these experiments open new perspectives for control of the black vine weevil in glasshouses.

H.K. Kaya et al. (1981). Laboratory and field evaluation in Neoaplectana carpocapsae against the elm leaf beetle and the western spruce budworm. Can. Ent. 113 (9) : 787-793

Laboratory studies showed that elm leaf beetle, *Pyrrhalta luteola*, larvae and pupae were susceptible to the nematode *Neoaplectana carpocapsae* ; adults were less likely to be infected because of their dispersal ability. Spruce budworm, *Choristoneura occidentalis*, larvae were susceptible to the nematode in the laboratory. Field application of the nematode in 2 % aqueous Volck oil suspension against elm leaf beetle or spruce budworm larvae did not significantly reduce the populations when compared with controls. Desiccation of the infective nematodes may be a factor in the variable results for elm leaf beetle, and cool temperatures and rain may have been factors in the poor results for spruce budworm. However, significant population reduction occurred in nematode treatments against elm leaf beetle pupae in litter. This nematode may be used against beetle pupae in conjunction with other control tactics.

iii) Behavioural Means

G.E. Haniotakis (1981). Field evaluation of the natural female pheromone of Dacus oleae. Environ. Ent. 10 (6) : 832-834

Traps baited with 30-50 female equivalents of natural female pheromones were tested for efficiency in capturing lab-cultured male olive fruit flies during the 1979 olive

growing season. Densities of 2, 1, 0.5 and 0.266 traps/tree were tested ; the average percent of fly recovery was 57.2, 40.1, 36.7 and 20.7, respectively. A single trap in an olive tree attracts males of that tree and neighboring trees, provided that no other pheromone traps are present. Flies of a tree with a trap do not respond to traps of neighboring trees. Male response to pheromone traps decreases with increasing distance. A trap density of 0.5 trap/tree throughout the experimental field and one trap/tree in the periphery is proposed for mass-trapping tests with this pest.

M. Kehat et al. (1982). Sex pheromone traps as a means of improving control programs for the cotton bollworm, Heliothis armigera. Environ. Ent. 11 (3) : 727-729

Pheromone traps were reliable for detection and estimation of *Heliothis armigera* adult populations in cotton fields. An increase in male catches in traps was usually followed by an increase in larval density, but no correlation was found between the two. Pheromone traps may therefore serve as a warning device indicating potential attack, but larval counts are required before deciding on control procedures.

F.C. Tingle & E.R. Mitchell (1982). Disruption of pheromone communication of the tobacco budworm in tobacco fields treated with pheromone components. J. econ. Ent. 75 (1) : 50-56

Two tobacco fields were treated throughout the growing season with a blend of three aldehydes and one alcohol components of the sex pheromone of the tobacco budworm, *Heliothis virescens*. Captures of tobacco budworm males in pheromone-baited cone traps were greatly reduced in the pheromone-treated fields compared with the control field under conventional insecticide treatment. Moreover, mating of laboratory-reared females confined on mating tables in the pheromone-treated fields was reduced from 88 to 98 %. However, it was necessary to spray the pheromone-treated fields to control the tobacco hornworm, *Manduca sexta*, and green stink bug, *Acrosternum hilare*. Because these insecticide treatments also killed tobacco budworm larvae, it was impossible to assess the full impact of the pheromone treatment on control of this species. Nevertheless, these results indicate that the air permeation technique will not be adaptable for control of the tobacco budworm in tobacco until similar remedies are available for control of the tobacco hornworm and possibly other pest species.

M.R. Strand & S. Bradleigh Vinson (1982). Behavioural response of the parasitoid Cardiochiles nigriceps to a kairomone. Ent. exp. appl. 31 : 308-315

The parasitoid *Cardiochiles nigriceps* responds to a kairomone from its host *Heliothis virescens* by exhibiting an increase in speed and turning over unit time. The parasitoid turns back toward the interior of the « patch » when the patch edge is encountered. Experienced *C. nigriceps* females are more responsive to the kairomone of *H. virescens* than inexperienced females. Oviposition results in the immediate departure of *C. nigriceps* from a kairomone patch.

K.V. Raman (1982). Field trials with the sex pheromone of the potato tuberworm. Environ. Ent. 11 (2) : 367-370

Two formulations of potato tuberworm, *Phthorimaea operculella*, sex pheromone, *trans*-4, *cis*-7-tridecadien-1-ol-acetate (PTM 1) and PTM 1 + *trans*-4, *cis*-7, *cis*-10, tridecatrien-1-ol acetate (PTM 2) were tested in the field during 1980 and 1981 in Lima, Peru. Mixtures of PTM 1 + PTM 2 were more attractive than PTM 1 alone. Tuber damage of potato clone DTO 33 was related to trap catches. Fields with low moth populations during winter plantings of 1980 did not sustain economic damage. When moth populations were high during summer plantings of 1980, potato clone DTO 33 sustained 42 % tuber damage.

P.J. Landolt et al. (1982). Field trials of potential navel orangeworm mating disruptants. J. econ. Ent. 75 (3) : 547-550

Several compounds were tested for disruption of sex pheromone communications in *Amyelois transitella*. Catches of males in female-baited traps were significantly reduced by in-trap treatments with (*Z*)9- and (*Z*)11-tetradecen-1-ol formate and isomers of 9, 11-tetradecadien-1-ol formate. Disruption by air permeation with (*Z,Z*)9, 11, tetradecadien-1-ol formate was better with a plastic laminate formulation than hollow fibers or polyvinyl-chloride rods but was still inferior to treatments with the navel orangeworm pheromone (*Z,Z*)11, 13-hexadecadienal

J.L. Robertson & R.A. Kimball (1981). Variables affecting the practical use of juvenile hormone for control of the western spruce budworm (Choristoneura occidentalis). Can. Ent. 113 (9) : 827-844

Variables affecting the efficacy of seven juvenile hormone analogues on western spruce budworm, *Choristoneura occidentalis*, were examined in laboratory bioassays. Those tested were epofenonane, hydroprene, kinoprene, methoprene, triprene, ZR-587, and ZR-1662. Selected intrinsic variables – stage of development, sex, and extent of direct contact with sprays – were examined in bioassays involving direct exposure of third instars, direct applications to three pupal age classes, and indirect applications to sixth instars. An extrinsic variable, persistence in the environment, was assessed by determining the residual effectiveness of each juvenile hormone analogue to sixth instars. Sixth instars, rather than third instars, appeared to be the target of choice for two reasons. First, less active ingredient would be required for equivalent mortality by the time of adult eclosion. Second, greater, more consistent, deleterious reproductive effects coupled with a lower incidence of sexual variation in lethal effectiveness, would occur. Pharate pupae and untanned pupae were very susceptible to most of the chemicals and may provide a secondary target for the primary target, sixth instars. The importance of direct chemical-insect contact in achieving maximum reproductive inhibition suggests that these chemicals might be used most effectively in ways such that contact can be maximized, as in ground applications. Finally, some juvenile hormone analogues such as epofenonane and ZR-1662 appeared to persist long enough to permit flexibility with respect to instar distribution in a population.

L.L. Sower et al. (1982). Control of Eucosma sonomana by mating disruption with synthetic sex attractant. J. econ. Ent. 75 (2) : 315-318

Synthetic pheromone, when applied by air in ConRel ® fibers or Hercon ® flakes at 10 to 20 g of a.i./ha, reduced damage to pines caused by larvae of a pine shoot borer, *Eucosma sonomana*, by 76 to 88 %. Lesser dosages of 0.2 to 2 g/ha were less effective.

L.M. McDonough et al. (1982). Sex attractant for the western lawn moth, Tehama bonifatella. Environ. Ent. 11 (3) : 711-714

A combination of (*Z*)11-hexadecenal and (*Z*)13-octadecenal is a sex attractant for male *Tehama bonifatella*. Neither

compound alone produced trap catch. Optimum ratios were from 1:1 to 7:3 (hexadecenal to octadecenal) in natural rubber septa, and optimum dosage was 0.45:0.30 to 4.5:3.0 mg of (Z)-11-hexadecenal:(Z)-13-octadecenal. The strongest electroantennogram (EAG) response was evoked by (Z)-9-tetradecenal followed by (Z)-11-hexadecenal. Addition of (Z)-9-tetradecenal or (Z)-11-hexadecen-1-ol acetate to the two component lure greatly decreased trap catch. Addition of other EAG active compounds to the two-component lure failed to increase trap catch. Traps baited with the two-component lure caught more males than traps baited with females.

J.A. Kamm et al. (1982). Sex attractant for Protagrotis obscura, a pest of grass grown for seed. Environ. Ent. 11 (1) : 118-120

Screening trials were conducted in commercial fields of bluegrass grown for seed to identify a sex attractant for the cutworm pest, *Protagrotis obscura*. Only Z11-16:A1 produced significant trap captures. Attemps to increase trap captures by addition of electroantennogram-active compounds were unsuccessful. When the dosage of Z11-16:A1 was raised from 0.01 to 3.0 mg per trap, the 1-mg bait produced the highest catches.

L.S. Mian & M.S. Mulla (1982). Biological activity of IGRs against four stored-product coleopterans. J. econ. Ent. 75 (1) : 80-85

Four insect growth regulators (IGRs), BAY SIR 8514 [1-4-trifluoromethoxyphenyl)-3-(2-chlorobenzoyl) urea], diflubenzuron, methoprene, and MV-678 [2-methoxy 9-(*p*-isopropylphenyl)-2,6-dimethylnonane], applied at 5 ppm to wheat flour or grain, were evaluated against *Oryzaephilus surinamensis, Tribolium castaneum, Rhyzopertha dominica*, and *Sitophilus oryzae*. BAY SIR 8514 and diflubenzuron were highly active against the eggs and younger larvae of *O. surinamensis, T. castaneum*, and *R. dominica*. Methoprene, besides its ovicidal action against *O. surinamensis* and *R. dominica*, caused substantial mortality in the full-grown larvae of the three species. BAY SIR 8514 and methoprene also affected the subsequent progeny production of parent adults preexposed to IGR-treated food for 2 weeks. MV-678 appeared to be the least active compound tested. Diflubenzuron and methoprene had no adverse effects on the development of *S. oryzae* inside grain kernels infested with parent adults 1 day after grain was treated. However, in grain treated with BAY SIR 8514, diflubenzuron, and methoprene and infested with this insect after 12 months of posttreatment storage, the development of this species was arrested significantly. BAY SIR 8514 and diflubenzuron were more active against the eggs and younger larvae, with methoprene showing activity against all stages from egg to preemergence adults of this species. In testing IGRs against internal feeders, it is important to allow for penetration of the active ingredients into the inner portions of grain kernels before assessing effects.

A. Szentesi (1981). Antifeedant-treated potato plants as egg-laying traps for the Colorado beetle (Leptinotarsa decemlineata). Acta Phytopath. Acad. Sci. Hung. 16 (1-2) : 203-209

Following an antifeedant (2 % Bordeaux mixture) treatment of a field plot, during two consecutive weeks, the number of eggs laid by Colorado beetle females on treated potato plants was significantly higher (P = 1 %) compared with that on the untreated control ones. Laboratory choice and no-choice experiments have also strengthened the above. Substance(s) of insect-origin have induced a similar distribution of eggs in choice tests. It is thought that the phenomenon is primarily caused by the differential decrease in the surfaces of the two kinds of foliage and to a lesser extent, by substance(s) accumulated on untreated plants, because of the presence of various developmental stages. The unequal distribution of eggs might bear some effect on the decrease of a local Colorado potato beetle population.

M.D. Proverbs et al. (1982). Codling moth : a pilot program of control by sterile insect release in British Columbia. Can. Ent. 114 (4) : 363-376

Codling moth, *Cydia pomonella*, control by sterile insect release (SIR) was assessed in 320-526 ha of apples and pears in the Similkameen Valley, BC, from 1976 to 1978. In preparation for SIR, the moth population was first reduced to low numbers by removal of neglected trees in 1972 and by chemical sprays in 1975. Sterile (35 krad) male and female moths were released in each orchard 2 or 3 times weekly from 1 May until early September. A total of 23,600 sterile moths/ha was released in 1976, 36,500 in 1977, and 31,800 in 1978. Populations of sterile (marked) and wild moths were monitored by sex pheromone traps, and damage was assessed by fruit examination at harvest. Control was very good except for a few orchards in which overwintering populations were to high to achieve adequate overflooding with sterile moths. Damage exceeded the economic threshold (0.5 %) in only 1 of 86 treated orchards in 1976, in 6 of 193 orchards in 1977, and in 0 of 157 orchards in 1978. Results in 32 orchards showed that when wild populations are brought close to extinction all codling moth control measures can be omitted for 2 or more years depending on degree of orchard isolation. Omission of codling moth sprays from 1976 to 1978 did not result in any important change in population levels of other apple pests. Cost of control by SIR was ca. $ 225/ha per year vs. ca. $ 95 for chemical control.

M.G. Waldvogel et al. (1982). Evaluation of pheromone-mediated responsiveness of laboratory-reared irradiated, laboratory-reared nonirradiated and feral male gypsy moths. Environ. Ent. 11 (2) : 351-354

Laboratory-reared irradiated, laboratory-reared nonirradiated, and feral male gypsy moths, *Lymantria dispar*, were compared for their responses to various doses of the synthetic pheromone (+)-disparlure, and for the periodicity of this response, in a sustained-flight tunnel. The proportions of males responding from each group were not significantly different ($P = 0.56$). Time of day and pheromone dose were significant in affecting percent male response ; male response was greatest during the afternoon at 13.00 and 15.00 h EST, and at doses of 25 and 50 ng (range 0.01 to 50 ng tested). Response latency periods for males exposed to various doses of (+)-disparlure were not significantly affected by time of day, but were related inversely to pheromone dose. These results support previous field studies which have shown that laboratory-reared irradiated and nonirradiated males were competitive with feral males.

J.H. Brower (1982). Mating competitiveness of irradiation-substerilised males of the tobacco moth. J. econ. Ent. 75 (3) : 454-457

Males of *Ephestia elutella*, substerilized with 15 krad of gamma irradiation, were released at ratios of 4:1 and 9:1 to untreated males into a simulated empty warehouse. The

mating competitiveness of irradiated males was 91 to 93 % as good as that of the untreated males, and the percentage of hatched eggs was reduced accordingly. In trials where irradiated males and untreated males were released, the majority (55.8 to 73.5 %) of the F_1 progeny was offspring of the irradiated males and inherited sufficient genetic damage to be sterile when intermated. These results suggest that populations of the tobacco moth within tobacco storages might be greatly reduced or eliminated by the release of a high ratio of substerilized males.

J.H. Werren et al. (1981). Paternal inheritance of a daughterless sex ratio factor. Nature 293 (5832) : 467-468

The authors report an unusual case of extrachromosomal inheritance in the parasitic wasp *Nasonia vitripennis*. The trait, termed « daughterless » (D1), is transferred paternally and causes the mates of carrier males to produce only sons. After introduction at low frequency, the trait increases to predominance in an experimental population within a few generations. The D1 trait is of theoretical interest because of its paternal inheritance, and may have practical applications as a biological control agent in pest organisms with haplodiploid sex determination.

iv) Techniques

F.M. Davis (1982). Southwestern corn borer : oviposition cage for mass production. J. econ. Ent. 75 (1) : 61-63

A new system was developed for mass production of eggs of *Diatraea grandiosella* for use in plant resistance studies. The system utilizes large screen cages to which pupae are added weekly. This provides a continuous source of adults for oviposition. The moths oviposit on both sides of vertical wax paper sheets that are easily removed from the cages. A detailed account is given of the materials, construction and daily operation of the cages. Also, the increased efficiency of the new system over the previous cage system is discussed.

G.G. Hartley et al. (1982). Rearing of Heliothis sterile hybrid with a multicellular larval rearing container and pupal harvesting. J. econ. Ent. 75 (1) : 7-10

Modification of methods and of a multicellular larval rearing unit for production of *Heliothis* spp. pupae, particularly the backcross (BC) [BCn female × *H. virescens* male] from the intercross [*H. virescens* male × *H. subflexa* female], are described. Essential components of the unit are a fiber glass tray, a polystyrene insert with 903 cells, and a polypropylene cover with 125-µm openings. More than 10 million BC pupae have been produced during the last 4 years in Stoneville with this unit. Optimum egg density was determined to be two to four eggs per cell. Neither benomyl nor folpet affected growth or development of BC larvae when incorporated into the larval diet at rates from 0.25 to 2.0 g/3.8 liter to control contaminants such as the mold *Aspergillus niger*. The pupal harvesting method collects pupae in a cushioned tray, separates pupae from large particles with a grating, and removes smaller, lighter particles with a high-volume blower.

N. Tanaka et al. (1982). Automated larval rearing system for tephritids. J. econ. Ent. 75 (3) : 517-519

A prototype unit of an automated conveyor belt larval rearing system performed equally with the standard tray method in rearing larvae of the melon fly, *Dacus cucurbitae*, the oriental fruit fly, *D. dorsalis*, and the Mediterranean fruit fly, *Ceratitis capitata*. All phases of larval culturing are facilitated by the belt rearing system ; moreover, rearing can be done at a constant temperature of 27°C, unlike the tray system, which requires cooling of the culture to prevent larval losses due to overheating. Overall labour costs can be reduced by 80 %.

A. Samsinakova et al. (1981). Mass production of Beauveria bassiana for regulation of Leptinotarsa decemlineata populations. J. Invert. Path. 38 : 169-174

A simple liquid medium which enhanced the production of conidiospores by an isolate of the entomophagous fungus *Beauveria bassiana* is described. Spore production was attained using cultures floating in inflated sections of plastic tubing (« polyethylene cushions ») and glass bottles. A method is described for determining lethal doses and lethal times for second- and third-instar *Leptinotarsa decemlineata* larvae.

M. Shapiro et al. (1982). Potential use of the saltmarsh caterpillar as a production host for nucleopolyhedrosis viruses. J. econ. Ent. 75 (1) : 69-71

The virulence of the NPVs of Douglas fir tussock moth, *Orgyia pseudotsugata*, spruce budworm, *Choristoneura fumiferana*, and gypsy moth, *Lymantria dispar*, for larvae of the saltmarsh caterpillar, *Estigmene acrea*, was enhanced after successive passage in the alternate host. In all cases, yields of 2×10^9 polyhedral inclusion bodies were obtained per *E. acrea* larva, which represented at least a fourfold increase in *O. pseudotsugata* and *C. fumiferana* NPVs obtained from the respective natural hosts. The *O. pseudotsugata*-NPV-E. *acrea* system appears to be an excellent system for production of Douglas fir tussock moth NPV on the basis of both virus yield and activity. The *C. fumiferana* NPV-E. *acrea* and *L. dispar* NPV-E. *acrea* systems appear less promising on the basis of virus activity.

W.M. Wouts (1981). Mass production of the entomogenous nematode Heterorhabditis heliothidis on artificial media. J. Nematol. 13 (4) : 467-471

Heterorhabditis heliothidis is reared monoxenically on an artificial medium consisting of commercially available nutrient broth, yeast extract, and vegetable oil. These components are cooked with flour and coated onto polyether polyurethane sponge, autoclaved, inoculated with a suspension of the bacterial symbiont (*Xenorhabdus luminescens*) of the nematode, and incubated at 25°C for 3 d. The bacterial garden on sponge provides an excellent rearing medium. Up to 10 million infective juveniles are produced per 250 ml rearing flask in one month.

R.S. Ochieng et al. (1981). Studies on the legume pod-borer, Maruca testulalis. II. Mass-rearing on natural food. Insect Sci. Applic. 1 (3) : 269-272

A procedure has been developed which allows production of 75,000 eggs per month of the legume pod-borer, *Maruca testulalis*. More than 170 eggs per moth were obtained. The optimal number of moths placed in the mass oviposition cage having potted cowpea plants was 30. The average life-span of the moths was 7.7 and 9.5 days for females and males, respectively. The optimal number of larvae in the rearing box was 50 ; larval survival declined sharply above a density of 50 per box.

K.P. Jayanth & S. Nagarkatti (1981). An artificial diet for rearing Crocidolomia binotalis and Hellula undalis, two major pests of cole crops in India. Entomon 6 (2) : 95-97

An artificial diet is described for laboratory rearing of *Crocidolomia binotalis* and *Hellula undalis*, two major pyralid pests of cole crops in India. Larvae fed on the diet produced healthy moths with normal fertility and fecundity.

E.F. Boller et al. (1981). Measuring, monitoring and improving the quality of mass-reared Mediterranean fruit flies, Ceratitis capitata. I. The RAPID quality control system for early warning. Z. ang. Ent. 92 (1) : 67-83

A standardized program for the establishment of quantitative quality profiles in mass-reared *Ceratitis capitata* is described. It consists of a package of 5 laboratory tests that measure besides pupal size aspects of motility (flight ability and startle activity) and sexual activity (response to pheromone and mating propensity). The relevance of RAPID data, their graphical display in Shewhart control charts as well as the application of RAPID for monitoring, problem analysis, and strain improvement is discussed.

E.J. Bechinski & L.P. Pedigo (1982). Evaluation of methods for sampling predatory arthropods in soybeans. Environ. Ent. 11 (3) : 756-761

Sweep-net, plant shake and vacuum net procedures were evaluated for sampling *Orius insidiosus*, *Nabis* spp., adult *Chrysopa* spp., adult Coccinellidae and adult *Anthicus cervinus* in Iowa soybeans. Absolute-density estimates, taken by whole-plant removal procedures, provided standards for comparison. Plant shaking generally produced the most precise and cost-efficient estimates and is recommended for sampling the majority of predators. Sweep-net sampling was superior in terms of cost and in variability analyses for adult *Nabis* spp., *Chrysopa* spp. and Coccinellidae. The vacuum net was least satisfactory and is not recommended. Correlation of relative estimates with absolute population trends varied between years and seemed to be influenced by soybean plant growth factors.

H.G. Wylie (1981). Effects of collection method on estimates of parasitism and sex ratio of flea beetles that infest rape crops in Manitoba. Can. Ent. 113 (8) : 665-671

Similar percentages of parasitized adults and of females of *Phyllotreta cruciferae* were collected in traps baited with allyl isothiocyanate and in a D-Vac vacuum insect net early in spring and in August-September, when non-reproducing adults predominated. In contrast, a lower percentage of parasitized adults and a higher percentage of females were collected in the traps than in the D-Vac during the beetles' reproductive period, May-July. A similar difference between the traps and D-Vac was recorded for *Phyllotreta striolata* during April-May, when this species begins to reproduce. Therefore, the results indicate that traps used in this study are unsuitable for measuring parasitism and sex ratio of reproducing *P. cruciferae* and *P. striolata*.

M.W. Brown et al. (1981). Development and evaluation of a sampling method for the gypsy moth egg parasitoid Ooencyrtus kuvanae. Can. Ent. 113 (8) : 575-584

Four sampling methods for *Ooencyrtus kuvanae* populations were compared for efficiency using coefficients of variation. On this basis, none of the sampling methods was uniformly superior to any other, but a cluster of 0.01 ha subplots was chosen as the best method because of the aggregation of both gypsy moth egg masses and parasitoids. From the estimated population variance per egg mass, it was calculated that 150 egg masses should be sampled per plot to provide an error bound of 0.2 parasitoid per egg mass ($\alpha = 0.1$). An analysis of variance indicated that variation among study areas was the largest source of variant, and that among day, within day, and plot configuration variations were significant. Estimates of parasitoid activity are most reliable during the period between 1300 and 1600 h EST. Activity of parasitoids was reduced on overcast days. In August, the distribution of *O. kuvanae* approximates that of the negative binomial but with too many individuals in the high frequency classes. In a compromise between cost and accuracy, the sampling scheme selected consists of thirty 0.01 ha subplots per plot sampled between 13.00 and 16.00 h EST on sunny days. This sampling scheme was found satisfactory using field evaluation.

A.T. Drooz (1981). Subfreezing eggs of Lambdina pellucidaria alters status as factitious host for Ooencyrtus ennomophagus. Can. Ent. 113 (8) : 775-776

The egg parasite *O. ennomophagus* is a good candidate for the biological control of certain defoliators. In this note, the author reports the development of *O. ennomophagus* in eggs kept at $-10°C$ but not in fresh egg of the pine looper, *L. pellucidaria*. The results indicate a potential for rearing parasites on treated eggs of non-host insects.

M.A. Hoy & N.F. Knop (1981). Selection for and genetic analysis of permethrin resistance in Metaseiulus occidentalis : genetic improvement of a biological control agent. Ent. exp. appl. 30 : 10-18

A strain of *Metaseiulus* (= *Typhlodromus*) *occidentalis* was treated with increasing dosages of the pyrethroid insecticide permethrin, starting with 1 g a.i./100 l. Initially, survival on dipped leaf discs was 21 % at this dose. After 18 selections, the strain had developed moderate resistance (ca. 10 ×) with survival averaging 23 % at 8 g a.i./100 l. Dose mortality lines were established using sprayed leaf discs for the selected strain, the base strain from which it was derived, their reciprocal F_1 hybrids, F_2 progeny and backcross (to the base strain males) progeny. The respective LC_{50} values (in g a.i./100 l) using this method are : 3.81, 0.39, 0.88, 0.75 and 0.30. Permethrin resistance in this strain probably is determined quantitatively. Field releases into orchards or vineyards of this genetically improved strain therefore should be done after a permethrin spray has been applied to facilitate replacement of native *M. occidentalis* populations. Unidirectional genetic incompatibility was observed in crosses between the base strain males and selected strain females. The cause of this incompatibility is unknown, but could influence release strategies or field success. The base colony is resistant to azinphosmethyl and the selected strain retained its azinphosmethyl resistance, indicating there was no negatively correlated cross resistance. There was cross resistance to other pyrethroids (fenvalerate, Shell 57706).

L.J. Goldberg & J. Ford (1982). A study of the entomotoxic activity of selected commercial formulations of B. thuringiensis var. israelensis utilising a novel titration method with an aquatic microbial flora. Mosquito News 42 (1) : 19-27

A test challenge procedure has been outlined, using 3rd instar *Culex pipiens* larvae held in a defined aquatic

microbial test flora AS 2(7), which provides for a standardized bioassay of the entomotoxic activity per cell of *Bacillus thuringiensis* var. *israelensis (Bti)*. AS 2(7), a selected soil microbial isolate, following inoculation and incubation with a sterilized Tetramin® suspension in dilute alfalfa infusion, provides an excellent mosquito larval nutritional food source as evidenced by an 89 % adult emergence rate. Since the rate of mosquito larval filter feeding is nominally 10 ml/hr, a larval test challenge using 2 larvae held in 4 ml of fluid results in near complete larval filter feeding of a test challenge within less than one hour. As a consequence, a larval test challenge can be directly expressed in terms of ingested dose. Using the outlined standardized larval test challenge procedure, a comparative evaluation of several commercial formulations of *Bti*, both liquids and wettable powders, has been reported.

H. Hänel (1981). A bioassay for measuring the virulence of the insect pathogenic fungus Metarhizium anisopliae against the termite Nasutitermes exitiosus. Z. ang. Ent. 92 (1) : 9-18

A bioassay method is described, in which termite workers from one colony of *Nasutitermes exitiosus* were used to test the virulence of one strain of *Metarhizium anisopliae* originally isolated from *Aneolamia* sp. The termites were sprayed with suspensions of conidia and kept for 11 days at 25 ± 1°C and approximately 100 % relative humidity. Data on mortality after 8 and 11 d were probit analysed, to give LC_{50}, 95 % and 99 % fiducial limits, slopes and G for the bioassays. The mean LC_{50} value was $5.16 \pm 0.67 \times 10^5$ conidia/ml after 8 d, and $3.56 \pm 0.040 \times 10^4$ conidia/ml after 11 d. The weighted mean slope was 0.789 ± 0.025 after 8 days and 0.916 ± 0.027 after 11 d. This study shows that *M. anisopliae* is a promising candidate for biological control of *N. exitiosus*.

W.A. Gardner et al. (1981). Precipitin test for examining predator-prey interactions in soybean fields. Can. Ent. 113 : 365-369

Precipitin test techniques were utilized for the identification of predators on three lepidopteran pests – *Anticarsia gemmatalis, Heliothis zea*, and *Pseudoplusia includens*. The test was sensitive enough to detect these prey in a whole-body extract of one small predator or from a midgut extract of larger predators. Some cross-reactivity among the prey antigens was found which limited somewhat the applicability of the test. However, test results from field-collected predators indicated the precipitin test is a simple and rapid technique which can be used to evaluate the number of encounters between predators and prey in soybean fields.

v) Integrated Pest Management, General Papers

A.B. Hearn et al. (1981). Computer-based cotton pest management in Australia. Field Crops Res. 4 : 321-332

A prototype pest management system for cotton incorporating data handling and decision making by computer was progressively modified during 1978 and 1979 to increase its efficacy and practical feasibility. A more realistic assessment of crop status was developed. Threshold population densities of pests were revised. Labour requirements were reduced by sequentially sampling insects on terminals three times a week and by simulation of fruit development during week-long intervals between plant sampling. Decision making was refined using recent experience. The developing system, tested in 1978-79 on a 14 ha field and in 1979-80 on 360 ha of cotton grown on four farms, maintained yields at commercial levels although insecticide usage was decreased by 40 %.

P.L. Adkisson et al. (1981). Organisation and implementation of an integrated pest management system. Southwestern Ent. 6 (4) : 279-287

During the 1970s, an integrated insect control programme in cotton was developed. The Texas Agricultural Extension Service, in cooperation with the Texas Pest Management Association (TPMA), has been successful in implementing the programme on a wide scale. The steps from research to transfer of the new technology package to farmers are described, together with the basic elements required, and problems associated with statewide implementation of IPM. By 1980, more than 562,00 acres and 750 farmers were in various units administered by TPMA.

P.L. Lorio, Jr et al. (1982). Stand risk rating for the southern pine beetle : integrating pest management with forest management. J. For. 80 (4) : 212-214

Stand risk rating for the southern pine beetle, *Dendroctonus frontalis*, is a first step toward dealing with a serious but sporadic insect problem. Two approaches, one utilizing readily available resource data, the other employing data obtained from aerial photographs, illustrate application of current knowledge to meet the protection needs of resource management – the primary role of integrated pest management. During a 36-month period in Louisiana, high-risk stands accounted for 13.4 infestations per 1000 acres, four times the rate of low-risk stands ; in Texas high-risk stands accounted for 9.9 infestations per 1000 acres during 1973-1978, almost five times the number for low.

T.F. Branson & J.L. Krysan (1981). Feeding and oviposition behaviour and life cycle strategies of Diabrotica : an evolutionary view with implications for pest management. Environ. Ent. 10 (6) : 826-832

Among the species of the genus *Diabrotica* that occupy the United States, voltinism and adult collection sites are closely related to the presence of suitable larval hosts ; thus, species in the *fucata* group are multivoltine polyphags and species in the *virgifera* group are univoltine oligophags (or monophags). The group-specific differences in voltinism are attributed directly to the seasonal availability of the host plant and only indirectly to the climate. In the *virgifera* group, univoltinism combined with a narrow larval host range and limited search capability suggest that oviposition behavior is the primary determinant of whether the newly hatched larvae reach a suitable host. Reviews of the biosystematic, archaeological and historical records indicates that *D. virgifera sensu lato* and *D. barberi* have become pests of corn by convergent evolution. This evolutionary view suggests new avenues of research that are discussed in the text.

B. Sechser (1981). An approach to integrated pest management from the chemical industry. Acta Phytopath. Acad. Sci. Hung. 16 (1-2) : 239-243

The development of ecologically safe pesticides is a major contribution of the chemical industry to Integrated Pest Management (IPM). In a first selection process nowadays, only pesticides with acceptable mammalian toxicity are promoted for further development. A further step in our company is the screening at an early stage in the laboratory against the following representative beneficial species :

Anthocoris nemorum (flower bug), *Chrysopa carnea* (lacewing), *Coccinella punctata* (ladybird beetle), *Coccygominus (Pimpla) turionellae* (ichneumonid wasp) and *Amblyseius fallacis* (predatory mite). Laboratory selectivity tests are then complemented by field trials against the whole beneficial complex in deciduous fruit and cotton. New approaches in the chemical syntheses aim at the type of selectivity exemplified by compounds such as chlordimeform and diflubenzuron. Efforts are also made to synthesize compounds similar to natural plant products, which have hormonal and behavioural effects. One such compound, CGA-29' 170, is acutally in development. In the field of more potent toxins, a further diversification is derived from *Bacillus thuringiensis*. The final aim is the development of integrated systems in various crops built around selective pesticides. A first such long-term project has been started in deciduous fruit and will last for several years.

M. Kosztarab (1981). Recent advances in the study of Coccoidea with special reference to integrated pest management. Acta Phytopath. Acad. Sci. Hung. 16 (1-2) : 151-156

Conventional insect control methods are being replaced by integrated pest management (IPM) programs which are based on detailed biological, ecological and systematic information. Some of the new discoveries and techniques applied in IPM programs against scale insects and other related topics are reviewed here

P.L. Adkisson et al. (1982). Controlling cotton's insect pests : a new system. Science 216 : 19-22

Cotton is more heavily treated with insecticides than any other crop in the United States. In southern Texas, this heavy treatment resulted in insecticide-resistant strains of major pests which almost destroyed the industry in the late 1960's and early 1970's. An integrated insect control program based on new short-season cotton varieties and traditional cultural practices has restored production in the area. The new system has been widely implemented because it produces greater net returns by reducing the use of insecticides, fertilizer and irrigation.

S.W.T. Batra (1982). Biological control in agroecosystems. Science 215 : 134-139

Living organisms are used as biological pest control agents in (i) classical biological control, primarily for permanent control of introduced perennial weed pests or introduced pests of perennial crops ; (ii) augmentative biological control, for temporary control of native or introduced pests of annual crops grown in monoculture ; and (iii) conservative or natural control in which the agroecosystem is managed to maximize the effect of native or introduced biological control agents. The effectiveness of biological control can be improved if it is based on adequate ecological information and theory, and if it is integrated with other pest management practices.

B. Bisabri-Ershadi & L.E. Ehler (1981). Natural biological control of western yellow-striped armyworm, Spodoptera praefica, in hay in northern California. Hilgardia 49 (5) : 1-19

The effect of natural enemies on populations of western yellow-striped armyworm *(Spodoptera praefica)* was assessed in hay alfalfa in the Sacramento Valley of California. Analysis of partial age-specific life tables (i.e. egg to pupa) revealed that most of the generation or real mortality of *S. praefica* occurred during the egg-small-larval age interval. Experimentation revealed that such mortality was largely due to a complex of polyphagous predators. Predators included larvae of *Chrysopa carnea* ; adults and nymphs of *Geocoris pallens, G. punctipes, G. atricolor, Nabis americoferus, N. alternatus*, and *Orius tristicolor* ; adults of *Collops vittatus*, and the notorious « pest » species, *Lygus hesperus*. Parasites and disease had a relatively minor impact on populations of *S. praefica*. The results provide further support for biological control of insect pests in temporary agroecosystems and illustrate the importance of polyphagous predators in such biological control.

J. Chesson (1982). Estimation and analysis of parasitoid search and attack parameters from field data. Environ. Ent. 11 (3) : 531-537

Methods of estimating the probability of encounter and probability of parasitism given encounter are described for situations in which a host patch that has not been encountered by a parasitoid cannot be distinguished from one that has been encountered but none of the hosts have been parasitized. These methods provide estimates of quantities which do not vary with host density per patch unless parasitoid behavior changes, and therefore are the appropriate ones to use to detect effects of host density on the intensity of parasitism. An example is given, using published data on the parasitism of *Heliothis zea* eggs by *Trichogramma* spp.

A.A. Berryman (1982). Biological control, thresholds and pest outbreaks. Environ. Ent. 11 (3) : 544-549

Pest populations are frequently regulated below their potential levels of abundance by natural enemies, host resistance, or other biological interactions. However, if these regulating processes operate imperfectly, or are intolerant to variations in pest density, then we may observe periodic outbreaks of the pest. In effect, intolerant regulating processes create thresholds separating distinct dynamic behaviors, usually referred to as endemic and epidemic behaviors. If threshold functions can be defined in terms of measurable system variables, they offer a powerful approach for evaluating the risk of epidemics in managed ecosystems. Methods for defining threshold functions and constructing risk decision models are discussed.

L.E. Ehler & R.W. Hall (1982). Evidence for competitive exclusion of introduced natural enemies in biological control. Environ. Ent. 11 (1) : 1-4

The rates of establishment of exotic natural enemies introduced against exotic pests in the orders Homoptera, Lepidoptera, and Coleoptera were found to be inversely related to (1) the number of species released at a given time and place and (2) the number of exotic incumbent species of natural enemies present. Thus, competitive exclusion of introduced natural enemies has probably occurred and contributed to the relatively low rate of establishment in biological control. It is suggested that, in cases in which less-than-complete control was obtained through multiple-species releases, natural enemies capable of effective control of the target pest may have been competitively excluded. Because of this possibility, use of the empirical approach of releasing all available species of natural enemies, with the hope that the best species or combination of species will be sorted out in the field, should be questioned. In modern biological control, a more rational release strategy is in order.

2. CONTROL OF FUNGI, BACTERIA AND VIRUSES

J.J. Marois et al. (1981). Biological control of Fusarium crown rot of tomato under field conditions. Phytopathology 71 (12) : 1257-1260

Conidial suspensions of five fungal antagonists of *Fusarium oxysporum* f. sp. *radicis-lycopersici* were applied to the roots and crowns of tomato transplants at the time of planting. The suspension contained 5×10^5 conidia of each of three isolates of *Trichoderma harzianum*, one isolate of *Aspergillus ochraceus*, and one isolate of *Penicillium funiculosum*. The pathogen was added at the time of planting to soil 10 cm from the transplant as 0, 50, 500, and 5000 chlamydospores per plant in 20 ml of water. The incidence of disease increased as the inoculum density of the pathogen was increased in fumigated soil not augmented with the antagonists ; disease incidence, however, did not increase as the inoculum density was increased in fumigated soils that were augmented with the antagonists. At 5000 chlamydospores of the pathogen per plant, disease incidence at harvest was 7 % in soils augmented with antagonists and 37 % in nonaugmented soils. The pathogen population decreased from 600 to 200 propagules per gram in soil augmented with antagonists, but increased from 1000 to over 5×10^4 propagules per gram in nonaugmented soils. Yield was not affected significantly by treatment or planting date.

S.A. Anagnostakis (1982). Biological control of chestnut blight. Science 215 : 466-471

After 77 years of being attacked by the chestnut blight fungus, American chestnut trees continue to sprout from gradually declining root systems. The blight fungus in Italy is now associated with virus-like agents that limit its pathogenicity, and attempts have been made to introduce these controlling agents into the blight fungus in the United States. If a way can be found to help the spread here of strains of the fungus with controlling agents, it may be possible to save the American chestnut trees in our eastern forests.

P. Davet et al. (1981). About the production, in non-sterile conditions, of a Trichoderma harzianum inoculum, with a view to biological control trials. Agronomie 1 (10) : 933-936

The substrate is prepared in large plastic bags. Chopped straw is moistened by an acid mineral solution, to which selectivity is confered by addition of 12.5 mg/l of vinclozolin and 2.5 ml/l of allyl alcohol. Such a preparation was employed to treat a soil that had been previously infested by *Sclerotinia minor*. In amended plots, lettuce drop was significantly reduced, compared with non-treated controls, in spite of too short a period between *T. harzianum* application and planting. Usual chemical control with vinclozolin still gave the best results.

T.H. Abd-El Moity et al. (1982). Induction of new isolates of Trichoderma harzianum tolerant to fungicides and their experimental use for control of white rot of onion. Phytopathology 72 : 396-400

Prolonged exposure of mycelia and conidia of *Trichoderma harzianum* to the fungicide benomyl did not produce isolates tolerant to the fungicide. Exposure of four wild strains of *T. harzianum* to the fungicides chlorothalonil, procymidone, iprodione, and vinclozolin resulted in selection of several isolates tolerant to these fungicides. Some of the fungicide-tolerant isolates grew better radially on media containing the fungicides than their respective wild strains did. Other isolates lost their tolerance after being cultured on fungicide-free media. Conidia of certain isolates of the wild strains WT-6 and T, tolerant to chlorothalonil and iprodione, respectively, germinated better on media containing high concentrations of the fungicides than did conidia of their respective wild strains. Exposure of conidia of the wild strain T-14 to 0.1 % (active ingredient) chlorothalonil for 4 wk reduced germination by 80 % when the conidia were placed on a fungicide-free medium. Similar exposure of conidia of T-14 (3M), a chlorothalonil-tolerant isolate, reduced germination by only 20 %. An iprodione-tolerant isolate derived from the Egyptian strain T produced more toxin, as measured by inhibition of mycelial growth of *Sclerotium cepivorum*, than did the wild strain. One fungicide-tolerant isolate of strain Th-1 (Th-1 | procy-2M) reduced white rot of onion caused by *S. cepivorum* more effectively than did Th-1 or other fungicide-tolerant isolates. The iprodione-tolerant isolate T(ipro-25M) and iprodione combined with T(ipro-25M) gave the best control of white rot of onion in the field in Egypt.

J.P. Hubbard et al. (1982). Interaction of a biological control agent Chaetomium globosum, with seed coat microflora. Can. J. Microbiol. 28 (4) : 431-437

The mechanism by which *Chaetomium globosum*, applied as ascospores to squash, snap bean, and pea seeds, reduces damage caused by larvae of the seed-corn maggot, *Hylemya platura*, and soilborne plant pathogens was investigated. *Chaetomium globosum* ascospores germinate rapidly and cover the seed coat with a dense mat of mycelium soon after seeds are planted in soil. However, if seeds are not treated with *C. globosum* before planting, other organisms rapidly colonize the seed coat during germination. Seed flies oviposit near seeds in response to the growth of pseudomonads on the seed surface. Studies employing a selective medium indicate that *Pseudomonas* become the most prevalent genus occurring on the seed coat during seed germination. Treatment of seed with *C. globosum* suppresses the logarithmic growth of pseudomonads on the seed coat but affects neither bacterial populations in the soil surrounding the seed nor germination of *Fusarium solani* f. sp. *pisi* chlamydospores, either on the seed coat or in the soil surrounding the seed. A water-insoluble antibiotic was extracted from *C. globosum* treated seeds. After systemic examination of other possibilities, it was concluded that this nondiffusable antibiotic substance produced by *C. globosum* suppresses pseudomonads responsible for stimulation of oviposition by seed flies as well as the soilborne plant pathogens.

J. Ponchet (1982). Realities and prospects for biological control of plant diseases. Agronomie 2 (4) : 305-314

The concept of biological control differs somewhat depending on whether one is an entomologist or plant pathologist. In the restrictive entomological sense, it means exploitation of single combatants ; this is practised in a few cases only in plant pathology. Our purpose is to point out recent progress in this field. In the fight against soil-borne diseases, using the natural resistance of soils, real success has been achieved. Whether the antagonism has been brought about by the inclusion of suppressive soil or by the addition of very active control agents (such as *Trichoderma*), attacks by *Rhizoctonia*, *Sclerotium*, *Sclerotinia*, *Verticillium* and other pathogens have been reduced. Integrated control of potato soil-borne pathogens using solar heat treatment, specific chemotherapy and *Trichoderma* treatment has been suggested. *Trichoderma* has also shown good antagonistic properties against aerial parasites such as *Stereum purpu-*

reum, *Botrytis* and *Phomopsis* on grapevine, or *Sphaeropsis* on cucumber. Roots and collars of pine and eucalyptus have been successfully protected against *Phytophthora cinnamomi* by mycorrhizal fungi. Effective biological control can also be achieved by cross-protection with living avirulent strains, acting through the intermediate agency of the host. Thus, pre-inoculation reduces tristeza virus on *Citrus* and looks promising on some fruit trees. The method is already of practical value in controlling TMV on tomato. *Agrobacterium radiobacter* strain 84 finds practical use all over the world in the control of crown gall. Immunization of beans or cucumbers is systematically obtained by pre-inoculation with a non-pathogenic race of *Colletotrichum* specific to the particular crop. Cross-protection through the application of hypovirulent strains is still successful in wheat take-all disease or in chestnut blight. *Endothia* is excluded from cankers and the disease cured. Whether or not virus particles are involved in breaking down the virulence of the pathogenic strain, control is effective and reliable. Plant pathologists are slowly advancing along the road of biological control, especially for diseases not readily controlled by use of chemicals. The slowness of the progress may be attributed to the usually narrow field of application, which discourages industrial development, to competition with fungicides and to lack of enthusiasm on the part of the farmers.

3. CONTROL OF WEEDS

D.P. Peschken & A.T.S. Wilkinson (1981). Biocontrol of Canada thistle (Cirsium arvense) : releases and effectiveness of Ceutorhynchus litura in Canada. Can. Ent. 113 (9) : 777-785

Ceutorhynchus litura is established since 1967 in Ontario, and is increasing slowly on nine release sites in five provinces. The weevil is not a good control agent because its reproductive capacity does not compensate for losses inflicted by cultivation and the stress resulting from larval mining is so light that it produces no noticeable reduction in the vigour of Canada thistle. In contrast to earlier findings, it is doubtful that *C. litura* aids in the spread of the rust *Puccinia punctiformis*. Further stress factors from other insects or pathogens are needed to control this vigorous weed.

D.P. Peschken et al. (1982). Biocontrol of the weed Canada thistle (Cirsium arvense) : releases and development of the gall fly Urophora cardui in Canada. Can. Ent. 114 (4) : 349-357

The gall fly, *Urophora cardui*, native to Europe, was released at 24 locations across Canada, beginning in 1974. It became established in Ontario, Quebec, and New Brunswick but died out in all but one location in western Canada. Evidence for winter mortality in the west does not explain the failure of these colonies. Although galls, in particular those on the main shoot, reduce the height of Canada thistle, so far the impact on the host weed, Canada thistle, is slight.

L.T. Kok (1981). Status of two European weevils for the biological control of Carduus thistles in the USA. Acta Phytopath. Acad. Sci. Hung. 16 (1-2) : 139-142

Carduus thistles are introduced Eurasian weeds causing major problems in pastures, ranges, croplands, and along state highways in many parts of the USA. Two of the most troublesome species are *Carduus thoermeri* (musk thistle) and *Carduus acanthoides* (plumeless thistle). They have been able to rapidly take over mismanaged land, especially in overgrazed pastures. In the search for an effective long-term control measure, several biological agents were imported into the USA. Two European weevils which have been released have become well established and have potential as biological control agents of the musk thistle : *Rhinocyllus conicus*, a thistle head weevil, was first introduced from France and Italy in 1969 into 3 states : California, Montana and Virginia. It has subsequently been relocated to at least 15 other states. Eggs of the weevil are laid on thistle heads and the developing larvae feed on tissues of the receptable, preventing seed formation. Significant impact has been reported in Virginia, Montana and Missouri. A second weevil, *Ceuthorhynchidius horridus*, was imported for host specificity testing under quarantine in 1970. Based on results of the tests, it was officially approved for field release in Virginia in 1974 and has become established in at least 7 release sites. Several other states have subsequently released this rosette-feeding weevil which is currently being evaluated for efficacy in thistle control. Eggs are laid in leaf midribs, larvae feed towards the crown and kill the growth point. Compatibility studies of both weevils, with 2,4-D, the most commonly used herbicide for thistle control in the USA, revealed that adult survival, fecundity and vitality were not adversely affected. With proper timing, the herbicide and both weevils can be compatibly used in an integrated program for control of *Carduus* thistles.

E.U. Balsbaugh, Jr et al. (1981). Insects for weed control : status in North Dakota. North Dakota Farm Res. 39 (3) : 3-7

Two foreign species of weevils have been introduced into North Dakota for the biological control of musk thistle, *Carduus nutans* – *Rhinocyllus conicus*, a seed feeding weevil, and *Ceuthorhynchidius horridus*, an internal root and lower stem inhabiting species. *R. conicus* has survived for several generations and is showing some promise for thistle suppression in Walsh County, but releases of *C. horridus* have been unsuccessful. The pigweed flea beetle, *Disonycha glabrata*, which is native in southern United States, has been introduced into experimental sugarbeet plots in the Red River Valley for testing its effects at controlling rough pigweed or redroot, *Amaranthus retroflexus*. Although both larvae and adults of these beetles feed heavily on pigweed, damage to the weed occurs too late in the season for them to be effective in suppressing weed growth or seed set. An initial survey for native insects of bindweed has been conducted. Feeding by localized populations of various insects, particularly tortoise beetles, has been observed. Several foreign species of flea beetles and a stem boring beetle are anticipated for release against leafy spurge.

T.L. Kirkpatrick et al. (1982). Potential of Colletotrichum malvarum for biological control of prickly sida. Pl. Dis. 66 (4) : 323-325

Colletotrichum malvarum was evaluated as a bioherbicide for prickly sida control in agronomic crops. Of 38 plant species tested, only hollyhock (*Althaea rosea*) and prickly sida (*Sida spinosa*) were susceptible. In growth chamber experiments, disease symptoms on prickly sida seedlings were severe after single and multiple dew periods of 16 hr. In small field plot studies, inoculations with an aqueous suspension of 4×10^6 conidia per ml applied at 378 l/ha killed 84-95 % of the prickly sida plants after 3 wk.

J.V. Shireman & M.J. Maceina (1981). The utilisation of grass carp, Ctenopharyngodon idella, for hydrilla control in Lake Baldwin, Florida. J. Fish Biol. 19 (6) : 629-636

Grass carp > 300 mm T.L. were stocked in Lake Baldwin, Florida during 1978 (24 fish ha^{-1}) to evaluate their effectiveness for hydrilla control. *Hydrilla verticillata* was nearly eradicated from Lake Baldwin 2 years after stocking. Control was effective with 130 kg grass carp ha^{-1} of hydrilla and control was definite when biomass exceeded 185 kg ha^{-1} of hydrilla. Grass carp growth was rapid during the first two years as fish reached 9-17 kg by June 1980. Grass carp > 6 kg consumed 25-28 % of their body weight of hydrilla per day. The use of grass carp for vegetation management is discussed.

J.J. Burdon et al. (1981). The impact of biological control on the distribution and abundance of Chondrilla juncea in south-eastern Australia. J. appl. Ecol. 18 (3) : 957-966

Changes in the distribution, frequency and abundance of three forms of *Chondrilla juncea* occurring in south-eastern Australia are documented for the period 1968-1980. The abundance of the most widespread form has declined as a result of the impact of a number of host-specific natural enemies deliberately introduced as biological agents. The distribution of the other two forms has extended. The effect of the most aggressive of these agents, *Puccinia chondrillina*, on the competitive interaction between the two morphologically most dissimilar forms of *C. juncea* is demonstrated in a replacement series experiment. When grown in the absence of *P. chondrillina* both forms competed equally ; when form A plants were regularly infested with *P. chondrillina*, dry weight of the non-susceptible form C was increased by at least 10 %, whilst that of form A declined substantially.

N.S. Irving & M.O. Beshir (1982). Introduction of some natural enemies of water hyacinth to the White Nile, Sudan. Trop. Pest Manage. 28 (1) : 20-26

The introduction and rapid spread of the water hyacinth *Eichhornia crassipes* in the White Nile system of southern Sudan has produced serious problems for the use of that river as a resource. Not least of these is the increasing cost of chemical control of the weed in a very large and often inaccessible area. Biological control of the plant by the introduction of some of its natural insect enemies had been earlier suggested as an alternative method. A programme for the mass culture and release of insects in the Sudan commenced early in 1979. During the following two years three species, *Neochetina eichhorniae*, *N. bruchi* and *Sameodes albiguttalis* were reared and released. The *Neochetina* weevils became successfully established and are dispersing in the river system. Heavy infestations have been observed in some areas. The moth *S. albiguttalis* has apparently failed to establish so far, but it is considered that further releases will improve the chance of producing stable populations of this species.

J.J. Burdon & D.R. Marshall (1981). Biological control and the reproductive mode of weeds. J. appl. Ecol. 18 (3) : 649-658

The genetic structure of agricultural plant populations has long been recognized as an important factor in their vulnerability or resistance to disease and pest attack. However, in the biological control of weedy plants, the potential significance of the population genetic structure of the target species appears to have been severely underestimated. An examination of the degree of control achieved in eighty-one different control attempts demonstrated a significant correlation between the degree of control achieved and the predominant mode of reproduction of the target plant : asexually reproducing species were effectively controlled significantly more often than sexually reproducing ones. It is argued from this result that the genetic structure of the target species has important implications with respect to the selection of species to be controlled, using biological agents.

b) Public Health

W.A. Ramoska et al. (1982). Field tests of two commercial formulations of Bacillus thuringiensis serotype H-14 against Aedes mosquito larvae in Montana pastureland. Mosquito News 42 (2) : 251-?

Two commercially formulated and registered *B. thuringiensis* serotype H-14 (= *israelensis)* products, Vectobac™ and Teknar™ were tested against *Aedes* species mosquito larvae in flooded pastureland in Montana. Good control was achieved by both products at label dosages over the 16 and 40 ha plots.

R.E. McLaughlin & T. Fukuda (1982). Effectiveness of B. thuringiensis serotype H-14 against Culex quinquefasciatus in small ditches. Mosquito News 42 (2) : 158-?

Culex quinquefasciatus larvae were effectively controlled by applications of *B. thuringiensis* serotype H-14. Two roadside ditches were treated every 1-4 days from August 16 through October 14, 1979 with ca. 0.6 gm/m^3 of a preparation assayed at 491 International Toxic Units per mg. A large, continuously ovipositing adult population maintained a newly hatching larval population throughout the test. A population of 4th instar and pupae developed in the untreated ditch as normally expected, but these stages were not produced in the treated ditches.

F.W. Van Essen & S.C. Hembree (1982). Simulated field studies with four formulations of B. thuringiensis var. israelensis against mosquitoes : residual activity and effect of soil constituents. Mosquito News 42 (1) : 66-71

A study was undertaken to determine the effects of suspended and dissolved soil constituents on the residual larvicidal effectiveness of *B. thuringiensis* var. *israelensis* in large outdoor artificial containers. Mortality decreased progressively with time although one formulation was still effective 4 days posttreatment. The presence of soil constituents was associated with a lowering of larval mortality. In the absence of soil constituents, stirring the medium tended to enhance the duration of effective control, while in the presence of soil constituents stirring tended to reduce the duration of effective control. Settling patterns of the *Bti* formulations were also affected by the presence of soil constituents. *Bti* tended to settle out faster in those troughs containing soil, probably because of adsorption to the soil particles.

B.F. Eldridge & J. Callicrate (1982). Efficacy of B. thuringiensis var. israelensis for mosquito control in a western Oregon log pond. Mosquito News 42 (1) : 102-104

Field tests of *B. thuringiensis* var. *israelensis* were conducted in a moderately to heavily polluted log pond in

Lane Co., Oregon containing a mixed population of *Culex peus* and *Cx. pipiens*. Five dosages were applied ranging from 0.40 to 1.63 kg/ha. Reductions of 73-99 % were observed after 48 hours, but with no significant differences among the dosage rates tested. One week following each test, treated areas had returned to pre-treatment levels of larvae, but with significant differences in age class distribution. Laboratory bioassays produced estimated ED_{50}'s approximately three times higher in water from the log pond compared with those conducted with distilled water.

S.P. Wraight et al. (1982). A comparison of laboratory and field tests of Bacillus sphaericus strain 1593 and B. thuringiensis var. israelensis against Aedes stimulans larvae. Can. Ent. 114 (1) : 55-61

B. thuringiensis var. *israelensis* (serotype H-14) and *B. sphaericus* strain 1593 were tested against *Aedes stimulans* larvae in the laboratory and in 38-cm-diam, open-ended cylinders embedded in the bottom detritus of a woodland pool. Estimates of LC_{50} were lower against fourth instars in the field at a mean temperature of 15.9°C than in the laboratory at 21.1°C. The greater efficacy in the field was attributed to high daytime water temperatures (mean 20.5°C) following treatment and exposure of the larvae to substantially greater amounts of toxic material in a larger volume of water than in the laboratory. The regression of probit on $\log_{10}$ concentration was not linear over the entire range of mortality caused by *B. sphaericus*, increasing the difficulty of estimation of LC values. *B. sphaericus* was significantly less active than *B. thuringiensis*.

A.D. Nugud & G.B. White (1982). Evaluation of B. thuringiensis serotype H-14 formulations as larvicides for Anopheles arabiensis (species B of the An. gambiae complex). Mosquito News 42 (1) : 36-40

Formulations of *B. thuringiensis* serotype H-14 were evaluated in the laboratory for larvicidal potency against the Afro-tropical malaria vector *Anopheles arabiensis*. The 3 formulations tested were : standard IPS-78 water-dispersible powder ; an experimental water-dispersible powder (ABG-6108) ; a water-dispersible concentrate (SAN 402 I). Mortality was recorded for batches of 25 second instars exposed for 24 hr, giving LC_{50} values of 0.159, 0.211 and 0.163 ppm, and for 48 hr giving LC_{50} values of 0.113, 0.119 and 0.099 ppm, respectively, for the 3 formulations. When compared with the IPS-78 standard wdp the relative activity at LC_{50} level was 0.75 for 24 hr and 0.94 for 48 hr exposure to ABG-6108 wdp ; 0.97 for 24 hr and 1.14 for 48 hr exposure to San 402-I wdc. It is concluded that wdp formulations are less efficacious than emulsion which has prolonged availability for ingestion by surface-feeding anopheline larvae.

M.S. Goettel et al. (1982). Laboratory bioassays of four formulations of B. thuringiensis israelensis against Aedes polynesiensis, Ae. pseudoscutellaris and Ae. aegypti. Mosquito News 42 (2) : 163-167

Laboratory bioassays using 3 formulations of *B. thuringiensis israelensis*, SAN 402 I, IPS-78, and R153-78 were conducted with 3 species of mosquito : *Aedes polynesiensis*, *Ae. pseudoscutellaris* and *Ae. aegypti*. Another formulation, Bactimos ® was tested with only *Ae. aegypti*. Additional bioassays were performed with *Ae. polynesiensis* in 0.5 % salt water. The presence of salt did not deter the action of the bacterium. The 3 mosquito species proved to be susceptible to the various formulations, Bactimos being the most active formulation followed by R153-78, IPS-78 and SAN 402 I.

W.A. Ramoska et al. (1982). Influence of suspended particulates on the activity of B. thuringiensis serotype H-14 against mosquito larvae. J. econ. Ent. 75 (1) : 1-4

The efficacy of spore-crystal formulations of *B. thuringiensis* serotype H-14 (var. *israelensis*) decreased against mosquito larvae when in aqueous environments containing a concentration of soil or clay particles $\geqslant$ 0.5 mg/ml. Fresh whole-culture *B. thuringiensis* var. *israelensis* was similarly affected by the soil and clay particles. Sand grains did not have a strong effect on efficacy except when finely ground into particles of 147 µ or less. Settling out of the particulates before the addition of *B. thuringiensis* var. *israelensis* did reduce their suppressive effect on the bacterium.

M. Laird et al. (1982). Establishment and long-term survival of Romanomermis culicivorax in mosquito habitats, Tokelau Islands. Mosquito News 42 (1) : 86-92

Man-made treeholes (« tungu ») hollowed out from the lower part of the trunk of standing coconut palms are a feature of the Tokelau Islands (tropical Polynesia). Rainwater trapped in them is near neutrality and of low electrical conductivity, and serves as an important permanent source of the Bancroftian filariasis vector, *Aedes polynesiensis*. From 2-5 June 1978 the population of this mosquito on the islet of Fenuafala, Fakaofo atoll, was exposed to imported *Romanomermis culicivorax* (eggs in sand cultures). A temporary establishment was confirmed in August 1978 and a monitoring visit in November 1980 revealed that the worm was still causing infections in at least 3 of the tungu initially treated. Subsequently (15 May 1981) these yielded additional parasitized larvae. The establishment had thus persisted for almost 3 years following a single inoculative application. Data presented suggest the future usefulness of *R. culicivorax* as an element in an integrated mosquito control methodology designed for the Tokelaus.

R.K. Sharma & L.N. Gupta (1982). Role of photoperiod and temperature on biological control of Culex fatigans larvae by the mermithid nematode Romanomermis culicivorax. Z. ang. Ent. 93 (2) : 187-190

The effect of seven photoperiods, say 0 L : 24 D, 4 L : 20 D, 8 L : 16 D, 12 L : 12 D, 16 L : 8 D, 20 L : 4 D and 24 L : 0 D at three temperature ranges, viz. lower (23-24°C), optimum (26-31°C) and higher (33-34°C), on the ability of *Romanomermis culicivorax* as a biological control agent of *Culex fatigans* larvae was studied. The ratio of late first instar larvae of *C. fatigans* and preparasites of *R. culicivorax*, used in tests was 1 : 10. The different photoperiods at lower, optimum and higher temperature ranges were observed not to have any significant effect on the survival of the larvae exposed to infection and also on those in the control groups. The correlation between the survival of the larvae exposed to infection and photoperiod is noted. The photoperiod at all the temperature ranges significantly affects the parasitism of the larvae by the preparasites. At 12 L : 12 D the number of nematodes per larva was highest. The number of infected larvae surviving at 16 L : 8 D was lowest. At all the temperature ranges the general trend of the survival of the infected larvae was found to have correlation with the increase or decrease in the photoperiod. The interaction between temperature and photoperiod was also observed. The survival of the infected larvae and the number of parasites per host was maximum at the optimum temperature range.

G.O. Poinar, Jr & H.N. Kaul (1982). Parasitism of the mosquito Culex pipiens by the nematode Heterorhabditis bacteriophora. J. Invert. Path. 39 : 382-387

Various concentrations of the nematode *Heterorhabditis bacteriophora* were added to dishes containing second, third, and fourth larval instars of the mosquito *Culex pipiens*, respectively. The infective stage nematodes were ingested by the mosquito larvae, they then penetrated through the alimentary tract in the neck region and entered the haemocoel. A melanization reaction killed many invading nematodes, but heavier concentrations overwhelmed the hosts' defense reaction and 100 % mortality of third- and fourth-instar larvae was achieved using between 170 and 200 nematodes per host. Death was either due to the nematode releasing cells of the symbiotic bacterium, *Xenorhabdus luminescens*, into the haemocoel or to foreign bacteria (mostly *Pseudomonas aeruginosa*), which were introduced by the penetrating nematodes. The potential use of this nematode as a biological control agent of larval culicine mosquito is discussed.

G.O. Poinar, Jr et al. (1982). Inoculation of entomogenous nematodes, Neoaplectana and Heterorhabditis, and their associated bacteria, Xenorhabdus spp. into chicks and mice. Environ. Ent. 11 (1) : 137-138

Live cells of *Xenorhabdus nematophilus* and *X. luminescens* were inoculated subcutaneously into 9-day-old white leghorn chicks and adult Swiss albino mice and intracerebrally into suckling mice. Infective-stage juveniles of *Neoaplectana carpocapsae* and *Heterorhabditis bacteriophora* were inoculated subcutaneously into adult Swiss albino mice. No disease symptoms or mortality appeared in any of the experimental animals during the course of the experiment.

M.S. Dhillon & M.S. Mulla (1982). Impact of green alga, Chlorella ellipsoidea, on the development and survival of mosquitoes, breeding in cemetery vases. Environ. Ent. 11 (2) : 292-296

The alga *Chlorella ellipsoidea* caused 85 % reduction in the populations of mosquitoes breeding in cemetery vases. Annual mean larval densities of 9 and 61 larvae per vase were observed in algal and nonalgal vases, respectively. The maximum mean larval density of 17 larvae per vase in algal vases was significantly lower than the corresponding maximum (131 larvae per vase) in the nonalgal vases. The low numbers of mosquito larvae prevailing in the algal vases were likely due to the action of toxins produced by *C. ellipsoidea*. Lower larval densities, « 0 » and « 1-10 » larvae per vase, were found in 57 and 24 % of the algal vases, respectively, whereas these densities occurred in 22 and 12 %, respectively, of the nonalgal vases. The percentages of nonalgal vases supporting the three higher densities (26-50, 51-100, and > 100 larvae per vase) were significantly higher than those of the algal vases. The number of vases with and without algae supporting first- and second-stage larvae was similar, however, the number of vases supporting third- and fourth-stage larvae and pupae was significantly higher in the nonalgal than in the algal vases. The percentage of algal vases containing dead larvae or pupae was significantly higher (ca. 11 times) than that of the nonalgal vases. Studies on algal growth revealed that an overall average of 23 % of the vases contained *C. ellipsoidea* during the study period. The incidence of this alga peaked during May (33 % vases with algae) and was lowest in December (7 %). No apparent relationship between algal density and mosquito numbers was observed.

T. McInnis, Jr & W.C. Zattau (1982). Experimental infection of mosquito larvae by a species of the aquatic fungus Leptolegnia. J. Invert. Path. 39 : 98-104

Leptolegnia sp., an apparently undescribed species of water mold, has proven to be a virulent parasite of mosquito larvae. The mycosis is initiated when zoospores encyst either on the cuticle or in the gut of the host and subsequently grow into the coelomic cavity where rapid proliferation of hyphae and destruction of tissues results in the death of the larva. Populations of first- and second-instar larvae of *Aedes aegypti* typically suffer 100 % mortality within 24 hr of exposure, but third- and fourth-instar populations are less than 40 % infected after 72 hr. The fungus is most virulent at temperatures of 28°C or lower, with no infection occurring in water over 30°C. Populations of *Culex pipiens quinquefasciatus*, *Anopheles quadrimaculatus*, and *Anopheles albimanus* are equally susceptible. These results demonstrate the potential of *Leptolegnia* for biological control of mosquitoes ; however, further studies are necessary on host range, effectiveness in the field, and the role of the oospore in transmission of the disease.

J.A. Shadduck et al. (1982). Mammalian safety tests of Metarhizium anisopliae : preliminary results. Environ. Ent. 11 (1) : 189-192

Preliminary mammalian safety tests were conducted on the entomopathogenic fungus *Metarhizium anisopliae*. No animals died or were clinically ill after injection of or exposure to *M. anisopliae*. There was no evidence of ocular irritation, and tissue lesions were confined to local sites at which large numbers of spores were collected. There was no histologic evidence of spore germination in mammalian tissues. *M. anisopliae* was recovered from stomach, lung, and spleen after 2 weeks of exposure of mice to dusts but not at the end of week 3. Fungi were recovered also from focal granulomas that followed intraperitoneal injections of *M. anisopliae* spores into rats. Fungi were recovered from spleens of rats given spores intraperitoneally, but the spleens were sterile 21 days after exposure. We concluded that our tests reveal no evidence of human or mammalian pathogenicity of *M. anisopliae*.

S.C. Hembree (1982). Dose-response studies of a new species of per os and vertically transmittable microsporidian pathogen of Aedes aegypti from Thailand. Mosquito News 42 (1) : 55-60

Results are presented of dose-response studies of a new species of *per os* and vertically transmittable microsporidian pathogen of *Aedes aegypti* from Thailand. The relationship between duration of exposure and percent transmission to *Ae. aegypti* larvae was determined. Estimated IC_{50}s for 1st, 2nd, 3rd and 4th stage *Ae. aegypti* larvae were 54, 110, 210 and 1100 spores/ml, respectively. Concentrations of about 10^4, 5×10^4, 10^5 and 5×10^5 spores/ml for 24 hr were required to cause cumulative mortality of 90 % or more by the time the exposed population was 14 days of age (post-hatch), when exposures were made to 1st, 2nd, 3rd and 4th stage larvae, respectively. The low IC_{50}s indicate the pathogen is very infectious, while the LC_{90}s suggest it is not very virulent. The fact that it might be dispersed by survivors within the target population by vertical transmission enhances its attractiveness as a potential microbial control agent. Infectivity to *Ae. taeniorhynchus* was demonstrated. *Culex quinquefasciatus* and *Anopheles stephensi* were not susceptible.

S.L. Durso et al. (1982). Oviposition behaviour of Toxorhynchites amboinensis in a tyre yard. Mosquito News 42 (2) : 255-260

The oviposition behavior of the predatory mosquito, *Toxorhynchites amboinensis*, was examined in a 1.0 ha tyre yard in St. Joseph County, Indiana. A total of 129 laboratory-reared *Tx. amboinensis* females was released. Egg production was monitored by checking for eggs daily in 86 marked tyres distributed in 4 distinct habitats. Of the 3134 eggs recovered during the 28-day period after release, 49 % were from a transect of 26 tyres in a wooded area, 28 % were from 20 tyres in a completely shaded tyre pile, 22 % were from 20 tyres in a partially shaded pile, and the remaining 1 % were recovered from 20 tyres in an exposed tyre pile. *Toxorhynchites* eggs were found in every available tyre sampled in the wooded area and in both types of shaded tyre piles, but only 15 % of the tyres sampled in the exposed tyre pile received any eggs. On the 24th day after release, 3rd and 4th instar *Toxorhynchites* larvae were common in shaded tyres. The high fecundity and the preferential oviposition in shaded areas indicates that *Tx. amboinensis* should be considered for the control of mosquitoes that develop in shaded tyres.

S.P. Singh et al. (1981). Control of mosquito Culex pipiens fatigans by releasing radiation sterile males – a field study. J. Environ. Biol. 2 (3) : 9-18

In the present investigation, field trials on the experimental basis, for the control of *Culex pipiens fatigans* were made. The male pupae were irradiated with a gamma radiation dose of 8050 r and the irradiated pupae as well as emerged sterile male adults were transported and released in the field (in Prahladpur). The egg rafts were collected and observed for viability. Up to 90 per cent sterility was obtained and a significant decline in the population density was observed.

C.F. Curtis et al. (1982). A field trial on control of Culex quinquefasciatus by release of males of a strain integrating cytoplasmic incompatibility and a translocation. Ent. exp. appl. 31 : 181-190

A strain of *Culex quinquefasciatus* with European cytoplasm and Indian chromosomes, including a male-linked translocation, was reared and males were released in two villages near Delhi which were surrounded by a 3-km wide zone kept free of mosquito production by conventional larvicides. 5000-40,000 males were released per day per village and this produced very high ratios of released to wild males. As a result of matings of wild females to released males, up to 68 % of the egg rafts laid in the villages showed cytoplasmic incompatibility (sterility) but, despite continued releases, the sterility rate plateaued and eventually declined. This can be partly explained by a decline in emergence of virgin females in the villages but it was concluded that immigration of already inseminated females must also have had an important influence. The trend in the wild adult female populations and the breeding in the release villages in comparison with untreated villages indicated that the releases produced partial population suppression.

T.W. Coates & P.A. Langley (1982). Laboratory evaluation of contact sex pheromone and bisazir for autosterilisation of Glossina morsitans. Ent. exp. appl. 31 : 276-284

Using a combination of varying chemosterilant dose and exposure time, the ability of the compound bisazir, P, P-bis (1-aziridinyl)-N-methylphosphinothioic amide, to induce sterility in adult male *G. m. morsitans* has been evaluated by mating sterilized males to normal females and measuring their fecundity over 90 days. The product of dose and exposure time in hours is a constant for a given level of fertility reduction. The duration of copulatory responses of males to inanimate decoys dosed with *G. m. morsitans* sex pheromone and bisazir is such that a fertility reduction to less than 10 % of normal can be achieved within the dose range of bisazir that causes no reduction in copulatory response, and within a time period that at least 75 % of males are expected to remain in contact with the decoy. Chemosterilization with bisazir has no apparent deleterious effect upon the ability of males to engage in normal copulatory activity with a female and within the limits of laboratory experimentation such males compete equally with normal males to secure a mate. The prospects for utilisation of a sex pheromone/chemosterilant system to achieve autosterilization of *G. m. morsitans* males in the field are discussed.

J.P. Kramer & D.C. Steinkraus (1981). Culture of Entomophthora muscae in vivo and its infectivity for six species of muscoid flies. Mycopathologica 76 (3) : 139-143

A method for the continuous culture of *Entomophthora muscae* in adult house flies *(Musca domestica)* is described. Using this method we have maintained the host-pathogen system in the laboratory for more than one year. The ability of this isolate to cause fatal infections in virtually all of the house flies at risk has remained constant. The face fly *(Musca autumnalis)*, the onion fly *(Hylemya antiqua)* and the seed-corn fly *(H. platura)* are susceptible to this isolate. The stable fly *(Stomoxys calcitrans)*, the black blow fly *(Phormia regina)* and the false stable fly *(Muscina stabulans)* are not.

J. Jourdane & S.D. Kulo (1981). Experimental study of the life cycle of Echinostoma togoensis n. sp., a larval parasite of Biomphalaria pfeifferi in Togo. Ann. Parasit. 56 (5) : 477-488

The adult and larval stages of *Echinostoma togoensis* are described. *E. togoensis* develops into rediae in the ovotestis of *Biomphalaria pfeifferi* which is totally sterilized. The metacercariae were recovered either in the pericardial cavity of several aquatic Pulmonata, or in the kidney of amphibian tadpoles. The adult was experimentally obtained in the laboratory mice exclusively.

P.G. Lee et al. (1982). The giant Malaysian prawn, Macrobrachium rosenbergii, a potential predator for controlling the spread of schistosome vector snails in fish ponds. Aquaculture 28 : 293-301

Under laboratory conditions, the giant Malaysian prawn was found to prey upon two major South American species of schistosome vector snails, *Biomphalaria glabrata* and *B. tenagophila*. Juvenile prawns fed on the snails with a consumption rate of 2.65-3.5 % of prawn body weight per day, whether they were given an alternative food source (5 % of body weight per day in marine ration) or not. Post-larval prawn were fed at a rate of 25 % of prawn body weight per day in addition to the marine ration. The potential of *M. rosenbergii* to serve in the biological control of schistosome vector snails in fish ponds as well as its commercial value as an aquaculture crop is discussed.

H. de Barjac et al. (1981). Toxicity of Bacillus thuringiensis var. israelensis serotype H-14 for larvae of sandflies, the leishmaniasis vectors. Bull. Soc. Pathol. Exotique 74 (5) : 485-489

Demonstration is made of the pathogenicity of *B. thuringiensis* var. *israelensis* for larvae of *Phlebotomus*

papatasi and *Lutzomyia longipalpis* reared in the laboratory. This effect is mainly produced by the crystals (δ-endotoxin) of the bacteria.

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R.A. Hall, G. Zimmermann & A. Vey. Glasshouse Crops Research Institute, Littlehampton, UK ; Institut für biologische Schädlingsbekämpfung, Darmstadt, Germany ; Station de recherches de Pathologie Comparée, St Christol, France. Guidelines for the registration of entomogenous fungi as insecticides

An IOBC/WPRS study group was established in 1980 to consider what information a notifier should provide for registration of fungal insecticides. The safety protocols are arranged in a 3-tier system to facilitate decision-making when considering registration of a fungal product. Entirely negative results from the tier 1 test indicate acceptance of the fungus as safe. Positive results may lead to rejection of further tests in tiers 2 and/or 3 culminating in rejection or acceptance possibly with restrictions on the label. The guidelines are presented, under the auspices of the IOBC, purely as an advisory document.

R.L. Kirkland. Department of Entomology, University of Missouri, Columbia, USA. Biology of Iphialaux kimballi (Hym. : Braconidae), a parasite of Diatraea grandiosella (Lep. : Pyralidae)

In 1980, a survey of the natural enemies attacking *D. grandiosella* was undertaken in central Mexico. Ten primary parasites were found to attack *D. grandiosella*, or the related *D. saccharalis* and *D. lineolata* in corn. The gregarious parasite *I. kimballi* was the principal natural enemy at localized sites in the states of Morelos, Veracruz and Guanajuato. This paper elaborates its environmental requisites and behaviour as observed under laboratory and field conditions.

Aly H. Rasmy, S.M. Hafez & S.A. Elsawy. Department of Entomology, National Research Centre & Department of Plant Protection, Ain Shams University, Cairo, Egypt. Influence of prey species and stages on predatory efficiency and development of two phytoseiid mites

The effect of prey species and the different stages of prey on the predatory efficiency and biology of the phytoseiid mites, *Amblyseius gossipi* and *Typhlodromus mangiferus* sp.n., was studied. The tetranychid mite, *Tetranychus cucurbitacearum* is a more favourable prey for both predators than the twospotted spider mite, *T. urticae*.

S. Grenier & B. Delobel. Laboratoire de biologie animale, INSA, Villeurbanne, France. Pseudoperichaeta insidiosa, a new tachinid fly (Dip.) reared in Galleria mellonella (Lep.)

For the first time, *Pseudoperichaeta insidiosa*, a non-specific tachinid parasite of *Ostrinia nubilalis*, was reared on *Galleria mellonella*. With this substitution host, a yield of about 0.35 pupa per deposited planidium is obtained. Eight generations have been reared so far.

M.K. Giri, B.C. Pass, K.V. Yeargan & J.C. Parr. Department of Entomology, University of Kentucky, Lexington, Kentucky, USA. Behaviour, net reproduction, longevity and mummy-stage survival of Aphidius matricariae (Hym. Aphidiidae)

This study contributes to the understanding of the behaviour and biology of *A. matricariae*. The results, such as parasite-aphid ratio in culture and optimal temperature regimes for longevity and net reproduction, can be used to improve procedures for mass rearing of *A. matricariae* for biological control purposes.

A. Gröner & G. Döller. Institut für biologische Schädlingsbekämpfung, Darmstadt & Bundesforschungsanstalt für Viruskrankheiten der Tiere, Tübingen, Germany. Passage of infectious nuclear polyhedrosis virus by mice and chickens

After ingesting inclusion bodies of a nuclear polyhedrosis virus by mice and chickens, the faeces of these test animals showed virus activity, caused in mice by virions liberated from inclusion bodies and in chickens by unaltered inclusion bodies.

H. Van Waddill & W.H. Whitcomb. Agricultural Research and Education Center, University of Florida, Homestead & Department of Entomology and Nematology, University of Florida, Gainesville, USA. Release of Telenomus remus (Hym. Scelionidae) against Spodoptera frugiperda (Lep. : Noctuidae) in Florida, USA

Telenomus remus was released against fall armyworm, *Spodoptera frugiperda*, near Homestead, Florida, USA, from May 1975-May 1977. A small percentage (4.5) of the egg masses collected were parasitized by *T. remus* ; however, no recoveries were made in the months following the final release. *T. remus* apparently was not established in Florida.

D.P.A. Sands, R.C. Kassulke & K.L.S. Harley. CSIRO, Division of Entomology, Long Pocket Laboratories, Indooroopilly, Brisbane, Australia. Host specificity of Disonycha argentinensis (Col. : Chrysomelidae), an agent for the biological control of Alternanthera philoxeroides (Alligator weed) in Australia

The biology and host specificity of a colony of *D. argentinensis* imported from Brazil were investigated in quarantine in Australia to assess the suitability of this agent for biological control of *A. philoxeroides*. Host specificity studies indicated that establishment of this beetle in Australia would be without significant risk to non-target plant species. *D. argentinensis* was first released in Australia in 1980.

A.J. Wapshere, CSIRO, Biological Control Unit, Montpellier, France. Life histories and host specificities of the Echium flea beetles Longitarsus echii and L. laeneus (Col. Chrysomelidae)

Two halticine flea beetles, *Longitarsus echii* and *Longitarsus laeneus*, occurring on the boraginaceous plant *Echium plantagineum* in the western Mediterranean region are potential biological control agents in Australia where the plant has become a weed. The testing established that it would be safe to introduce the 2 insects into Australia for the biological control of *E. plantagineum* and they are now under quarantine.

W.V. Winnie & H.C. Chiang. Department of Entomology, Fisheries and Wildlife, University of Minnesota, Saint Paul, USA. Seasonal history of Macrocentrus grandii (Hym. : Braconidae) and Eriborus terebrans (Hym. : Ichneumonidae), two parasitoids of the European corn borer, Ostrinia nubilalis (Lep. : Pyralidae)

The seasonal histories and phenological relationships of European corn borer, *Ostrinia nubilalis*, and its 2 parasitoids, *Macrocentrus grandii* and *Eriborus terebrans*, were studied in south-central Minnesota. Both parasitoids overwintered in mature borer larvae, broke diapause, completed development and emerged at the same time as did borer adults. *M. grandii* was found to parasitize both generations of the European corn borer more effectively than did *E. terebrans*. The greater effectiveness of *M. grandii* was due to the closer synchrony of its seasonal history with that of the host.

P.A. Godwin & K.S. Shields. USDA, Forest Service, Northeastern Forest Experiment Station, Hamden, Connecticut, USA. Some interactions of Serratia marcescens nucleopolyhedrosis virus and Blepharipa pratensis (Dip. : Tachinidae) in Lymantria dispar (Lep. : Lymantriidae)

The entomopathogens *Serratia marcescens* and nucleopolyhedrosis virus were each fed alone and in combination with the parasite *Blepharipa pratensis* to 4th-instar gypsy moth *Lymantria dispar* larvae. The interaction between the NPV and the fly, or the bacterium and the fly, was not synergistic.

J.E. Henry & J.A. Onsager. USDA, Rangeland Insect Laboratory, Bozeman, Montana, USA. Experimental control of the Mormon cricket, Anabrus simplex, by Nosema locustae (Microspora : Microsporida), a protozoan parasite of grasshoppers (Ort. : Acrididae)

Spores of *Nosema locustae* were applied with aerial equipment for experimental control of the Mormon cricket, *Anabrus simplex*. The application resulted in infections in crickets during the season of application and the season following application. Reduced densities of crickets during the second season suggested effective control by *N. locustae*.

B.P. Condit & J.R. Cate. Department of Entomology, Texas A & M University, College Station, Texas, USA. Determination of host range in relation to systematics for Peristenus stygicus (Hym. : Braconidae), a parasitoid of Miridae

Several characteristics of the host selection process of *P. stygicus* were determined. Under laboratory conditions, the plants that the potential hosts inhabit do not generally deter these parasitoids in their search for hosts. In fact, olfactometer experiments indicated a synergistic effect of the presence of plant material on the host finding process. For *P. stygicus* the nature of phylogenetic relationships cannot effectively serve as the sole criterion on which to base predictions of host range.

L.C. Lewis, J. Lublinkhof, E.C. Berry & R.D. Gunnarson. USDA Corn Insects Research Unit, Ankeny Iowa & Department of Entomology, Iowa State University, Ames, Iowa, USA. Response of Ostrinia nubilalis (Lep. : Pyralidae) infected with Nosema pyrausta (Microsporida ; Nosematidae) to insecticides

The authors report the results of applying combinations of *Bacillus thuringiensis*, carbaryl and carbofuran to suppress larval populations of the European corn borer that were infected transovarially with *Nosema pyrausta*. The insecticides and *N. pyrausta* acted independently in reducing stalk damage by the European corn borer. There were no differences between percentage infected and intensity of infection in larvae treated with insecticides.

ENTOMOPHAGA

Many of you have been aware of recent difficulties in publishing Entomophaga and have voiced criticisms of the Journal. Recent delays in publication and poor quality of some numbers have been due entirely to the publisher whose contract we have at last been able to terminate. The Editor, Mr Hurpin, has now been able to negotiate a new contract with Lavoisier of Paris, a publishing house of high reputation with wide international links, so in future we can justifiably expect a high quality of production. Inevitably, there will be some increase in cost, though we hope that this will fall with increase in sales.

Entomophaga is technically the journal of the Global IOBC but naturally Regional Sections are concerned that it meets their needs, while the West Palaearctic Regional Section has administrative and financial responsibility for it. A representative *ad hoc* committee, chaired by the Editor, has been set up in order to examine how Entomophaga, as the only international journal devoted primarily to biological control, can hereafter meet the needs of biological control workers throughout the world.

At present, the policy of the journal is to accept original papers on biological methods of control against any noxious animals, diseases and weeds. Whilst papers on natural enemies are of prime importance, the journal also accepts contributions on other biologically based methods of control. Moreover, in keeping with its sub-title « A Journal of Biological and Integrated Control », contributions are welcomed on integrated control, notably where they involve significant biological control components.

We urgently solicit your current and constructive criticisms on the above terms of reference for the scientific content of the journal. We would also welcome comments and advice on all other aspects of journal content, organisation and objectives. Furthermore, we need advice on how the journal can better satisfy the needs of regions, especially in the tropics and Southern Hemisphere from which there are at present relatively few contributions (note that papers are accepted in English, French, German and Spanish languages). In offering advice, please remember that we are severely constrained by cost though this could be greatly lessened if the number of subscribers was increased. Therefore we also need your views and active assistance on how to increase sales. THIS IS YOUR JOURNAL. Its future depends on *you*. Do not delay in contacting us. Write as a matter of urgency to :

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