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Integrated Plant Protection in Stone Fruit

Protection Intégrée en Vergers de Fruit à Noyau

editors:

P. Cravedi & E. Mazzoni

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IOBC / WPRS

Working Group "Integrated plant protection in stone fruit"

OILB / SROP

Groupe de Travail "Protection intégrée en vergers de fruit à noyau"

PROCEEDINGS OF THE MEETING

COMPTE-RENDU DE LA REUNION"

Gödöllö (Hungary)
19-21 August 1998

Edited by
P. CRAVEDI & E. MAZZONI

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Introduction

The biennial meeting of the Working Group "Stone Fruit" was held between August 19th and August 22nd 1998 in Gödölló (Hungary).

Ferenk Kozár took over the organisation of the meeting. He organised also social events that have been very appreciated.

The site and the closeness with the VI European Congress of Entomology encouraged the participation of colleagues from very far countries. Participants were coming from Bulgaria, France, Greece, Hungary, Italy, Norway, Ukraine, Russia, United Kingdom and also from USA and Australia.

There were more than 20 papers read. Topics considered were about arthropod communities, biological and integrated pest control in stone fruit orchards, aphids' biology and resistance, Cherry Fruit Fly biology and control, and forecasting models of some pests. Scientists from European countries that never participated before in the WG "Stone fruit" meetings, were present (Norway, Greece, Bulgaria) and moreover also researchers from Australia and USA presented the results of their activity in stone fruit. So there was the opportunity to have also a few talks on phytosanitary problems in stone fruits in these countries and to make comparison between control strategies adopted.

Piero CRAVEDI
(Convenor)

Greetings to the joint meeting of IOBC/wprs and IOBC/eprs on "Integrated Pest Management in Stone Fruit"

Dr. JÓJÁRT László
Ministry of Agriculture and Rural Development

On behalf of the Ministry of Agriculture and Rural Development, I warmly greet all participants and guests of the Workshop on "Integrated Pest Management in Stone Fruit" organised by the West Palaearctic Regional Section (IOBC/WPRS) and East Palaearctic Regional Section (IOBC/EPRS) of the International Organisation for Biological and Integrated Control of Noxious Animals and Plants.

It is a great privilege for Hungary to host this extremely important and useful joint meeting which deals with several aspects of production of healthy fruits of high quality.

Prevention of the global ecological catastrophe threatening our Earth has become a common central subject and task of the international co-operation since the late 1980s. In 1992, twenty years after the first conference entitled "Man for the Environment", convened in Stockholm, 172 countries participated in Rio de Janeiro, at the World Conference of the UNO on the "Environment and Development". The President of the Hungarian Republic signed also these documents.

From the beginning of the 1990s, historical changes have taken place also in the food and agricultural sector in Hungary. Arrangement of the conditions for ownership, establishment of privately owned agricultural enterprises and holdings as well as adjustment of the production and distribution structure to the market requirements and criteria of the European Union have been realised at the same time.

All this has to be harmonised with the principles of the sustainable development, including sustainable agriculture. The Hungarian Government expressed his willingness to follow this line by signing the two agreements at the World Conference of UNO for Environment and Development. The environmental concept of the Hungarian agricultural government declares integration of the production objectives with the protection of natural resources taking the following factors into consideration during implementation:

- biological control methods,
- research, development and use in practice of environmentally-friendly, integrated pest management
- integrated production of high quality healthy food having a label or a trademark.

The Hungarian agricultural production considers as indispensable base for the research, development and introduction of integrated management

- the guidelines of the IOBC
- the guidelines of the International Society for Horticultural Science (ISHS) worked out jointly with the IOBC and approved as follows:
  - ⇒ principles and guidelines of the "Integrated Agricultural Production"
  - ⇒ criteria for integrated production (product having a label or trademark),
  - ⇒ Technical Guidelines for Integrated Production in Europe: pomefruits, stonefruits and small fruits.

Some results.

1) A milestone in our legislation was the ministerial law No. 79 on land tax including some tax reduction in case of the use of some environmentally friendly techniques in farming. Encouraging the use of integrated production, the objective of this regulation is

- the reduction of toxic chemicals harmful for the environment;
- the direct consumption, animal feeding or further processing of plants and plant products;
- the prevention of food contaminants harmful for the health;
- the spread of techniques maintaining and preserving soil productivity;
- establishment of biological diversity.

2) Methods of organic farming have been widely spread for decades. The Ministry of Agriculture provided, in 1997 and 1998, 100 million Hungarian Forints of grants and projects to the farmers engaged in organic farming.

3) The Hungarian plant protection and soil conservation organisation pays special attention to the protection of the living habitat, the agro-biocenosis and the natural enemies (parasites, predators, etc.) during the official registration procedures of the plant protection products. With this in mind, it runs special laboratories, e.g. Water Surface Lab (Százhalombatta), Ecotoxicity Lab (Fácánkert), Biological Control and Quarantine Development Lab (Hódmezõvásárhely). The Insect Parasitology Lab in county Vas (Kõszeg) has been internationally recognised and has wide international contacts.

4) The new "Plant Health Law" will be approved by the Hungarian Parliament next year. In conformity with the criteria of the European Union, it contains administrative and practical tasks of the

- integrated agricultural production,
- environmental friendly plant protection and soil management.

5) Another milestone for the quality fruit production in Hungary is that last year the first Hungarian product issued from integrated production and having a trademark was born. It is the so-called GEA-apple, which means "Guaranteed Ecological Apples". In October 1997 all passengers of the MALÉV, the Hungarian Airline got a GEA-apple inducing national and international recognition. This year several apple growers wanted to shift to producing GEA-apples.

At the turning of the millenary, at the beginning of the 21st century, during the process of Hungary in joining the European Union, it has become a critical and vital question for the Hungarian agriculture, the agricultural government as well as the growers

- to shape the ways to sustainable agriculture by maintaining the natural resources,
- to establish growing conditions to produce healthy products with a trademark.

I think that the IOBC workshop can greatly help us and contribute to solve our national and international tasks of the protection of health and environment that are ahead us. I wish therefore many successes in this difficult task.

I wish all of you an agreeable stay in Hungary. I hope you will enjoy the special events of the 20th of August, when we celebrate our first king, Stephan 1, founder of Hungary, as well as the new bread.

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Contents

Integrated plant protection of stone fruits in Hungary

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Abstract: The situation of stone fruit production in Hungary is reported. The main pests and diseases are listed togheter with the classification of pesticides according to their suitability for IPM.

Key words: IPM, extention service, guidelines

Introduction

In Hungary there is a significant declining in production of stone fruit during the last 10 years. Let me mention some of the many reasons: 1) getting old of orchards and new plantations are omitted; 2) changing of the owner system because of the change of regime and compensation; 3) dwindling of the eastern market; 4) privatisation of fruit wholesale trade.

This crisis is also on nowadays though the agricultural supporting system can bring flourish with some new plantations. We do not have precise statistical data about the extent of stone fruit growing area. According to 1996 statistical data collected by Hungarian plant protection service and taking into consideration the areas over 3000 m^2 the area of stone fruit growing is reported in table 1.

Table 1. Approximate Stone fruit orchard area in 1996, in Hungary

Stone fruit	ha
Cherry	635
Sour cherry	4111
Plum	3244
Apricot	3275
Peach	3310
Total	14575

This situation must be considered a temporary one because our situation of ecology, the existing biological fundaments our chance of joining to EU, national agricultural supporting system can bring the prosperity of stone fruit production.

Integrated fruit production has been quickly spread in Europe since the beginning of '90s. During 3 years the European integrated fruit growing area enlarged with 40 %.

Integrated fruit growing is a special economical growing method that produces outstanding quality fruit in such circumstances which reduces the agrochemical factors disadvantageous by effects to the least possible level in order to protect people and their environment. When growing fruit it especially takes care of the protection of environment.

In Hungary just like in other European countries the elaboration of the integrated pest Management of apple started the .earliest. But simultaneously in some stone fruit growing areas and cultures (apricot and peach) environment protecting, integrated control trials based on biological fundaments have also been started such as the foundation of integrated pest management. Nowadays it hasn't been a general growing practice but in many of its details there are some good results.

Among experts this environment protecting aspect is more and more known and it has got many enthusiastic followers.

But the change of Hungarian agriculture slowed down the introduction of integrated fruit production.

In Hungary we have the most experiences in two stone fruit cultures: apricot and peach. Hungarian technologies are guided by principles and requirements of IOBC'S recommendations. For plantation and type of fruit the area having the best site potentials can be chosen on requirements of the Hungarian Organisation "Survey about Suitable Fruit Growing Area of Hungary" (Fig. 1).

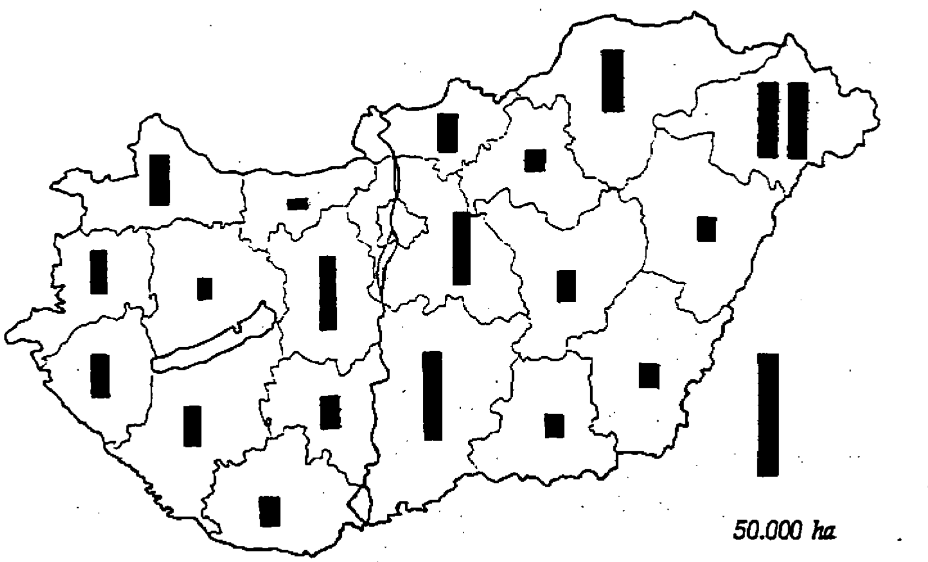

Figure 1. Survey about suitable fruit growing area in Hungary.

Choosing rootstock and species can happen only with knowing its resistance and tolerance against main pests.

Each of our growing species is sensitive to plum pox PPL virus. For plantation only propagation material controlled by state are used.

In Hungary the preparation of soil is by deep ploughing.

Meanwhile on the results of soil's analysis they do nutrient supply and if it's needed soil treatment, too.

Table 2. Some apricot variety behaviour of infection of *Gnomonia erythrostoma* with ascospora. Balatonboglár, 1995 (Makó, 1996)

Variety	Level of infection	Level of falling of the leaves	Level of falling of the fruit
C320	very heavy	total	Total
Gönci magyar kajszi	less infected	less falling	No falling
Gönci	less infected	no falling	No falling
Kécskei rózsa	less infected	less falling	less falling
Ceglédi óriás	middle infected	middle	less falling

In Hungary in stone fruit growing plantations, dominating nematode species is *Xiphinema vuittenezi* but *Xiphinema diversicaudatum* can also be found which is dangerous as a virus vector on the territories marked out to re - plantation it's necessary to control the appearance of nematodes.

Soil management

In Hungary precipitation system usually doesn't make it possible to form grass - grown space between two rows.

We have got a leading part in sour cherry's improvement to resistance. All over the world Hungary is the first country to have such sour cherry species (Csengõdi) which is not only economically valuable but also resistant to *Blumeriella jaapii* and *Monilia laxa*.

Table 3. Susceptibility of cherry and sour cherry varieties to *Monilia laxa* between 1990 and 1995 (Apostol, 1996) (Legend: 0 = no infection; 10 = totally infested).

Level of infection					
0	2	4	6	8	10
Csengödi	Favorit	Meteor korai	Cigány 59	Újfehértói fürtös	Pándy 48
	Érdi Nagygyümölcsü	Korai Pipacsmeggy	Cigány 3	Kántorjánosi	Pándy 279
		Maliga emléke	Hartai meggy		Érdi bötermö
			Debrecen bötermö		

When applying plant protection treatment the aim is keeping pests under danger level with an optimal ratio of chemical and non- chemical treatment.

Among useful living organisms the environment and plant protection technology based on insect - eater birds is well developed in the Hungarian Great Plain applied for the control of apricot. Between 1986 and 1995, 500 artificial cavities were set on 590 ha (1-2/ha). The more the cavities were, the larger number of birds appeared. The mass of insects eaten by birds was 36-40 kg/ha. On the plantations with cavities sex pheromone traps (2 traps/ha) and also diflubenzuron are used against moth. In these territories insecticides haven't been used since 1991. In such circumstances only *Enarmonia formosana* cause damage. The most important pests and pathogens on stone fruit in Hungary are reported in table 6.

Table 4. Susceptibility of cherry and sour cherry varieties to *Blumeriella jaapii* between 1990 and 1995 (Apostol, 1996) (Legend: 0 = no infection; 10 = totally infested).

	Level of infection					
	0	2	4	6	8	10
Sour cherry	Csengödi	Favorit	Érdi jubileum	Meteor korai	Cigány 59	Pándy 48
		Érdi nagy – gyümölcsü	Korai pipacs-meggy	Maliga emléke	Cigány 3	Pándy 279
						Érdi bötermö
						Újfehértói fürtös
						Kántorjánosi
						Debrecen bötermö
Cherry	Vega	Valerij cskalov		Germesdorfi 1		
	Müncheberg i korai	Solymári gömbölyü		Germesdofri 3		
	Szomolyai fekete	Margit		Biggarreau Burlat		
		Linda		Van		
		Katalin		Hedelfingeni		

Plant protection goes on with local observations with forecasting. E.g. at the appearing of ascosporas of *Gnomon erythrostoma* the beginning of application can be precisely timed. This usually happens in the middle of May in Bács - Kiskun County. It's a pleasure that more and more forecasting instruments (Lufft, HP - 100) help plant protection.

To monitoring insects, the use of *Grapholita molesta* and *Anarsia lineatella* sex - pheromone traps and *Rhagoletis cerasi* colour traps is spread. The time of application is adjusted to the appearance of first adults. In case of stone fruit chemical control follows the theory of logicality, defensive system according to systematic programmes is not characteristic. When choosing plant protection products the most updated chemicals belonging to integrated plant protection categories are most popular. They are divided in three lists: green, yellow and red, according to their IPM suitability (Tables 7-10).

Table 5. Pathogens and pests on stone fruit in Hungary.

Pathogens	Pests
Cherry and sour cherry	
Prune dwarf virus DDV Prunus necrotic ringspot virus PNRSV *Monilinia laxa* *Monilinia fructigena* *Blumeriella jaapii*	*Operophtera brumata* *Erannis defoliaria* Tortricidae *Rhagoletis cerasi* *Myzus cerasi*
Peach	
Plum pox PPV Apoplexy *Pseudomonas syrinage pv. Syringae* *Cytospora rubescens* *Cytospora leucostoma* *Taphrina deformans* *Spaerotheca pannosa var. Persicae* *Stigmina carpophylla* *Monilinia laxa* *Monilinia fructigena*	*Eulecanium corni* *Quadraspidiotus perniciosus* Mites *Myzus persicae* *Grapholita molesta* *Anarsia lineatella*
Apricot	
Plum pox PPV Apoplexy *Pseudomonas syrinage pv. Syringae* *Cytospora rubescens* *Cytospora leucostoma* *Verticillium dahliae* *Apiognomonia erythrostoma* *Monilinia laxa* *Monilinia fructigena*	*Quadraspidiotus perniciosus* *Enarmonia formosana* Tortricidae *Grapholita molesta* *Anarsia lineatella*
Plum	
Prune dwarf virus PDV Prunus necrotic ringspot virus PNRSV *Taphrina pruni* *Polystigma rubrum* *Monilinia fructigena* *Monilinia laxa*	*Eulecanium corni* Aphids Mites *Haplocampa flava* *Grapholita funebrana*

Table 6. Insecticides (Notes: 1 = according to registration; 2 = a single use per year is proposed)

Green	Yellow	Red
vaselin oil	Amitraz (in pears)	DNOC
Calciumpolysulphide	Bensultap	barium polysulphide
Pirimicarb	Endosulfan	alfamethrin
Diflubenzuron	Phosalon	Asymethrin
Teflyubenzuron	Formothion	bifenthrin
Fenoxycarb	Chlorphyriphos-methyl	cypermethrin
Flufenoxuron[2]		deltamethrin
Bacillus thuringiensis[1]		fenvalerate
		fenpropathrin
		lambda-cihalothrin
		permethrin
		permethrin+
		tetramethrin
		dimethoat
		parathion-methyl
		dichlorphos
		phosphamidon
		quinalphos
		anzinphosmethyl
		triazophos
		methomyl
		phosmethylan
		mevinphos
		carbaryl
		fenitrothion
		methidathion
		etophenprox

Table 7. Acaricides (Notes: 1 = other fruits – except pears; 2 = only 1 time a year its application with other acaricides is not recommended)

Green	Yellow	Red
vaselin oil	Amitraz (pears)	bariumpolysulphid
Polysulphid+minerl oil		DNOC
Tetradifon		mineral oil
Propargit		cyhexatin
Fenbutation-oxid		bromopropylate
Flucycloxuron[2]		amitraz
Flufenoxuron[2]		fenpropathrin
clofentezin[2]		pyridaben
Hexthyazox[2]		

Table 8. Fungicides (Notes: 1 = susceptibility to copper is to be taken into consideration; 2 = during the season at the max rate of 3-4 kg/ha; 3 = bee and fish toxicity are to be taken into consideration; 4 = 3-4 times a year; 5 = they can be used only 3-4 times a year in mixtures with contact products; 6 = they are proposed for use only 2-3 times a year).

Green	Yellow	Red
copper – compounds[1]	Mancozeb[4]	benomyl
copper – oxychloride[1]	Propineb[4]	thiophanate-methyl
copper-sulphate[1]	zineb[4]	dinocap
copper-hydroxide	thiram[4]	pyrozophos
dodine	metiram[4]	
captán	copper-oxychloride+ zineb	
folpet	copper-hydroxide+ sulphur[1]	
folpet copper-oxychloride	sulphur[2]	
bupirimate	mitrothal-isopropyl+ sulphur	
iprodione[6]	nitrothal-isopropyl+ metiram	
chlorthalonyl	dithianon[3]	
procymidone[6]	diniconazol[5]	
triforine[6]	bitertanol[5]	
vinclozolin[6]	fenarimol	
	flusilazole[5]	
	hexaconazole[5]	
	myclobutanil[5]	
	nuarimol[5]	
	penconazol[5]	
	pyrifenox[5]	
	triadimefon[5]	
	difenconazol[5]	

Table 9. Herbicides (Notes: 1 = only for tree-row treatment; 2 = for the treatment of spots infested with weeds).

Green	Yellow	Red
glyphosate[1]	Dichlobenil[2]	acetochlor
glufosinate-ammonium	Fluazifop-buthyl[2]	actinit
	Fluazifop-P-buthyl[2]	diquat
	Haloxyfop[2]	diuron
	Quizalofop-ethyl[2]	fluroxypyr
	Sethoxydim[2]	chlorbromuron
		linuron
		monolinorun
		oxadiazon
		paraquat
		propyzamide
		terbacil
		terbumeton
		terbuthylazine

Chemicals on the green list can be used without limits in integrated production. The ones on the yellow list can be applied only with the given limits, notes, technological methods. Those which are on the Red List are used strictly only in case of preventing damage.

In case of stone fruit to have autumn foliage disinfection and treatment in stage of rest is very important.

Among phytotechnical jobs the definition of pruning's exact time, and treatment of wounds' and damages are the effective protections against diseases causing early decay of trees (e.g. *Pseudomonas syringae*, *Cystospora* spp.)

At last we must say with self - criticism that in Hungary the weakest part of IPM technologies is applied technology. With overworn machines which are not in the required technical position and are not regulary servised the theory and practical realization are far from each other.

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Structure of the Arthropod Community on Peach in North America

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Abstract: A total of 162 species of arthropods were recorded as part of the arthropod community associated with peach in eastern West Virginia, USA. The community was composed of 33% phytophages, 35% insectivores, 14% scavengers, and 18% tourists. Diversity of the arthropod community was correlated inversely with intensity of orchard management. Diversity of the phytophagous arthropod community was significantly less in peach than was previously found in apple in the same region. Diversity of the communities on peach and apple were more similar in commercially managed orchards than in unmanaged orchards. In commercially managed orchards insecticides are the dominant factor controlling arthropod community structure, whereas in an unmanaged environment the communities develop a different structure as determined by characteristics of the host plant.

Key words: orchard management, beneficial arthropods

Introduction

A greater understanding of ecological interactions within an agroecosystem is needed as the use of insecticides is reduced and as fewer broad-spectrum chemicals are used. There has been little research conducted on the arthropod community dynamics in peach orchards beyond listing the species found in the orchard (Gorsuch *et al.*, 1989). This study was conducted to analyze the arthropod community in peach and evaluate the effect of different intensities of orchard management on that community. Level of pesticide use was the main difference in orchard management, but the level of horticultural management also varied. The results are compared with the community dynamics of arthropods on apple in the same region as studied by Brown & Adler (1989).

Materials and methods

Three peach orchards at the Appalachian Fruit Research Station, Kearneysville, West Virginia, USA, were sampled in 1991. The first orchard, planted in 1985, was managed using commercial practices including annual pruning, fertilization with 450 kg/ha 10-10-10 (N-P-K), irrigation, and intensive orchard floor management to eliminate broadleaf weeds. There were eight insecticide applications: dormant oil, 19 liters/ha, on 26 March; parathion, 0.2 kg (AI)/ha on 4 and 13 May; chlorpyrifos, 1.7 kg (AI)/ha, on 15 May; azinphosmethyl, 1.1 kg(AI)/ha, on 22 and 31 May; and carbaryl 2.8 kg (AI)/ha, on 13 June and 25 June. There were also eight applications of fungicide: ferbam, 1.7 kg (AI)/ha, on 26 March; captan, 2.2 kg (AI)/ha, on 4, 13, and 31 May; thiophanate-methyl, 0.78 kg (AI)/ha, on 4, 13, and 22 May; and sulfur, 16 kg (AI)/ha, on 22 May, 13 and 25 June, and 11 July.

The second orchard, also planted in 1985,was a planting of F1 crosses in the peach breeding program and was under reduced management. This orchard was not pruned or irrigated, was less intensively managed for weeds, and was fertilized with 280 kg/ha urea. Insecticides were applied 4 times: dormant oil, 19 liters/ha, on 21 March; and methomyl with phosmet, 0.3 kg (AI)/ha and 1.1 kg (AI)/ha, on 1 May, 28 May, and 24 June. There were also four applications of fungicides: ferbam, 1.7 kg (AI)/ha, on 21 March; captan, 2.2 kg (AI)/ha, on 11 and 28 May; thiophanate-methyl, 1.6 kg (AI)/ha, on 24 June; and sulfur, 12.8 kg (AI)/ha, on 24 June.

The third orchard, planted in 1981, with some additional plantings in 1984 and 1985, was a planting of exotic germplasm for use in the peach breeding program. The only management this orchard received was mowing and occasional herbicide application along the tree row to maintain tree vigor.

Orchards were sampled five times during 1991: 16 to 18 April, 14 to 17 May, 13 to 14 June, 9 to 12 July, and 21 to 28 August. Sampling was conducted at least 1 week after the most recent insecticide application. At each sample, 6 trees were randomly selected in each orchard. Six sub-samples were taken within each tree: 4 terminal branches, defined as all branches originating from a 3-year-old stem, in the mid-crown of the tree; and 2 scaffold limbs, from the tree trunk to 3-year-old wood, including minor limbs and sprouts originating from the scaffold limb. Sampling consisted of examining each branch section and recording the presence of all visible arthropods on that branch. The branch was approached slowly to record the more mobile species, followed by macroscopic and then closer examination with a 10X hand lens. Unknown specimens were collected for rearing and identification in the laboratory when possible. Species identifications and confirmations were provided by personnel at the Taxonomic Services Unit, Systematic Entomology Laboratory, U. S. Department of Agriculture, Agricultural Research Service, Beltsville, MD, USA.

Results

A total of 16 orders, 84 families, and 162 species were recorded as being part of the community of arthropods associated with peach. A complete species list was presented in Brown & Puterka (1997). Of these arthropods, 33% were phytophages, 35% were insectivores, 14% were scavengers, and 18% were tourists (as defined by Moran & Southwood (1982)). The total number of taxa was lowest in April and peaked in July. Abundance of phytophages followed the same pattern as for total taxa. Insectivores were the most abundant trophic group in April, July and August. Tourist species were most abundant in May, and scavengers were most abundant in July. There were no significant differences among orchards in the abundance of the various trophic groups.

In the commercially managed orchard, *Panonychus ulmi* (Koch) (Tetranychidae) was dominant in each sample, except in May; in the minimally-sprayed orchard this mite was dominant only in August. In the unsprayed orchard, *P. ulmi* was uncommon but *Aculus cornutus* (Banks) (Eriophyidae) was dominant in May. The eriophyid mite was uncommon in the sprayed orchards. Ants were rare in the commercially managed orchard but were dominant in the other orchards, especially *Prenolepis imparis* (Say), *Formica subsericea* (Say) and *Lasius* sp. The scavenger, *Bibio femoratus* Wiedemann (Diptera: Bibionidae), was dominant in May and thrips, *Frankliniella tritici* (Fitch) and *Neohydatothrips variabilis* (Beach), were dominant in the late season in the two sprayed orchards.

Diversity indices showed a significant increase in diversity of the arthropod community (all trophic groups combined) associated with a decrease in the intensity of management. There was a significantly higher number of species in the unsprayed orchard than in the commercially managed orchard (Friedman test, P=0.05). Differences were detected in the Shannon index among the three management intensities in each month (Table 1). The unmanaged orchard consistently had the highest species diversity and, except in May, the commercially managed orchard had the lowest diversity.

Table 1. Shannon index of diversity for the arthropod community on peach by orchard management type, all trophic groups combined. Index values followed by the same letter within the same month are not significantly different using 95% confidence intervals.

Month	Unsprayed	Minimal Management	Commercially Managed
April	2.59 a	2.30 ab	2.02 b
May	3.13 a	2.43 b	2.47 b
June	3.67 a	2.73 b	2.37 c
July	3.39 a	3.36 a	2.32 b
August	3.34 a	2.82 b	2.63 b

Comparing the diversity of the phytophagous trophic group in peach with that of the phytophagous community in apple studied by Brown & Adler (1989) showed the community diversity on apple was greater than on peach. The size of the differences between peach and apple communities was affected by the intensity of management (Table 2). For all four diversity indices tested, the phytophagous community in the unsprayed peach orchard was significantly less diverse than in the unsprayed apple orchard. The phytophagous community in the minimally managed peach orchard was less diverse than that of the organic apple orchard using all except one index, but two indices were significant only at the P=0.10 level. Species richness was the only diversity index that showed a significant difference between communities on the two host plants in the commercially managed orchards.

Discussion

The arthropod community on peach showed the same responses to insecticide use and other management practices as has been reported in other agroecosystems (Liss *et al.*, 1986). With increased intensity of orchard management, diversity of the arthropod community decreased (Table 1). Insecticide use is the most important aspect of orchard management; pruning, fertilization, and irrigation also impact the arthropod community. These horticultural practices are designed to produce more vigorous trees but they also produce more favorable food sources for many phytophagous arthropods. The effects of all aspects of orchard management must be considered when designing pest management plans that rely on biological rather than chemical regulation of arthropod populations.

The diversity of the phytophagous community on peach was lower than on apple in West Virginia (Table 2). This was especially true for the unmanaged orchards. As management intensity increased, the diversity of the phytophagous community on peach approached the diversity of the community on apple for all indices except species richness. These results indicate that in managed orchards the controlling factor for community development is the use of insecticides. Historical factors, such as pesticide use in orchards, have been shown to be important determinants in the development of communities (Tanner *et al.*, 1996). Insecticide use had the effect of making the structure, but not the number of species present, of the phytophagous community on apple and peach similar. In orchards allowed to evolve naturally, without insecticides, the communities on peach and apple diverged to reveal differences imposed by characteristics of the host plant to their respective communities.

Table 2. Comparison between the structure of phytophagous arthropod communities on apple and peach. Probabilities are given for the Wilcoxon sign rank test of the null hypothesis: the diversity of the phytophagous community on peach is greater than or equal to that on apple (a significant difference means that the community on peach is less diverse than on apple).

Diversity Index	Unmanaged	Minimal	Commercial
Species richness[a]	P=0.05	P=0.10	P=0.05
Diversity[b]	P=0.05	P=0.05	P>0.10
Dominance[c]	P=0.05	P>0.10	P>0.10
Shannon	P=0.05	P=0.10	P>0.10

[a] Number of species in the phytophagous community.

[b] (Species number-1)/log(number of individuals) (Gleason, 1922)

[c] Proportion of the sample belonging to the most abundant species (Berger & Parker, 1970)

References

Berger, W.H. & Parker, F.L. 1970: Diversity of planktonic Forminifera in deep-sea sediments. Science 168: 1345-1347.

Brown, M.W. & Adler, C.R.L. 1989: Community structure of phytophagous arthropods on apple. Environ. Entomol. 18: 169-183.

Brown, M.W. & Puterka, G.J. 1997: Orchard management effects on the arthropod community on peach with comparison to apple. J. Entomol. Sci. 32: 165-182.

Gleason, H.A. 1922: On the relation between species and area. Ecology 3: 158-162.

Gorsuch, C.S., Lee, G.T. & Alverson, D.R. 1989: Arthropod species collected from peach trees in South Carolina utilizing a whole-tree sampling method. J. Agric. Entomol. 6: 233-255.

Liss, W.J., Gut, L.J., Westigard, P.H. & Warren, C.E. 1986: Perspectives on arthropod community structure, organization and development in agricultural crops. Ann. Rev. Entomol. 31: 455-478.

Moran, V.C. & Southwood, T.R.E. 1982: The guild composition of arthropod communities in trees. J. Anim. Ecol. 51: 289-306.

Tanner, J.E., Hughes, T.P. & Connell, J.H. 1996: The role of history in community dynamics: a modeling approach. Ecology 77: 108-117.

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Conversion to biological farming: effects on a peach orchard biocenose

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Abstract: The effects of conversion to organic farming were observed in a peach orchard in Tuscany. In 1996-98 the major pests and diseases were recorded in two adjacent plots: in the first, in conversion to organic farming, no synthetic pesticide was applied, while in the second a conventional control program with a reduced chemical input was applied.
In the same period, a survey on the presence and abundance of different species of Coleoptera Carabidae, used as bioindicators, was carried out.

Key words: Carabidae, pitfall traps.

Introduction

Producers and customers showed, since several years, an increasing interest for organic farming, and market requires more products free from chemical residues, and generally healthy.

In this situation the improvement of farming techniques based on a minimum use of chemicals or on natural pesticides, fungicides and manure may be profitable.

ARSIA (Regional Agency for the Development and Innovation in Agriculture of Tuscany), that is engaged in activities aimed at introducing and testing new techniques, is carrying out demonstration trials for biological farming in different crops, in the province of Grosseto.

Starting in 1994, a study for assessing the major pests and diseases and the presence of natural antagonists has been performed in a peach orchard. After two years, in 1996, the conversion to organic farming was started in the peach orchard, taking into consideration the pedoclimatic conditions of southern Tuscany.

Materials and methods

The farm is located in a flat area of the Albegna river valley, near the town of Manciano; it is 10 hectares wide, with different crops. Peach is the main fruit crop, covering 2 hectares, followed by plum, nashi and diospyros. Important are olive and alfalfa, the latter for improving the quality of the soil and for increasing biodiversity.

The soil origin is alluvial, deep and fertile. The climate is characterised by hot and dry summers and mild winters, with rare frosts. Rain is mainly in spring and fall.

After the first survey, carried out in 1994 and 1995, in 1996 a conversion to the organic farming of peach orchard has been undertaken. The 1-hectare orchard, set out in 1988, was aimed at evaluating the productivity and quality of 13 varieties in the specific environment.

All the cultivars were on GF 677 rootstock, 5 per 3 metres apart, with drip irrigation. In 1996, some early ripening varieties have been grafted on other, ripening after the end of July: this mainly to avoid medfly that attacks in late July-August.

Fertility and environment management
Before conversion, the soil has been superficially tilled to reduce adventice development and to reduce loss of water in the warm period. A green mulching with *Trifolium* sp. has been applied to increase organic matter. In order to improve biodiversity, spontaneous vegetation of the surroundings has been enriched with a hedgerow *Laurus nobilis*, *Rosmarinus officinalis*, *Arbutus unedo*, *Pistacia lentiscus*, *Genista* spp. *Fillirea* sp..

Visual sampling was used to assess the importance of diseases; pests were sampled visually and by means of different traps when available.

Treatments were recorded in the orchard and in a nearby orchard in which a conventional control program with a reduced chemical input was applied, following the EC directive 2078/92

Bioindicators
Changes in the environment can be pointed out with the aid of bioindicators: carabid beetles are often used in ecological studies for pointing out changes in some environments.

Ten pitfall traps were placed in the plot and in the control orchard (Fig. 1).

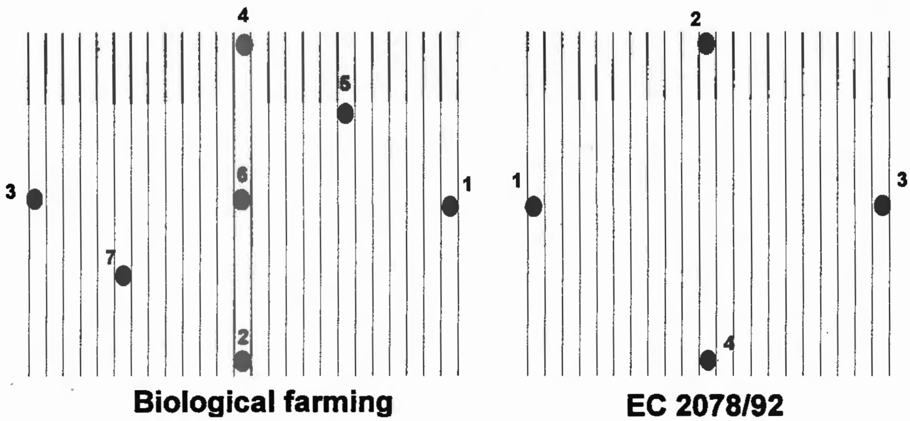

Figure 1. Layout of pitfall traps in the experimental peach orchard

Results

Diseases
Treatments are reported in tables 1-3. Leaf curl was present only in the spring of 1996, but no consequences on the production were recorded. The climate of the area is particularly favourable for Powdery mildew on nectarines, but the treatments with sulphur proved to be effective. Only pruning to air the canopy was applied against Blossom blight, that caused some heavy problems: in 1997, after cutting a central branch of each tree, less damage was recorded.

Table 1. Treatments applied in 1996 on biological (*) and "low input" peach orchards

Month	Pest/disease *	Active ingredient *	Pest/disease	Active Ingredient
February	Leaf Curl, Gum Spot, Canker Scales	Copper salt Lime Sulphur	Leaf Curl, Gum Spot, Canker Scales	Ziram Lime Sulphur
April	Thrips	Pyrethrum	Thrips, Leaf Curl	Pyrethrum + Ziram
May	Aphids	Pyrethrum	Aphids, Gum Spot P. mildew	Pirimicarb + Ziram Penconazole
June	P. mildew Aphids	Sulphur Pyrethrum	P. mildew , B. blight	Cyproconazole
July			Aphids	Heptenophos

Table 2. Treatments applied in 1997 on biological (*) and "low input" peach orchards

Month	Pest-disease *	Active ingredient *	Pest-disease	Active Ingredient
November 1996	L. curl, Gum spot, canker	Copper salt		
December 1996			L. curl, Gum spot, canker	Copper salt
January	Scales	Lime sulphur	Scales	Lime sulphur
February	L. curl, Gum spot, canker	Copper salt	Aphids	Oil + Pyrethrum
March	Aphids Thrips	Oil + Pyrethrum Pyrethrum		
April			Thrips, Leaf Curl	Pyrethrum + Ziram
May	Aphids P. mildew P. mildew Aphids	Sum. oil + Pyrethrum Sulphur Sulphur Sodium Silicate	Aphids P. mildew, B. blight P. mildew	Pirimicarb + Cyproconazole Sulphur
June	P. mildew P. mildew	Sulphur Sulphur	P. mildew, B. blight	Sulphur + Cyproconazole
July			Aphids P. mildew	Heptenophos Sulphur

Insects

The presence of *Cydia molesta* and *Anarsia lineatella* has been monitored with pheromone traps for adults and with shoot and fruit samplings for larvae. Except for the beginning of 1994 and 1997, low levels of *C. molesta* have been detected and fruit damage was also negligible. *A. lineatella* too showed low catches, with some increase in late July-early August, when all varieties of peach have usually been picked. For these reasons, no specific treatment has been applied for moths.

Aphids are a major pest: different species showed a similar pattern of presence in the different years. Early colonies of *Myzus persicae* and *Brachycaudus persicae* appear in April; the former became widespread, while the latter remained in scattered colonies. During May, colonies of *Myzus varians* and *Hyalopterus amygdali* are present. The last one spread out rapidly and during June completely infested plants can be found. This specie is active during all the summer time causing the biggest problems for the orchard. Predators (cecidomiids, syrphids, coccinellids and chrisopids) and parasitoids have been recorded in high numbers on aphid colonies, especially in June.

Ceratitis capitata, the Medfly, previously recorded in low populations, with some damage only on late ripening varieties, showed an increase in the years of the study, in connection with a series of mild winters. Natural products are scarcely effective and for this reason late ripening varieties have been replaced with early ones.

Thrips have been treated on nectarines with pyrethrum, but its efficacy was poor.

Table 3. Treatments applied in 1998 on biological (*) and "low input" peach orchards

Month	Pest-disease *	Active ingredient *	Pest-disease	Active Ingredient
November 1997	L. curl, Gum spot, canker	Copper salt		
December 1997	L. curl, Gum spot, canker	Copper salt	L. curl, Gum spot, canker	Copper salt
January	L. curl, Gum spot, canker	Copper salt	Scales	Lime sulphur
February	Scales	Lime sulphur	Aphids	Oil + Pyrethrum
April			Aphids, P. mildew, B. blight	Imidacloprid + Cyproconazole + Ziram
May	Aphids P. mildew (nectarines) Aphids	Sum. Oil + Pyrethrum Sulphur Pyrethrum + sodium Silicate	P. mildew, B. blight	Cyproconazole + Bitertanole
June	P. mildew	Sulphur	P. mildew P. mildew	Sulphur Cyproconazole

Bioindicators

A strong difference was recorded by the pitfall traps placed in the two plots: in the organic plot respectively 98.14 and 125.14 catches per trap were recorded in 1996 and 1997, while in the control only 12 and 28.5; more species were found in the organic plot as well (Table 4).

In the organic plot three species were dominant: *Steropus melas*, *Calathus fuscipes* and *Pseudophonus rufipes*.

Analysing the catches of each trap, it can be noticed that in 1996 the higher catches were in the trap 3, near the hedgerow and in 1997 in trap 6, in the middle of the plot. The lower catches were always recorded in trap 1, near the control plot, in which trap catches were less abundant (Fig. 2).

More observations are needed, but the first data seem to demonstrate a positive effect of hedgerow and organic practices on the complexity of the biocoenose.

Table 4. Catches of carabid beetles

	1996		1997	
Species	Organic	Control	Organic	Control
Steropus melas	586	4	666	24
Calathus fuscipes	59	7	81	45
Pseudophonus rufipes	15	13	107	37
Carabus coriaceus	2		10	1
Harpalus griseus			2	
Platysma macrum	1	8	2	1
Scybalicus oblongiusculus	4	8	2	3
Carterophonus cordicollis			1	3
Trechus quadristriatus	7	5		
Calathus melanocephalus	7			
Notiophilus biguttatus		2		
Nebria brevicollis	3			
Nebria sp.	3			
Calosoma auropunctatum			1	
Harpalus azureus			1	
Brachinus explodens		1		
Brachinus psophia			1	
Brachinus crepitans			1	
Dinodes decipiens			1	
number of species	10	8	13	7
total catches	687	48	876	114
catches/trap	98.1	12.0	125.1	28.5

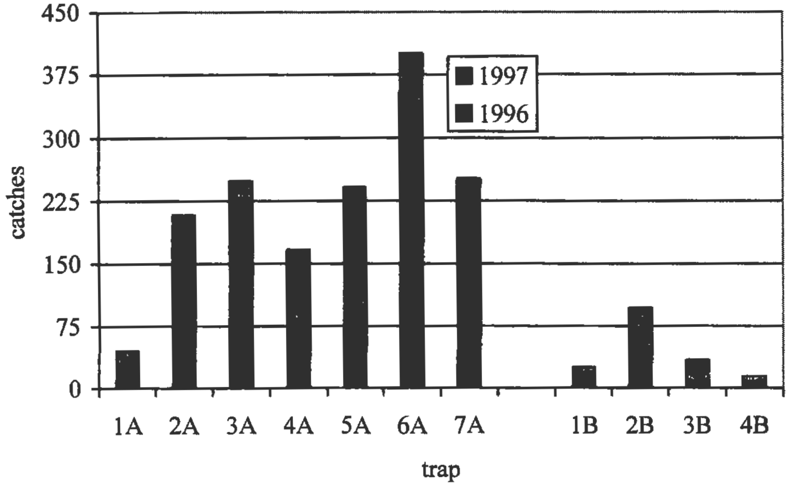

Figure 2. Total catches of carabids per trap

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Activity of aphid antagonists in peach orchards in northern Italy

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Abstract: From 1995 to 1998 the effects of aphids antagonists on aphids populations have been studied in some Emilia-Romagna peach orchards. The influence of different pest and disease control strategies on antagonist population was evaluated. The orchards with "advanced" IPM (control of *Cydia molesta* by mating disruption) where the best sites where antagonists are present and active. Coccinellids and Syrphids have been found in high numbers and alfa alfa fields nearby peach orchards also influenced the presence of antagonists. Population dynamic of the most important specie of Coleoptera Coccinellidae that has been found on peach: *Adalia bipunctata* L. was also investigated in 1997-98.

Key words: *Adalia bipunctata, Coccinella septempunctata, Myzus persicae,* Coccinellidae, Syrphidae.

Introduction

A decreasing efficacy of chemicals applied for aphid control is being recorded since some years: this fact adds a new technical meaning, besides the ecological one, to the research for improving antagonist activity.

The potential role of single species or of a natural enemies complex have been studied since many years and a general knowledge of their activity in orchards has been achieved after many authors' work (Savoiskaya, 1965; Niemczyk, 1987).

Nevertheless, the integration of aphid antagonist activity in IFP programs is still considered with some doubt.

The general IOBC IFP Guidelines (El Titi *et al.*, 1995), and the specific Guidelines for an Integrated Fruit production in Stone Fruit, give a clear indication for a need to study the complex of aphid antagonists, pointing out the most active species in each fruit growing area: "Populations of the main natural enemies of stone fruit pests must be preserved. At least two main natural enemies (e.g. parasites of scales or syrphid predators of aphids) in each crop must be identified in national/regional guidelines. This means plant protection products toxic to them may not be used." (Cross *et al.*, 1997).

The present research is a part of a program aimed at defining sustainable strategies for peach aphid control.

Materials and methods

A study on the effects of antagonists on aphid populations has been carried out in a four year period (1995-98) in some peach orchards in Emilia-Romagna (Table 1).

Preliminary observations were carried out in 1995 in three farms in which a noteworthy activity of aphid antagonists had previously been recorded. Two of these farms (Valle in S.

Romualdo-Ravenna and Belvedere, in Mezzano-Ravenna) have been examined through the whole four-year period. In 1996, other peach orchards have been inspected, to evaluate the influence of different pest control strategies on the aphid-antagonist situation.

Three typologies of orchards have been examined: chemical control, Integrated Pest Management and advanced Integrated Pest Management with strongly reduced chemical application, with Mating Disruption against *Cydia molesta* (Busk) (Table 1).

The ranking method proposed by ACTA (1974) has been used to give a measure of aphid infestation; according to this method, every tree is classified on the basis of the total number of colonies counted on it: class 0: tree without infested shoots; class 1: 1-5 infested shoots/tree; class 2: 6-25 infested shoots/tree; class 3: more than 25 infested shoots/tree.

In every orchard sampling has been carried out from March to August on 15 plants of the same variety; the average of the 15 values (from 0 to 3) has been considered as an infestation index.

The procedure has been integrated in 1998 with an estimation of the growing stage of the single colony of *M. persicae*. The number of shoots injured by aphids and with aphids (Well developed colonies), shoots injured by aphids but without aphids (Empty damaged shots) and infested undamaged shoots (New colonies), were counted on every plant.

Samples of colonies and insects have been carried to the laboratory. Predators were counted on each sample plant (Lövei & Radwan, 1988); specimens in different growing stages have been collected for identification.

Coccinellidae have been counted in a nearby alfalfa field, using the Quick Visual Method (Ives, 1981; Lapchin *et al.*, 1987): an operator walking in the field for 15 minutes counts the specimens he can observe.

In 1997 and 1998 data have been collected in the two farms near Ravenna which gave the best results in 1996, in order to know more about the different species of Coccinellid beetles. The sampling methods used in the study have given a good evaluation of the amount of aphids compared with the number of the most important antagonists.

Table 1. Experimental orchards.

Site	Province	1995	1996	1997	1998	Pest and disease control
Mezzano	Ravenna	X	X	X	X	Advanced IPM
San Romualdo	Ravenna	X	X	X	X	Advanced IPM
Carpinello	Forlì		X			Advanced IPM
Savarna	Ravenna		X			IPM
Castelvetro	Modena	X	X			IPM
Villa Rotta	Forlì		X			Chemical Control
Imola	Bologna		X			Chemical Control
Mordano	Bologna		X			Chemical Control
Castelguelfo	Parma		X			Chemical Control

Results

The activity of aphid antagonists, especially predators, has been very important in some orchards. In 1995 the colonies of *M. persicae* have been completely suppressed since the first period of development.

In 1996, different pest management strategy, showed an influence on the development of aphids and their antagonists. In fact, in chemically treated orchards, low aphid populations and no antagonist have been recorded. On the contrary, in S. Romualdo and Mezzano, antagonist presence has been always high. *M. persicae* has been the major aphid species in these farms, with some presence *Brachycaudus schwartzii* Börner and *Hyalopterus amygdali* (Blanchard) in late spring.

Table 2. Antagonists on peach.

Order	Species	On peach	On spontaneous vegetation
Neuroptera	*Chrysopa formosa* Brauer	+	+
	Chrysopa perla L.	+	+
	Chrysoperla carnea (Stephens) s.l.	+	
	Mallada prasinus (Burmeister)	+	
	Hemerobius micans Olivier	+	
Coleoptera	*Adalia bipunctata* L.	++++	+
	Propylea quatuordecimpunctata L.	++	++++
	Hippodamia variegata (Goeze)	+	+++
	Oenopia conglobata (L.)	+	
	Coccinella septempunctata L.	+++	+++
	Scymnus apetzi Mulsant	+	
Diptera	*Episyrphus balteatus* (DeGeer)	+++	+++
	Syrphus ribesii (L.)	+	++
	Scaeva pyrastri (L.)		++

Coccinellids and Sirphids have been found in high numbers (Table 2; Figs. 1 - 2). In S. Romualdo (Ravenna), *A. bipunctata* and *C. septempunctata* were present in high number on peach during the whole season (Figs. 3 - 4); *A. bipunctata* is generally considered the most active species against aphids on peach (Putman, 1964; Kreiter & Iperti, 1986); the activity of *C. septempunctata* is generally well-know for herbaceous plants (Iperti, 1965; Honek, 1985), even though it has been found on peach in Italy (Niccoli *et al.*, 1994).

The population dynamic of this two Coccinellid species have been pointed out in 1997. *A. bipunctata* adults arrived in May, in correlation with the growing up of aphids population, and they suddenly laid eggs (Fig. 3). First instar larvae appeared after a week, with a peak of presence at the end of May.

Many of *C. septempunctata* larvae were present since the week before (Fig. 4). A strong decrease of *M. persicae* was recorded in connection with the peak of Coccinellid presence. A constantly high presence of *C. septempunctata* has been recorded in a large alfalfa field nearby the peach orchard (Fig. 5).

In 1998 *A. bipunctata* has been the most active antagonist of aphids on peach (Figs. 6 - 7).

"New" colonies were quite constant in the whole infestation period, "well developed" colonies (damaging the plant) showed a single peak on the first decade of May (Mezzano, Fig. 8), or two different peaks, the higher one on the end of May (S. Romualdo, Fig. 9).

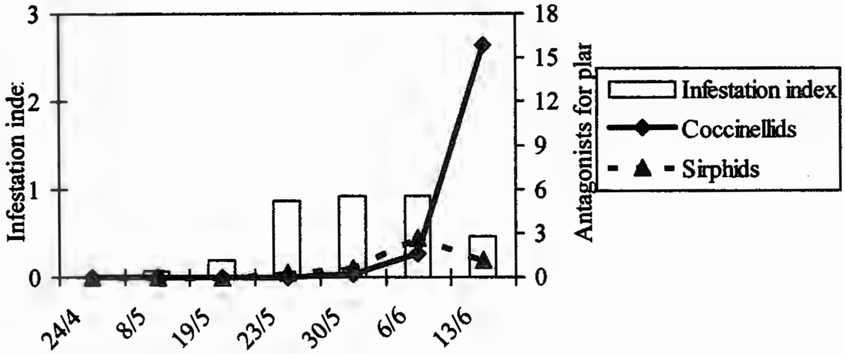

Figure 1.Valle farm (RA), 1996 - Major antagonists on peach and infestation level

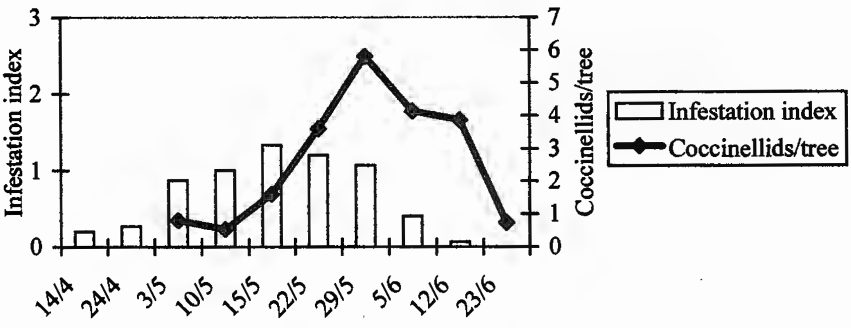

Figure 2.Valle farm (RA), 1997 – Coccinellids on peach.

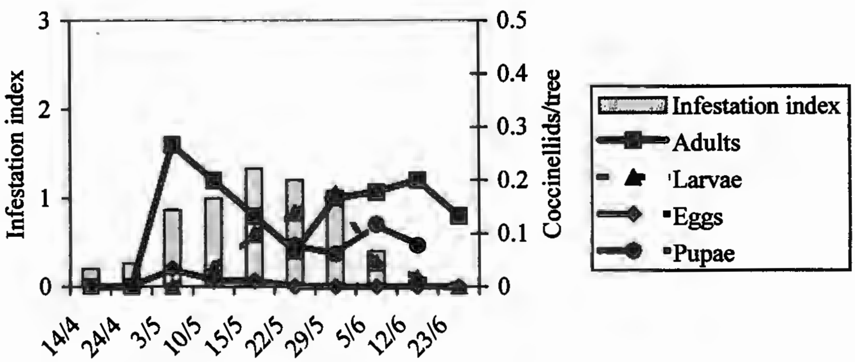

Figure 3. Valle farm (RA), 1997 – *Adalia bipunctata* on peach.

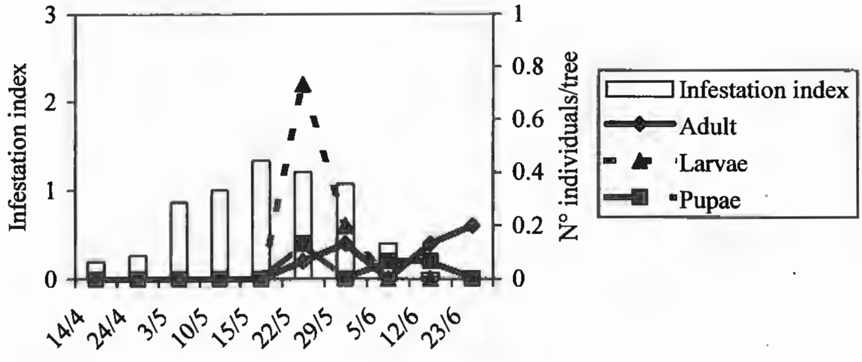

Figure 4. Valle farm (RA), 1997 – *Coccinella septempunctata* on peach.

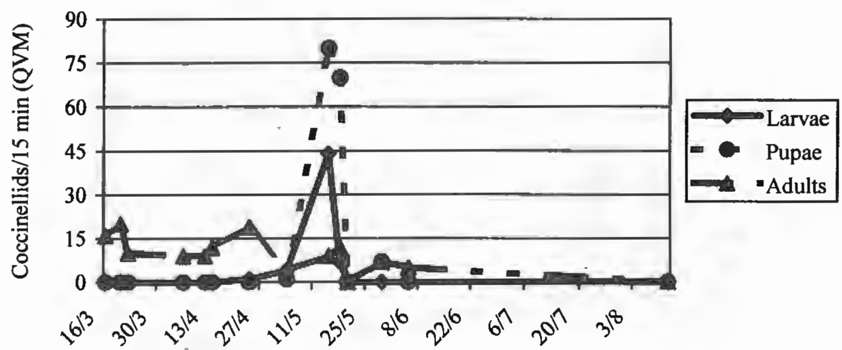

Figure 5. Valle farm (RA), 1997 – *Coccinella septempunctata* on alfalfa.

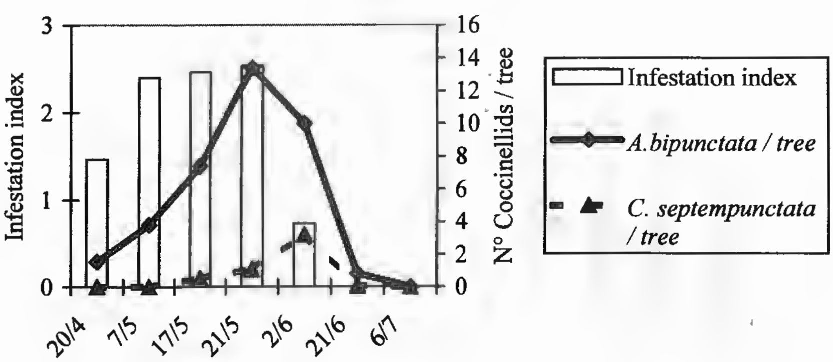

Figure 6. Valle farm (RA), 1998 – Development of *Adalia bipunctata* and *Coccinella septempunctata* on peach.

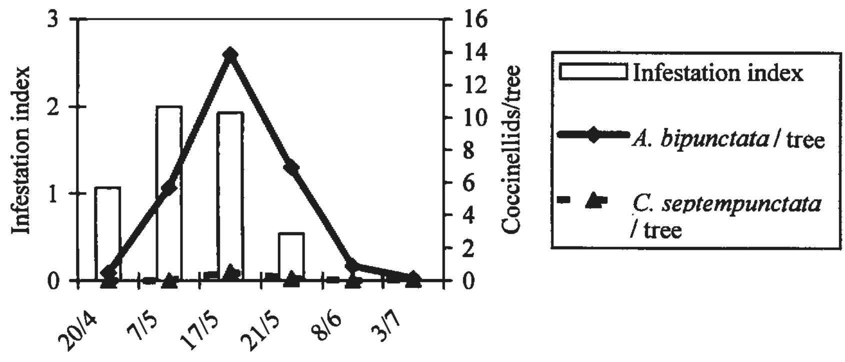

Figure 7. Belvedere farm (RA), 1998 – *Adalia bipunctata* and *Coccinella septempunctata* on peach.

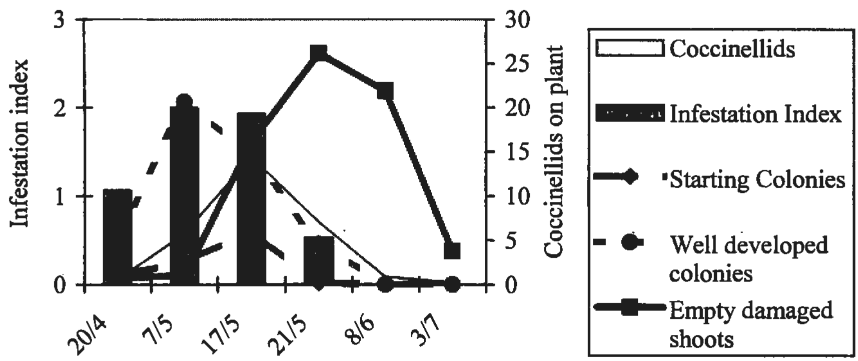

Figure 8. Belvedere farm (RA), 1998 – Infestation of *Myzus persicae* on peach.

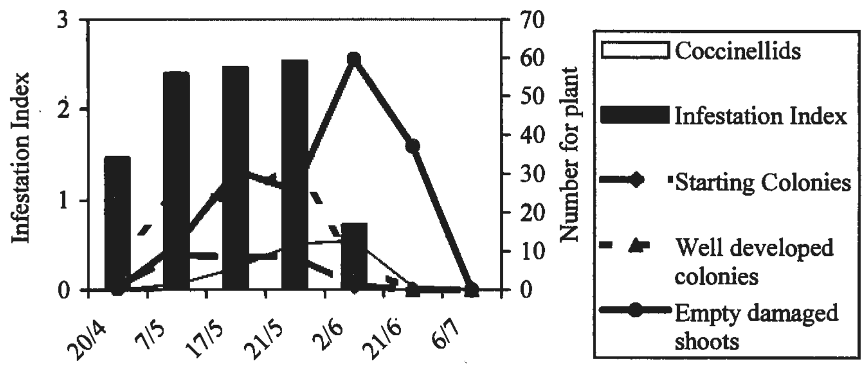

Figure 9. Valle farm (RA), 1998 – Infestation of *Myzus persicae* on peach.

The maximum numbers of Coccinellids have been observed in coincidence with these peaks, followed by an increase of the number of "empty damaged shoots".

Conclusions

The activity of beneficial insects can in some conditions control *M. persicae* colonies, but this action needs some help, like an IFP programme with a reduced use of pesticides for some years. In Mezzano and S. Romualdo, aphids are not controlled with pesticides since many years.

In these places the activity of *A. bipunctata* and *C. septempunctata*, seems to be synergic, according to the findings of Savoiskaya in apple orchards (1965). After the first control action made by *A. bipunctata* against the new "well developed colonies" and the "starting colonies", III° and IV° instar larvae of *C. septempunctata* came from the spontaneous vegetation present under the peach, and spread first on the sprouts of the trunk and afterwards on the whole plant.

C. septempunctata, from the preferred herbaceous habitat, tends to go on shrubs and trees when the preys aren't enough for it. This, considered the voracity of this species, often coincides with the presence of III° or IV° instar larvae.

The impact of these two species on aphid colonies is different, because *C. septempunctata* stays on the tree only for few days but its action could, however, be the final stroke on aphid colonies, reduced after the action of *A. bipunctata*.

The early presence of these two species on peach when aphids are in the starting period of growth, is probably the key for the antagonist's success. As many Authors suggest (e.g. Van Emden, 1965), in fact the "synchronisation" of the antagonist's appear with the phytophagous is one of the most important aspects to guarantee an effective control.

This active presence can be helped by a peach orchard management that keeps into consideration the positive effect of the presence of sites for hibernation and the surrounding vegetation as bushes and flowering plants: shelter and source of alternative hosts and prey, before aphid infestation on peach, can be found in crops (alfalfa fields) or spontaneous vegetation (inter-row with *Cirsium* sp. and *Sonchus* sp.).

Better sampling methods are needed to improve prediction of the number of antagonists and the level of aphid infestation, not only on peach tree, but also on herbaceous plants and shrubs. Spontaneous plants in the peach orchard can harbour a considerable number of antagonists in different instars, feeding on different species of aphids.

The observations could assess an unsatisfactory efficiency of the aphidophagous complex, which was active against *M. persicae*, against *Brachycaudus* sp. or *Hyalopterus amygdali*.

References

ACTA 1974: Protection integrée. Controles periodiques en vergers de pecher

Cross, J.V., Malavolta, C. & Jörg, E. 1997: Guidelines for integrated Production of Stone Fruits in Europe. Tecnical Guideline III. Bull. OILB/SROP 20(3): 1-51.

El Titi, A., Boller, E.F. & Gendrier, J.P. 1995: Produzione Integrata. Principi e Direttive tecniche. Bull. OILB/SROP 18(1,2): 1-27.

Honêk, A. 1985: Habitat preferences of aphidophagous Coccinellids (Coleoptera). Entomophaga 30(3): 253-264.

Iperti, G. 1965: Contribution a l'etude de la specificité chez les principales Coccinelles aphidiphages des Alpes-Maritimes et des Basses-Alpes. Entomophaga 10(2): 159-178.

Kreiter, S. & Iperti, G. 1986: Effectiveness of *Adalia bipunctata* against aphids in a peach orchard with special reference to ant/aphid relationships. In Hodek I. (ed.) Ecology of Aphidophaga. Academia, Prague: 537-543.

Ives, P.M. 1981: Estimation of coccinellid number and movement in the field. Can. Ent. 113: 981-997.

Lapchin, L., Ferran, A., Iperti, G., Rabasse, J.M. & Lyon, J.P. 1987: Coccinellids (Coleoptera: Coccinellidae) and syrphids (Diptera : Sirphidae) as predators of aphids in cereal crops: A comparisonof sampling metods. Can. Ent. 119: 815-822.

Niccoli, A., Fagnani, F. & Sacchetti, P. 1994: Predatori degli afidi del pesco in Toscana. Frutticoltura 43: 139-142

Niemczk, E. 1987: Effectiveness of aphidophaga in apple orchards. International Symposium of Ecology and effectiveness of aphidophaga, Teresin, Poland, 1987: 215-217

Putman, W.L. 1964: Occurrence and food of some Coccinellids (Coleoptera) in Ontario Peach Orchards. Can. Ent. 96: 1149-1155.

Savoiskaya, G. I. 1965: The significance of Coccinellidae in the Biological Control of apple-tree aphids in Alma-Ata fruit-growing region. In Hodek I. (ed.) Ecology of aphidophagous insects. Academia, Prague: 317-319.

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Arguments on the integrated plant protection in Hungary

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Abstract: The situation of pesticide use in Hungary, from the point of view of a chemical industry is reported. Environmental and economic considerations are presented.

Key words: pesticides, control strategies, economic analysis

Introduction

Summit-Agro Hungaria Kft. (the Hungarian subsidiary of the Japanese Sumitomo Corporation Trading House) distributes in Hungary more than 35 pesticides of 13 chemical factories. In respect of insecticides and fungicides it offers complex technologies in almost all cultures.

The wide range of pesticide available allowed the company to sell its products (already for more than 10 years) in view of the following professional priorities: a) environmental priority; b) rotation of products with different mode of action; c) economical priority.

These three priorities are interrelated and can collectively be defined as economic efficiency factor. This publication is not intended to analyse in details all of these relations but in this connection reference should be made to the high prices of the newly developed pesticide (it is economical to maintain the presently used products) or the quality or trade policy criteria and other sanctions making the export of agricultural products difficult mainly for reasons of presence of pesticide residue in the agricultural products.

The relationship of the environmental protection and the plant protection (pesticide usage) has been a highlighted issue lately discussed in both the daily papers and the scientific reviews.

Table 1. Farming (Plant Protection) Trends – Methods

Traditional farming	using all registered pesticides
Integrated pest management (IPM)	priority of environmental protection and chemical rotation
Organic farming	application of traditional chemicals is also allowed partly for sales considerations
Ecological farmers	Organic biological: e.g. the Hungarian biogrowers
Permaculture	harmony of the indigenous plants and the climatic conditions. A system based on the ecological relationship of the useful plants and animals.

In terms of environmental protection several cultivation trends (methods) and particularly plant protection methods have been established in the world, which are summarised in table 1, without aiming at completeness. In respect of Hungary it is worth mentioning two of the farming trends that take into account environmental aspects. These are "Integrated Pest Management" (IPM) and "Biofarming".

From environmental aspects the aim of "Biofarmers" is wider than that of the farmers applying integrated plant protection (IPM). The biofarmers are targeting the elimination of the following risk sources: a) pesticide production; b) pesticide transport; c) pesticide application; d) environmental damage of pesticide packaging waste.

Most of this aim seems to be correct, but regrettably, under the present world and especially hungarian economic conditions, these aims are unreal and infeasible. At the same time, the claim to reduce the mentioned risk sources to the minimum level is fully justified. Some ideas about this issue.

Pesticide production

In many cases the production itself may involve serious environmental risk, while the final product, the pesticide itself is provably harmless to the environment. The relevant risks can be reduced through closed-cycle automated systems to control all phases of production, as well as facilities for continuous air cleaning and wastewater purification.

Pesticide transport

This actually significant risk source can be reduced by adherence to the ever stricter specifications relevant to transport. For example: vehicles with ADR licence, documents for hazardous products to accompany the waybill (ADR Certificate), UN number, etc.

Pesticide application

This issue is covered in detail under the further parts of this article.

Environmental damage of pesticide packaging

This problem has been in existence all over the world for more decades, and it was only in the previous year that any remarkable action was taken in Hungary to mitigate this risk source by introduction of the environmental product duty. I do not intend to discuss here the relevant decree and its aspects affecting the development of pesticide formulations, but it is worth mentioning that it would serve the purposes of environmental protection if the granular and microgranular formulations (combining the advantages of the liquid and powder pesticide formulations) packed in environment-friendly paper or water soluble bag could be registered by expedite procedure (I mean by accelerating the bureaucratic process of the registration while not allowing technical and toxicological compromises).

It should be pointed out that the latter environmental risk sources (production, transport, packaging) apply not only to the pesticides but to almost all products surrounding us as well (production of pharmaceuticals, paints and other chemical products, production and transport of fuels, petrol, etc.), and thus discontinuation of pesticide production itself will only result in an insignificant improvement regarding reduction of the global environmental damage worldwide.

Interrelations of Biological Plant Protection, Integrated Plant Protection (IPM) and Environmental Protection

The biological plant protection only allows application of some natural substances (sulphur, copper, *Bacillus thuringiensis*, etc.), however it is easy to prove that: a) not all of the natural substances are at the same time friendly to the environment (e.g. sulphur kills the beneficial *Encarsia formosa* insect, etc.); b) several pesticides, though synthetically produced or artificially propagated (breeded), have natural origin. It would be reasonable to consider the application of these pesticides for production of Bio-products (examples: "Kasumin", "Polyoxin", that is kasugamicin and polyoxin antibiotics, fermentation products; "Bancol", that is bensultap; nereistoxin present in annelid and synthetically produced); c) several synthetic pesticides (not natural substances) also belong to the "environment-friendly" category (harmless to predators, parasites), such as a part of the systemic fungicides (triazoles), TMTD of the contact fungicides, acaricides: ("Nissorun") hexithiazox, etc.

To support these thoughts I listed in table 2 some pesticide active ingredients belonging to the natural substances and to synthetically or in factory produced pesticides, as well as the LD_{50} value of these active ingredients measured on rats (with the reservation that this indicator only refers to one of the environmental risk sources).

Table 2. Mammalian toxicity (LD_{50} in mg/kg) of some substances

Pesticide	LD_{50} (mg/kg)	Natural substance
Kasugamicin	20500	
	8000	Sugar
Malathion	2800	
	1000	Methanol
Acephathe	945	
	887	Methylsalicyl
	680	Cumarine
Cyhexatin	540	
	530	Phenol
Fenvalerate	500	
	380	Hydrochinon
Dimethoate	320	
Fenitrothion	170	
	150	Theine - caffeine
Pirimicarb	147	
Lindane	88	
	55	Nicotine
Carbofuran	14	
Parathion	13	
	2	Strychnine
	1	Atropine

It can be summarised that the environment friendly character of any pesticide will not depend primarily on its origin or production (synthetic or natural) but on its definable properties as follows:

- degradation (degradation dynamics, persistence);
- selectivity (effect on the useful creatures, such as predators, parasites, e.g. ladybird, Syrphidae, predatory mites, *Phytoseiulus persimilis*, *Amblysetus* sp.;
- toxicity of the pesticide and its decomposition product to mammalians fishes

and other living beings.

In view of the aforesaid, the pesticides can easily be classified from environmental aspects, as the above mentioned properties are included in the registration documents of the products and in the international technical literature.

Integrated Plant Protection (IPM)

The result of the pesticide classification according to the mentioned aspects (environmental and resistance breaking priority) is the so-called green-yellow-red categories. Application of chemicals belonging to the green and yellow categories is officially permitted in the "Integrated Plant Protection". The wide and ever expanding range of these products allows to select environment friendly IPM plant protection technologies in all crops without the need of any compromise in respect of quality and quantity (as compared to the traditional plant protection technologies). At the same time it should be pointed out that all these are only valid if the users follow the specifications stipulated in the relevant registration document (dosage, waiting time, etc.) and last but not least use up-to-date application techniques.

As I mentioned in the introductory part, one of the aspects (priorities) of the sales of pesticides is the economical priority.

The most common argument adduced against the integrated plant protection technologies (IPM) is that they are more expensive than the traditional (conventional) plant protection methods (ignoring the environmental aspects).

In order to discuss this issue I outline the aspects of economic priority already referred to in the foregoing part.

For calculation of the economic efficiency of pesticides of different characteristics it is reasonable to take into account the following aspects (in each situation different property of the product can be dominant by the economical calculation):

⇒ costs of pesticides (cost/ha) required for the protection of the given area; efficacy spectrum and in some situation it is economical if the given pesticide can kill at the same time more pest species (e.g. fenpropatrin (Danitol) - mites and Lepidopters, or whiteflies);

⇒ long lasting effect (residual activity) (e.g. hexythiazox (Nissorun) last 60-70 days);

⇒ waiting time (reentry and preharvest waiting time) and in some situations the short waiting time e.g. in case of Dipel, Novodor, Kasumin, Polyoxin may represent a special advantage;

⇒ environmental considerations (e.g. for IPM bioproduction Dipel, Novodor are indisputably economical);

⇒ formulation: EC (liquid), WP (powder spray), WG (microgranulate), etc. For example, in glasshouses the fumigant formulations (Sumilex GE) are much more economical than any other formulation;

⇒ packaging: size, quality, etc. (this issue was covered earlier).

In many cases even the monofactorial calculations can confirm that the costs per area unit of pesticides applicable for integrated protection (IPM) are not higher than those of the traditional (conventional) products (Table 3).

It appears from the table that though the absolute economic efficiency of piretroids (per 1 spray application) is indisputably favourable, nevertheless the costs per one hectare of methidation (Ultracid), dimethoate (Bi-58) applied in other traditional technologies are not lower than those of *Bacillus thuringiensis* (Dipel) or bensultap (Bancol) applied in IPM. At the same time, it is remarkable that the relatively wide range of pesticides recommended for IPM allows to meet the priority of pesticide rotation within IPM (given the above example, e.g. by application of Bancol and Dipel in rotation).

Table 3. Economic aspects of integrated plant protection in Hungarian apple orchards against Codling moth (Prices, in Hungarian Forints, refers to 1996).

Trade Name	Price HUF/kg-l	Dosage kg-l/ha	Cost HUF/ha	waiting time re-entry	pre-harvest
Traditional pesticides					
40% metidation	2821	1.0	2821	8	14
38% dimetoat	1038	2.5	2595	3	7
Pesticides of favourable mammalian toxicity (piretroids)					
25 g/l deltametrin	2919	0.3	875	3	3
5% esfenvalerat	2600	0.2	520	1	14
Environmental-friendly IPM pesticides					
25% diflubenzuron	10684	0.5	5342	0	14
150 g/l teflubenzuron	9524	0.75	7143	0	14
50% bensultap	1904	1.5	2856	1	21
Bacillus thuringiensis	1812	1.5	2718	0	0

It should be noted, however, that for consideration of the economic efficiency of the integrated protection (IPM) it is more reasonable to make polyfactorial calculations rather than monofactorial ones. The evaluation of the economic efficiency of acaricides is a good example thereof (Table 4).

Table 4. Economical judgement of acaricides (polyfactorial calculation) in 1998

	Nissuron (hexithiazox)	Magus (fenazaquin)	Ortus (fenpiroximat)	Sanmite (piridaben)	Mitac (amitraz)	Neoron (bropropilat)	Omite (propargit)	Danitol (fenpropatrin)
Distributor price (Ft/kg-l)	9850	9337	5570	12800	1794	3960	3736	3072
Dosage in apple (kg-l/ha)	0.5	0.7	1.0	0.75	6.0	1.3	1.7	1.0
Ha cost in apple Ft/ha	4925	6536	5570	9600	10764	5940	6351	3072
%	100%	132%	113%	195%	218%	120%	129%	62%
Long lasting efficacy (days)	60	50	60	50-60	12-14	25	25	25
Re-entry waiting time (days)	0	0	0	0	0	0	3	2
Pre-harvest waiting time (days)	7	14	4	7	14	30	10	14
Effect on predatory mites (beneficial mites) best: 99 %	99	99	99	99	58	62	68	89

The table shows that application of Danitol (pirethroid) seems to be the most economical if we only take into account the pesticide costs per area. On the other hand, if we consider 2 factors both the pesticide costs per area and the relevant effect duration long lasting (residual) efficacy, in this case the environmental-friendly (IPM) Nissorun proves to be the most economical of all acaricides.

Following this train of thought, the real economic efficiency of the integrated protection (IPM) can be calculated by complex comparison of the plant protection costs of the given culture through at least 1 year (but possibly more years). For example, in respect of protection against *Lema melanopus* in cereals (comparing the IPM bensultap (Bancol) with the not IPM pyrethroid "Decis") it is not reasonable to compare the costs of one application only. It is advisable to consider also the costs of protection against aphyds that can be saved through the integrated protection resulting in propagation of the aphyd predators. In case of using cheap pirethroids against *Lema* because of killing the aphyd predators, in the near future against aphyd a separate application can be necessary.

An actually true result can be obtained from complex calculations to take into account the plant protection costs of a farm integrating different cultures through more years, as the predators and parasites to propagate in the different cultures may coactively have beneficial effect on more cultures as well, and their real economic advantage (reduced number of applications) can only be demonstrated in this way.

Conclusion

The integrated plant protection (IPM) is an alternative to reduce the environmental hazard caused by pesticides, which is in the long term economical too, without the need of any compromise as to the quality and quantity of the crop. The border between "biogrowing" and the so-called integrated plant cultivation (IPM) (respecting environmental priorities) is not as sharp as it is thought to be, and in future is likely to fade away by expansion of the biological protection possibilities.

There is no point to overexpose the differences between the two trends. Our common duty is to protect the environment by all applicable means.

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Biology of *Myzus cerasi* and potential biological controls

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Abstract: There is a strong numerical relationship between the growth populations of cherry black fly (*Myzus cerasi*) and potential predators on *Prunus avium*. Spring migrants of *M. cerasi* did not respond to odours of *Galium aparine* and *Veronica persica* in an olfactometer, however, they did colonise plants of these species in a cage experiment. Male *M. cerasi* did not respond to odours from virgin sexual females in the olfactometer. They were repelled by odours of *Prunus avium*, the primary host of *M. cerasi*. Eggs of *M. cerasi* were hatched at a range of temperatures in order to determine the lower thermal threshold for development. That information could be used by growers to predict spraying times.

Key words: cherry, olfactometer, predators

Introduction

Cherry black fly (*Myzus cerasi* Fab.) is an economically important pest of *Prunus avium* (L).L. in Europe, North America and Australia. During spring the aphids aggregate on young growth, contorting the elongating shoots and producing honeydew that contaminates foliage and immature fruit.

The development of alternative strategies for the control of *M. cerasi* requires a detailed knowledge of the aphid's biology. There is little reliable information about *M. cerasi* in the UK, and controversy exists as to whether *M. cerasi* is autoecious (Gilmore, 1960) or heteroecious (Theobald, 1909). *Galium* spp. and *Veronica* spp. are purported to be the aphid's main secondary hosts.

Holocyclic aphids overwinter in the egg stage. Oviparous *M. cerasi* lay their eggs on *P. avium*, their primary host plant. The number of accumulated day degrees required for hatching *M. cerasi* eggs and their lower thermal threshold for development is unknown, but is known for other aphids such as *Chaetosiphon fragaefolii* (Cockerell) (Frazer & Raworth, 1984)

This paper describes field and laboratory studies aimed at gaining an improved understanding of the aphid's biology in order to develop alternative, more environmentally acceptable methods of control than the current reliance on pesticides.

Materials and methods

Counts were made of the number of aphids, predators and parasitoids on four branches on each of six trees at Horticulture Research International East Malling, UK. The aim was to determine the influence of the predator population development on *M. cerasi*.

A four-arm olfactometer (Petterson, 1970) was used to test the responses of winged spring migrants of *M. cerasi* to odours of *G. aparine*, *V. persica* and *P. avium*. Plants of *G. aparine* and *V. persica* plus a non-host (*Phaseolus vulgaris* L.) were arranged randomly in a large cage. Ten spring migrant aphids were released into the cage and the number of aphids on each plant was recorded after one hour. The experiment was repeated ten times using new aphids and plants for each replication.

Males were collected from the field site in October 1997 and their response to *M. cerasi* sexual females (oviparae) and odours of *P. avium* was tested using the olfactometer. Each treatment was replicated eight times.

Fertilised aphid eggs on flower buds were collected from the field in January and kept at 0 °C in an incubator. On 6 February batches of 10 eggs were placed at each of 5, 10 and 15 °C. The eggs were monitored daily to determine time of hatching. The accumulated number of day degrees and lower thermal threshold for development was calculated (Bodenheimer & Swirski, 1957). This procedure has been carried out on other aphids in order to determine thermal requirements and egg hatch (Dixon, 1976; Hand, 1983; Frazer & Raworth, 1984; Messing & AliNiazee, 1991).

Results

The numbers of *Myzus cerasi* ($p<0.05$) and predators ($p<0.09$) on *Prunus avium* increased 10 and 34 fold respectively between the 29 April and the 20 June. Numbers peaked on the 20 June and had dropped by 85% on the 27 June ($p<0.05$). Figure 1 shows the relationship between aphid numbers and the average number of all natural enemies[1] during April, May and June. There is a significant correlation between the log of the number of predators and aphids at each time point ($p<0.1$).

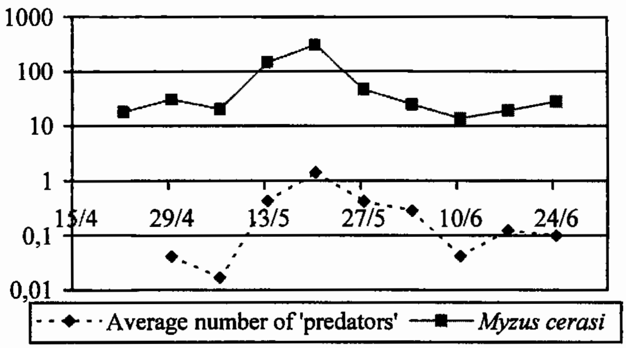

Figure 1: The number of *M. cerasi* and its potential predators on *Prunus avium* in 1998.

The first spring migrants began leaving fruiting trees of *Prunus avium* from 20 June, with increasing numbers of the nymphal population becoming alatoid thereafter. By contrast on young maiden trees that do not fruit, and continue growing during the summer, *M. cerasi* may persist for a much longer period and few winged individuals developed on these trees.

Spring migrants were produced on the experimental trees and the remaining apterae died.

[1] The average 'predator' population contains parasitoid mummies, syrphid and coccinellid eggs and larvae, and coccinellid adults

Migrant female (gynoparae) and male aphids re-colonised trees of *P. avium* in autumn, confirming that the aphid was heteroecious. None of the purported secondary hosts in the surrounding area was infested with *M. cerasi*.

No significant olfactory response by alate *M. cerasi* was found to odours, although for each secondary host alates remained longer in the treated arm than in the controls and the reverse for the primary host. In the cage experiment, spring migrants colonised both *G. aparine* and *V. persica* significantly more frequently ($p<0.01$) than they did the non-host *P. vulgaris* (Figs. 2 - 3).

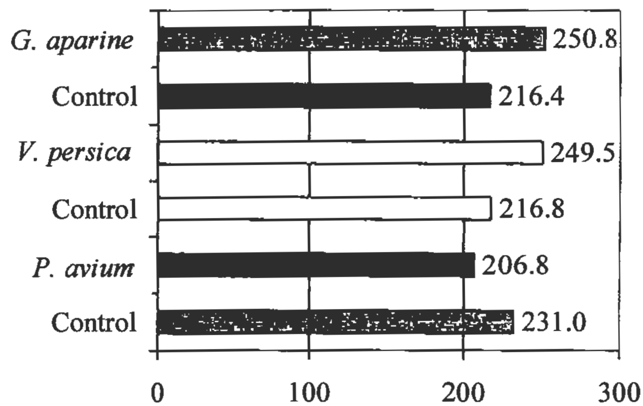

Figure 2: The response of *M. cerasi* to purported hosts in an olfactometer (seconds).

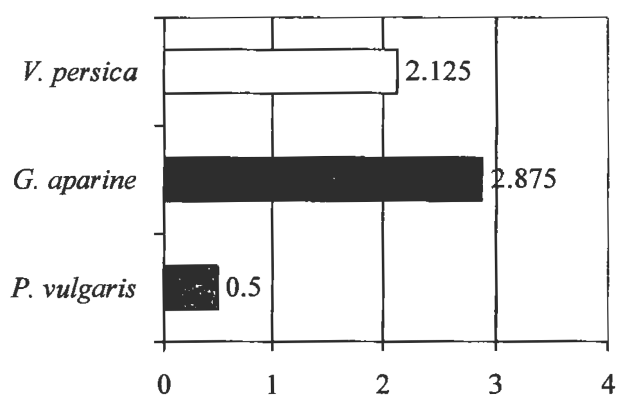

Figure 3: The response of *M. cerasi* to two purported secondary hosts and a non-host in a cage environment, 1997.

Male aphids did not respond significantly more to odours from conspecific oviparae than to controls, and inexplicably they were repelled significantly by odours from *P. avium* in the olfactometer ($p<0.01$) (Fig. 4).

The lower thermal threshold for *M. cerasi* egg development is calculated as –4.1°C. Figure 5 shows the development of *M. cerasi* eggs at three temperatures, 5, 10 and 15°C.

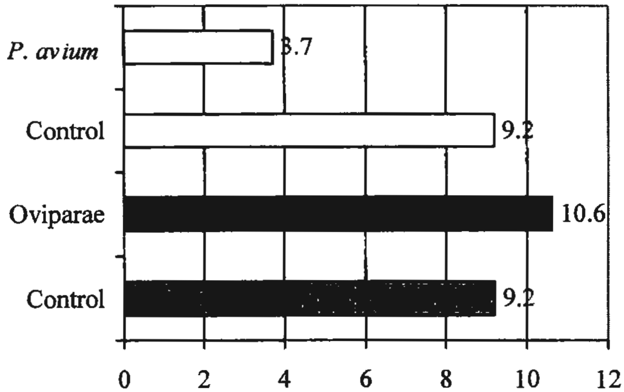

Figure 4: The response of male *M. cerasi* to conspecific oviparae and *P. avium* respectively (frequency) 1997.

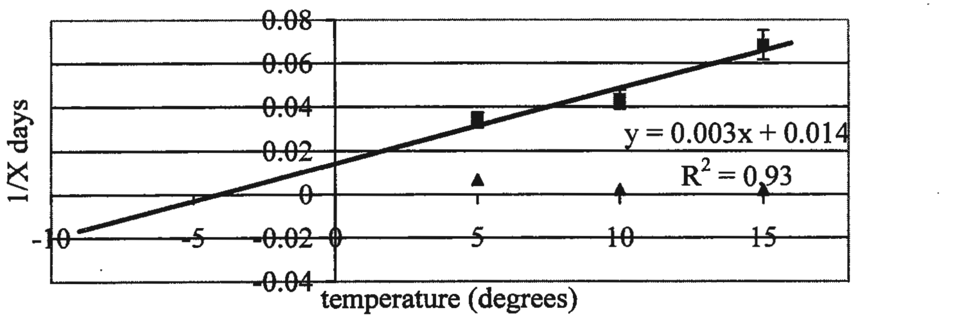

Figure 5: The relationship between the development of *M. cerasi* eggs at three different temperatures: 5, 10 and 15 °C, 1998.

Conclusions

The correlation between the growth of *M. cerasi* populations and natural enemies shows a significant relationship. The results suggest that the natural enemies were controlling the aphid population's growth. These data, provide information that potentially may be manipulated in the future as part of an integrated pest management (IPM) programme.

The lack of significant responses by spring migrants to *G. aparine* and *V. persica* and the repellency of *P. avium* to males in the olfactometer suggests that odour may not be an important cue for host-recognition by *M. cerasi.* The cage experiment confirmed that spring migrants would colonise *G. aparine* and *V. persica,* but the absence of colonies on *V. persica* and only two colonies found on *G. aparine* in the field, suggests that they may not be the principle hosts of this aphid in UK. Gynoparae of *M. cerasi* produced on *V. persica* in the laboratory (Pamphilon, unpub.) were significantly smaller than those on *P. avium* in the autumn. Further work is needed to identify the secondary hosts of this aphid. In addition, the growth period of *G. aparine* finishes in July, but *M. cerasi* do not return to *P. avium* until September. Therefore, there is a possibility of another unknown secondary host plant being involved in the life cycle of the aphid.

The lack of response of males to oviparae in the olfactometer and the negative response to odours of *P. avium* require further study in order to establish the role of anemotactic behaviour in mate finding by this aphid.

The estimated lower thermal threshold for development of eggs shows that embryonic development may occur even at low winter temperatures. The lower thermal threshold of *M. cerasi* eggs provides growers with the possibility of accurately determining the time at which fundatrices will hatch and therefore allow improved timings of spray applications. Additional work is required to determine the degree of accumulated cold required to end diapause, in order to produce more precise predictions of egg hatch.

Acknowledgements

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References

Bodenheimer, F.S. & Swirski, E. 1957: The Aphidodea of the Middle East. The Weizmann Science Press of Israel. Jerusalem. 378 pp.

Dixon, A.F.G. 1976: Timing of egg hatch and viability of the sycamore aphid *Drepanosiphum platanoidis* (Schr), at bud burst of sycamore, *Acer pseudoplatanus* L. Journal of Animal Ecology 42(2): 593-603.

Gilmore, J.E. 1960: Biology of the black cherry aphid in Willamette Valley, Oregon. Journal of Economic Entomology 53: 659-661.

Hand, S.C. 1983: The effect of temperature and humidity on the deviation of development and hatching success of eggs of the aphid *Sitobion avenae*. Entomologia experimentalis et applicata 33(2): 220-222.

Frazer, B.D. & Raworth, D.A. 1984: Predicting the time of hatch of the strawberry aphid, *Chaetosiphon fragaefolii* (Homoptera: Aphididae). The Canadian Entomologist 16: 1131-1135.

Messing, R.H. & Aliniazee, M.T. 1991: Thermal requirements for egg development of the filbert aphid *Myzocallis coryli* (Goetze). Journal of Applied Entomology 111(4): 391-396.

Pettersson, J. 1970: An aphid sex attractant. I. Biological studies. Entomologica Scandinavica 1: 63-73.

Theobald, F.V. 1909: The insect and other allied pests of orchard, bush and hothouse fruits. London, 550 pp.

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Present status of insecticide resistance in *Myzus persicae* in northern Italy peach orchards

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Abstract: Several peach-potato aphid populations were collected in northern Italy peach orchards between 1997 and spring 1998. These population were analysed for their total esterase content and, using a simple bioassay procedure, for their susceptibility to pirimicarb. None of the population was "susceptible" and moreover the most of them showed a high capacity to hydrolyse 1- nafthyl-acetate has as extremely resistant strain of *M. persicae* do. These populations were also tested for resistance toward pirimicarb and in 28% of them all the specimens treated survived to a diagnostic dose of this aphicide.

Key words: peach-potato aphid, esterase, bioassay.

Introduction

Myzus persicae (Sulzer) (Homoptera: Aphididae) is one of the most serious pests in Italian peach orchards.

Multiple mechanisms of insecticide resistance have been discovered in this species and sometimes, in the same population, more than one mechanism is present. At present three different resistance mechanisms have been described for *M. persicae* as reviewed by Field *et al.* (1997).

The insecticide resistance in *M. persicae* can be due: a) to an enhanced production of a carboxylesterase (E4 or FE4), conferring resistance to organophosporous, carbammate and pyrethoroid insecticides (Devonshire & Moores, 1982); b) to a form of acetylcholinesterase insensitive to pirimicarb (Moores *et al.*, 1994); c) a single mutation in the sodium channel, conferring resistance to pyrethroids (Martinez-Torres *et al.*, 1997).

To know the status of insecticide resistance of *M. persicae* populations in northern Italy peach orchards we started, some years ago to study the distribution of resistant aphids using in vitro biochemical analyses to find the esterases contents in individual aphids (Cravedi & Cervato, 1996). Now the analyses have been widened including more population in different year and to know the incidence of modified acetylcholinesterase in Italian population of *M. persicae*.

Materials and methods

The populations of *M. persicae* studied were collected between 1997 and spring 1998 in various peach orchards in different moments of the cycle of the green peach aphid, and under various pesticide treatments strategies.

Aphids were transferred to herbaceous plants (*Pisum sativum*) and maintained on these ones in a climatic chamber at a 16 : 8 hours light:dark regime. The temperature being on the average 21 °C degrees and the relative humidity being between 65 and 70%. Each population in maintained in a separate plastic box. The lid of the box is provided with a fine net to allow ventilation and avoid escaping of aphids.

Biochemical analyses to measure the total esterase activity have been carried out on individual aphids, mainly winged partenogenetic females, according to Devonshire *et al.* (1992).

Bioassays were carried out on filter paper impregnated with different doses of the insecticides to be tested. Mortality was scored after two hours and data analysed with probit analysis (Finney, 1970).

Results

On the whole 20 populations of *M. persicae* have been analysed. Two of them are laboratory reference strain: a susceptible strain and a moderately resistant one. The other ones are wild populations collected on peach in various places as shown in figure 1.

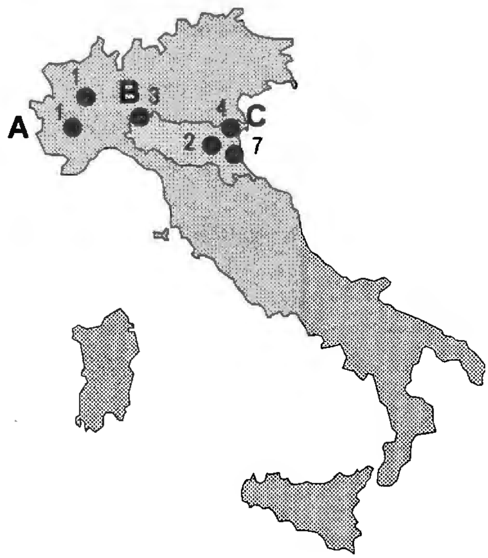

Figure 1. *M. persicae* collection sites. Dots show the province were aphids have been collected, figures are the number of population collected and letters the area of collection (A: Piedmont; B: surroundings of Piacenza; C: Emilia Romagna).

A couple of populations have been collected in Piedmont, from commercial orchards in peach growing areas; 3 populations have been collected around Piacenza, on gardens or on isolated plants. The remaining populations have been collected in commercial peach orchards in various places in Emila Romagna.

All these populations have been analysed to measure their total esterase content. According to the result achieved with this biochemical assay the aphids were scored, as "susceptible" (S; when the absorbance measured at 620 nm is $A_{620}<0.4$); moderately and very resistant (R_1-R_2; when the absorbance measured at 620 nm is $0.3<A_{620}<1.5$) and extremely resistant (R_3; when the absorbance measured at 620 nm is $A_{620}>1.5$) (Devonshire *et al.*, 1992). Of the 18 wild populations none have been scored as "S" (susceptible), the most of them (14 population) have been found to be "R_3" and only 4 populations have been classified as R_2 (Fig. 2).

These populations were also tested for resistance towards pirimicarb using a filter paper bioassay. In 5 populations all the specimens treated survived to a diagnostic dose of this aphicide. Only in 3 population (1 from Piacenza and 2 from Piedmont) all the specimens treated have been killed by the diagnostic dose. In the remaining population the situation is more variegated (Table 1).

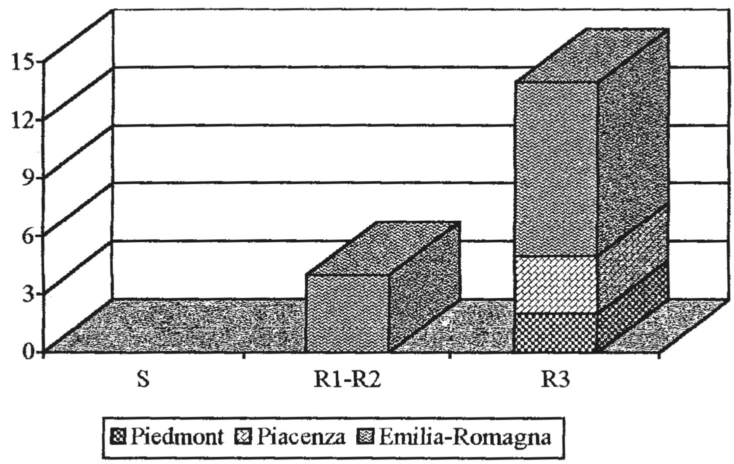

Figure 2. Numbers of population of *M. persicae* in the different resistance classes in the 3 areas were aphids have been collected.

The link between "esterase content" and "resistance towards pirimicarb" is shown in figure 3. All the 5 populations whose all tested specimens survived in bioassay have been classified as "R3". In the remaining populations there are a few cases of "R3" aphids population that have not shown any resistance towards pirimicarb but in the most of cases there is an intermediate situation: quite high esterase content and a variable amount of specimens able to survive at the diagnostic dose (Fig. 3).

Conclusions

The resistance status of *M. persicae* in northern Italy peach orchards is undoubtedly became worst than a few years ago. So now it is more important to know the real situation, combining all the available tools, from the more classic ones as bioassays to more updated molecular tools as PCR. Knowledge of biochemical and molecular basis of different resistance mechanisms will allow to use in the best way all the available insecticides. More over it will be possible to programme strategies to reduce the onset of this phenomenon in a more general framework needed to apply IFP in peach orchards.

Table 1. Percentage of specimens survived and dead in bioassay with a diagnostic dose of pirimicarb. Collecting areas: A - Piedmont; B - surroundings of Piacenza; C - Emilia-Romagna.

Population	Collecting area	dead (%)	alive(%)
S	UK	100.0%	0.0%
PcexPisa (L)	Lab selected	99.4%	0.6%
CN97-01	A	100.0%	0.0%
TO98-01	A	100.0%	0.0%
Pnt98-01 (PC)	B	0.0%	100.0%
Rvg97 (PC)	B	57.9%	42.1%
SNic97 (PC)	B	100.0%	0.0%
FE97-02	C	0.0%	100.0%
FE97-03	C	20.0%	80.0%
FE98-02	C	63.6%	36.4%
FE98-04	C	95.0%	5.0%
BO97-01	C	79.9%	20.1%
BO98-02	C	90.0%	10.0%
RA97-01	C	0.0%	100.0%
RA98-02	C	85.7%	14.3%
RA98-05	C	0.0%	100.0%
RA98-06	C	37.5%	62.5%
RA98-08a	C	87.5%	12.5%
RA98-08b	C	0.0%	100.0%
RA98-10	C	61.9%	38.1%

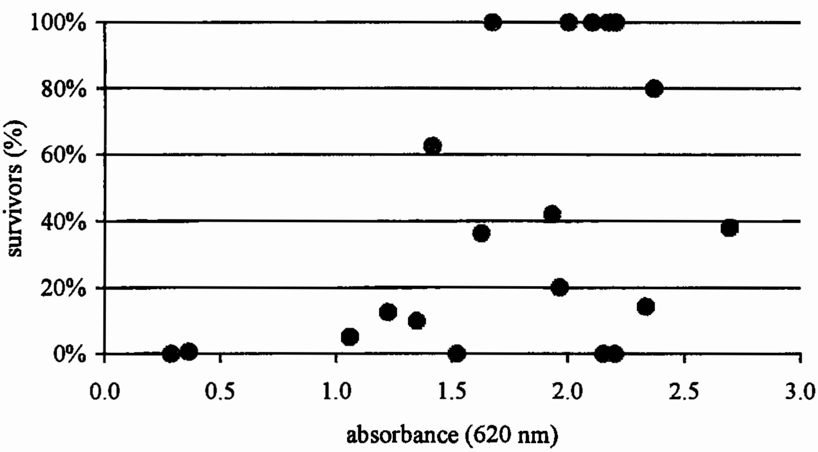

Figure 3. Relationship between "esterase content" and survival in a bioassay with a diagnostic dose of pirimicarb in *M. persicae* population collected in northern Italy peach orchards.

Infact it is very important to choose the best active ingredient and / or adopt the best strategy for resistance management. Unfortunately, many farmers and technicians base too much, if not exclusively, their aphid control strategies on new molecules. In fact, new active substances with different target site and / or mode of action are now available (eg: imidacloprid and pymetrozine) and they can overcome classic resistance mechanisms, but to get the best results and to preserve their efficacy their use should be considered together old products.

References

Cervato, P. & Cravedi, P. 1996: Resistance to insecticides in *Myzus persicae* (Sulzer) (Rhynchota Aphididae) in Italian peach orchards. Boll. Zool. agr. Bachic., Ser. II, 27 (3): 191-199.

Devonshire, A.L., Devine, G.J. & Moores, G.D. 1992: Comparison of microplate esterase assays and immunoassay for identifying insecticide resistant variants of *Myzus persicae* (Homoptera: Aphididae). Bull. Ent. Res. 82 (4): 459-463.

Devonshire, A.L. & Moores, G.D. 1982: A carboxylesterase with broad substrate specificity causes organophosphorus, carbamate and pyrethroid resistance in peach--potato aphids (*Myzus persicae*). Pest. Biochem. Physiol. 18 (2): 235-246.

Finney, D.J. 1971: Probit analysis. University Press. Cambridge. 334 pp.

Field, L.M., Anderson, A.P., Denholm,I., Foster, S.P., Harling, Z.K., Javed,N., Martinez-Torres, D., Moores, G.D., Williamson, M.S. & Devonshire, A.L. 1997: Use of biochemical and DNA diagnostics for characterising multiple mechanisms of insecticide resistance in the peach-potato aphid, *Myzus persicae* (Sulzer). Pest. Sci. 51(3): 283-289.

Martinez-Torres, D, Devonshire, A.L. & Williamson, M.S. 1997: Molecular studies of knockdown resistance to pyrethroids: cloning of domain II sodium channel gene sequences from insects. Pesticide-Science 51(3): 265-270.

Moores, G.D., Devine, G.J. & Devonshire, A.L. 1994: Insecticide-insensitive acetylcholinesterase can enhance esterase-based resistance in *Myzus persicae* and *Myzus nicotianae*. Pesticide Biochemistry and Physiology 49(2): 114-120.

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Some observations on aphid abundance in peach orchards in north-eastern Italy

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Abstract: During 1995, populations of aphids and of their natural enemies were monitored in three peach orchards in which different pest control strategies were adopted. In the first orchard (V) conventional insecticides were applied according to 2078/92 EC regulations. In the second orchard (P), the mating disruption technique was used to control moths but insecticides were applied against aphids. The last orchard (N) was situated within a biodynamic farm and thus synthetic pesticides were not used. *Myzus persicae* (Sulzer) was a key pest in all three sites independently of pesticide use but four different aphid species occurred in the biodynamic orchard. In untreated plots, aphid densities reached high levels and the role of predators appeared to be ineffective in most cases. The importance of pests declined as the use of pesticide increased but persistence was great on some cultivars.

Key words: peach aphids, *Myzus persicae*, cultivar susceptibility, natural control.

Introduction

Factors affecting the seasonal abundance of peach aphids in Italian orchards have been studied in some sites (e.g. Niccoli & Sacchetti, 1993; Niccoli & Fagnani, 1994; Moleas *et al.*, 1995). In particular, the role of host plants and the impact of natural enemies on aphid populations have received attention. The variability of environmental characteristics, cultural practices and cultivar use in Italian peach growing areas, greatly affects aphid-host plant interactions. Therefore, there is a particular need for studies to be carried out in different Italian regions.

In this work, observations on aphid abundance and on their antagonists were conducted in three peach orchards situated in a homogeneous fruit growing area of north-eastern Italy. Among factors affecting aphid abundance and diversity, pest control strategies and cultivar features appeared to be the most important.

Materials and methods

Orchard characteristics

The first orchard (V) was rectangular in shape and measured approximately 1 hectare. The plants were 20 years old, 3.5-4.5 m tall, and pruned according to the palmet system; the planting space was 4 x 5 m. Observations were carried out on three cultivars: Redhaven (4 rows), Fayette (4 rows) and Rosa del West (2 rows). Fertilization and treatments were carried out in accordance with 2078/92 EC regulations. Conventional insecticides were applied to control aphids and fruit moths. Concerning aphid control treatments, methamidophos was used before blooming (21st March, 390 g of a.i./hectare) on the three varieties, pirimicarb was applied twice on Redhaven (2nd and 22nd May, 350 g of a.i./hectare) and three times on Fayette and Rosa del West (2nd, 22nd and 27th May, 350 g of a.i./hectare). Moreover, Fayette received a further treatment with ethiofencarb (2nd June, 460 g of a.i./hectare).

The second orchard (P) had similar features, and samplings involved the Suncrest cultivar (2 rows). Cultural practices and pest control were consistent with 2078/92 EC regulations. Mating disruption techniques were used to control moths and insecticides were applied against aphids. Pirimicarb was applied on 2nd May (350 g of a.i./hectare) and ethiofencarb on 2nd June (460 g of a.i./hectare).

The last orchard (N) was situated within a biodynamic farm. It was rectangular in shape and measured approximately 7,500 m^2, and contained 9 cultivars. Among these, only Suncrest was considered. The plants were 10 years old, 2-2.5 m tall, and pruned according to the "open-center tree" system; the planting space was 4 x 5 m. Synthetic pesticides were not allowed. A mixture of decoctions and infusions containing stinging nettle, common horsetail, elder, tobacco, Savoy cabbage, wormwood oil was applied every 7-10 days (approximately 1000 l/hectare) from April to August.

Experimental design and sampling methods

In orchard V, pesticides had been used regularly to control aphids and moths (*Cydia molesta* Busck and *Anarsia lineatella* Zeller). In 1995, five plants belonging to the Rosa del West cultivar were not treated with insecticides in order to evaluate aphid abundance and the impact of natural enemies. An additional five plants, treated with insecticides and situated at least 30 m from the untreated plants were selected for a comparison. The susceptibility to aphids of two cultivars (Redhaven and Fayette) characterized by different ripening periods, to aphids was also evaluated. A total of 36 plants was selected on different rows (9 plants per row) of the two cultivars.

In orchard P, the mating disruption technique was applied from 1989 to control moths. Data collected in this orchard during 1995 was included in this work in order to observe whether the reduction of pesticide treatments could have promoted colonization by natural enemies with positive effects on aphid control. A total of 36 plants (18 per row) were selected for samplings.

Concerning orchard N, interactions between aphids and their antagonists were studied apparently in natural conditions since synthetic pesticides were not applied here. We assumed that the effects of decoctions and infusions on natural enemies were not relevant. Data collected on 13 plants of the Suncrest variety are reported.

Sampling methods were similar in the three orchards. On each plant 4 twigs situated on different branches with similar characteristics (length, rising) were selected. The apical shoot of these twigs was considered as the unit to be sampled during the season in accordance with previous investigations. Samplings were made every 7-10 days, from April to September, in order to assess the density of the aphid species and of their natural enemies. The identification of aphid species on plants was carried out using a specific key (Cravedi & Bolchi Serini, 1981). Samples of aphid females were collected and later mounted and identified in accordance with Blackman & Eastop (1994).

A number of sticky yellow traps (respectively 6 and 4) was placed in orchards P and N in order to obtain more data on the colonization dynamics of aphid antagonists. The traps were examined during each sampling and then renewed. Natural enemies potentially associated with aphids were identified in the laboratory.

The data from experiments carried out in orchard V was analyzed using the REPEATED option of Proc GLM of SAS (SAS Institute, 1989) with a one-way analysis of variance considering the date as a repeated measure. The means were separated by using the option REGWG of SAS and the significance used in this study was set at a P level of 0.05. Before running the ANOVA logarithmic transformation, i.e. log (y+1), was applied to the data.

Results

Orchard V (Rosa del West)

A single aphid species, i.e. *Myzus persicae* (Sulzer), occurred in this orchard. In the control, the percentage of infested shoots increased from the end of April to the beginning of June and later declined (Fig. 1A). In the first half of May the colonization of natural enemies was correlated with pest increase but later the occurrence of aphid antagonists appeared to be less important. Predators were the main component of this complex and thus their number only is reported. Their role in the decline of the aphid populations was probably less important than other factors, e.g. overcrowding and substrate quality deterioration (Van Emden *et al.*, 1969).

In insecticide treated plants, populations of *M. persicae* and its antagonists reached significantly lower levels ($p < 0.0001$) than those observed in the untreated plants (Fig. 1B).

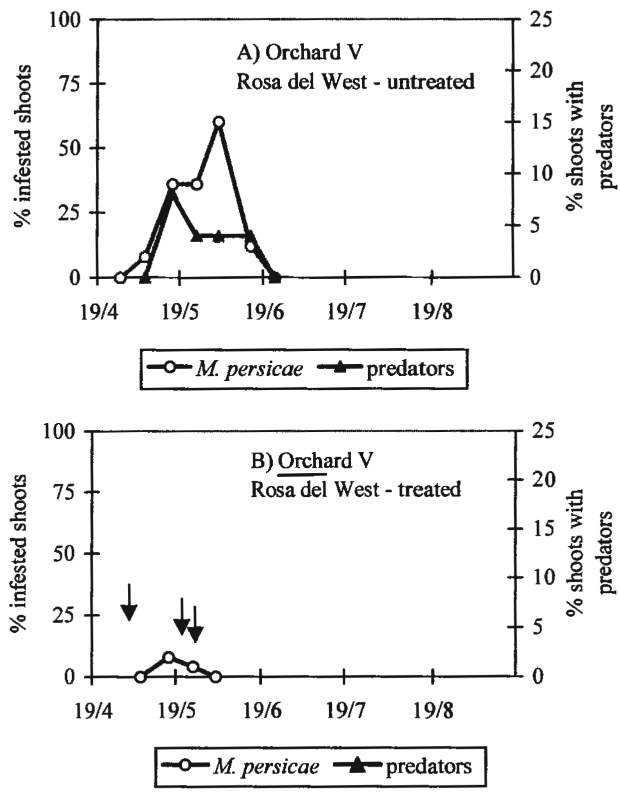

Figure 1: Seasonal abundance of *M. persicae* and its predators in the untreated (A) and treated (B) plots of Rosa del West cultivar (orchard V). Treatments are indicated by arrows.

Orchard V (Fayette and Redhaven)

Observations carried out on two cultivars (Fayette and Redhaven), contiguous to the previous one (Rosa del West), gave additional information on the colonization of *M. persicae* and its antagonists in the same orchard. *M. persicae* infestation levels (% of infested shoots) reached significantly higher values ($p < 0.0001$) on Fayette than on Redhaven despite the fact that twice the number of insecticide treatments were carried out on the former cultivar (Fig. 2). Aphid population densities (number of individuals per shoot) were also significantly higher on Fayette than on Redhaven ($p < 0.0001$). Predators, mainly syrphids, were recorded at low densities on Fayette only.

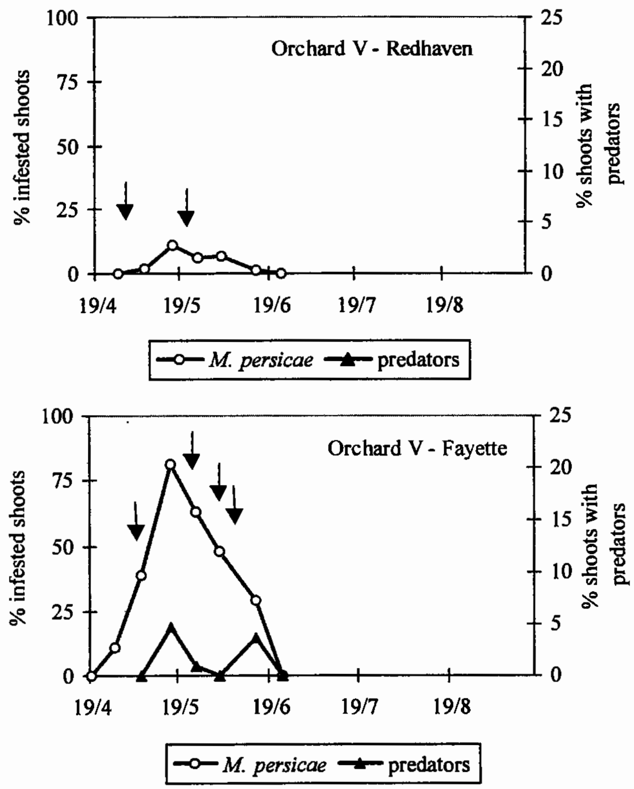

Figure 2: Seasonal abundance of *M. persicae* and its predators on two cultivars of orchard V. Treatments are indicated by arrows.

Orchard P

In this orchard two aphid species occurred, i.e. *M. persicae* and *Brachycaudus schwartzi* (Boer.) the former being dominant. *M. persicae* infestations increased from late April, despite the use of pirimicarb, reaching maximum values in mid May (47% of infested shoots) and later declining (Fig. 3A). *B. schwartzi* was observed in late season and at low population levels. Predators colonized infested plants rapidly, contributing partly to pest decrease (Fig. 3A). As far as predators were concerned syrphids, coccinellids and chrysopids were commonly found on the peach vegetation, the former being more abundant. Predator occurrence was also monitored on the yellow sticky traps showing high numbers of chrysopids in mid-summer when aphid densities on peaches were negligible (Fig. 3B). At the same time, the occurrence of aphids on the cover vegetation (mowing was constant) or of alternative prey for chrysopids in the orchard was also low. The presence of a hedgerow contiguous to the orchard could be involved in the high presence of chrysopids on traps.

The second insecticide treatment was applied erroneously in the phase of aphid decline.

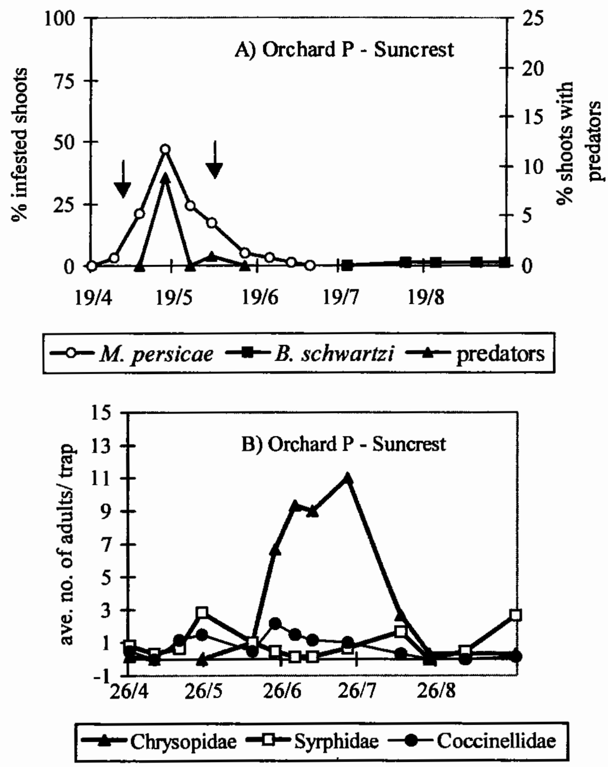

Figure 3: (A) Seasonal abundance of *M. persicae*, *B. schwartzi* and their predators on Suncrest cultivar (Orchard P), treatments are indicated by arrows; (B) Adults of Chrysopidae, Syrphidae and Coccinellidae catched on sticky traps placed on the same cultivar.

Orchard N

Four aphid species occurred in this orchard: *M. persicae*, *Myzus varians* (Dav.), *B. schwartzi* e *Brachycaudus persicae* (Pass.). *M. persicae* was the dominant species and the percentage of infested shoots reached high levels in late May (Fig. 4A). Its populations declined from June onwards. *B. schwartzi* infestation levels also peaked in this period but the pest was constantly recorded throughout the season in accordance with its monoecious behaviour (Fig. 4A). The population dynamics of *M. varians* followed a trend similar to that of *M. persicae* (Fig. 4A). *B. persicae* was seldom observed (Fig. 4A).

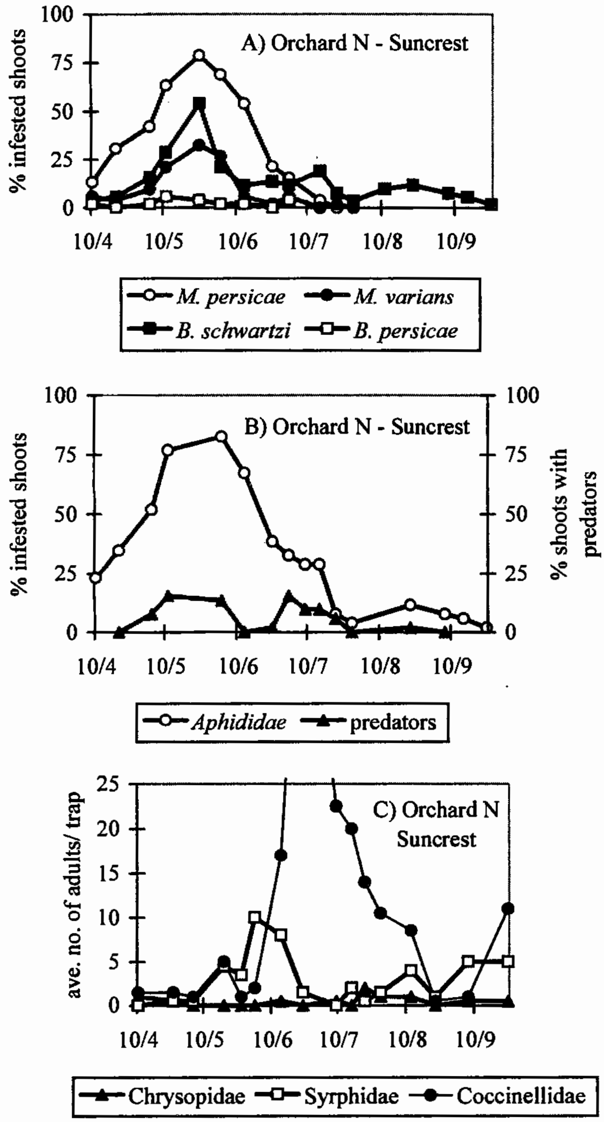

Figure 4: Seasonal abundance of: (A) *M. persicae*, *M. varians*, *B. schwartzi*, *B. persicae* on Suncrest cultivar (Orchard N); (B) Aphididae and of their predators; (C) Adults of Chrysopidae, Syrphidae and Coccinellidae catched on sticky traps placed on the same cultivar.

Syrphid, coccinellid and chrysopid larvae were constantly found in association with aphid colonies during the season, but at moderate population levels (Fig. 4B). Syrphids were the most important component of the predator complex. The role of aphid antagonists in this orchard appeared to be only partially involved in pest decline. A relevant number of adult predators was caught by the yellow sticky traps (Fig. 4C). Syrphids were more abundant during spring while coccinellids increased in number during late spring and summer. In contrast with the results obtained in orchard P, low chrysopid densities were found.

Discussion

The results obtained in the present work emphasised the status of the key pest of *M. persicae* in peach orchards in north-eastern Italy. Chemical control measures were sometimes ineffective in keeping aphid populations below threshold levels (7-10% of infested shoots according to Domenichini & Cravedi, 1984). Aphid resistance to pesticides may represent the most obvious factor in explaining these failures (Cervato & Cravedi, 1995). Moreover, in some cases the aphid response to pesticides appeared to be mediated by the features of the cultivars. The susceptibility of cultivars to *M. persicae* was observed to be very different even in a simultaneous experiment conducted in a pesticide-free orchard. Fayette resulted as being more susceptible to aphid infestations than other cultivars, but differences between Fayette and Redhaven (observed in orchard V) were not found. The susceptibility to *M. persicae,* among cultivars different from those studied in the present work, was also evaluated in southern Italy (Moleas *et al.*, 1995). The study of this phenomenon will contribute towards improving our knowledge of the ecology of *M. persicae* and IPM strategies on peaches.

M. persicae was the dominant species even in orchard N where a complex of species occurred. This situation was confirmed one year later (Duso & Fasoli, unpubl. data). Interspecific competition among peach aphid species is a matter for stimulating long-term studies in pesticide-free orchards, i.e. in organic farms. Since the latter are increasing in importance in north-eastern Italy, these studies may have some practical implications.

Data from experiments carried out in orchards N and V (Rosa del West, control), where insecticides were not used, showed the moderate impact of natural enemies in keeping the pest at non-damaging levels. Obviously, the role of aphid antagonists in treated orchards was less important, exception made for orchard P where mating disruption was adopted. In orchard V the low number of untreated plants and their position in the treated orchard were probably the most important factors affecting the colonization of predators and their response. However, the role of predators did not appear to be relevant even in orchard N, where pesticides had been avoided completely for a number of years. These results are consistent with those of research carried out in Tuscany (Niccoli & Sacchetti, 1993).

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References

Blackman, R.L. & Eastop, V.F. 1994: Aphids on the world's tree. An identification and information guide. CAB International.

Cravedi, P. & Bolchi Serini, G. 1981: Gli afidi del pesco. Conoscerli e riconoscerli. Collana del progetto finalizzato "Promozione della qualità dell'ambiente" del C.N.R.

Cervato, P. & Cravedi, P. 1995: Resistance to insecticides in *Myzus persicae* (Sulzer) (Rhynchota Aphididae) in Italian peach orchards. Boll. Zool. agr. Bachic. 27: 191-199.

Domenichini, G. & Cravedi, P. 1984: Il controllo integrato nei pescheti. Atti Convegno Internazionale del Pesco, Verona, Ravenna, Campania, 9-14.7.1984, 683-697.

Moleas, T., Addante, T. & Cilardi, A.M. 1995: Différent susceptibilité de quelques variétés cultivées de pêcher aux pucerons. IOBC/WPRS Bull. 18: 12-15.

Niccoli, A. & Fagnani, F. 1994: Indagine sull'andamento delle infestazioni di *Myzus varians* (Davidson) in pescheti della Toscana. Redia 77: 175-187.

Niccoli, A. & Sacchetti, P. 1993: Osservazioni sull'andamento delle infestazioni di afidi in pescheti della Toscana. Redia 76: 343-359.

SAS Institute Inc. 1989: SAS/STAT User's Guide (Release 6.11). SAS Institute Inc., Cary, NC.

Van Emden, H.F., Eastop, V.F., Hughes, R.D. & Way, M.J. 1969: The ecology of *Myzus persicae*. Ann. Rev. Ent. 14: 197-270.

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Migration of Oriental Fruit Moth *Grapholita molesta* Busk. (Lepidoptera: Tortricidae) under wide area mating disruption in Victoria, Australia

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Abstract: Mating disruption is now a corner stone of Integrated Pest Management (IPM) in Australian orchards. Mating disruption has been used for many years to control OFM in the Goulburn-Murray valley (GMV) region of Victoria, but recently fruit and shoot tip damage increased in peach blocks with mating disruption. Some farmers reported that more damage occurred on the borders of peach blocks near fruit blocks with chemical control. A project initiated to identify factors leading to failure of mating disruption at the edge of blocks and to develop integrated pest management guidelines for OFM.
The investigations focused on: (1) OFM population trends and migration; (2) fruit and shoot tip damage assessment.
The results indicate that OFM can build up the level of population in pear blocks under chemical control and provide a reservoir for infestation of adjacent peach blocks under mating disruption. Fruit damage assessments confirmed higher levels of infestation of OFM in the border of peach blocks next to the pear blocks. The difference between the levels of OFM in adjacent pear and peach blocks was able to indicate migration of OFM from pears to peaches.

Key words: IPM, Mating Disruption, Oriental Fruit Moth, Wide-area Mating Disruption, Migration

Introduction

Oriental Fruit Moth (OFM) (*Grapholita molesta* Busck) (Lepidoptera: Tortricidae) is one of the most important pest of commercial peach trees in the Murray-Goulburn valley region of Victoria. There are no natural enemies which can be used to decrease OFM population levels below the economic threshold. However, it is also recognised that in some other areas growing stone fruits, such as Swan Hill, OFM is not a problem. Some environmental and other factors that are not yet identified may be significant in determining OFM population levels. Sziraki (1979) reported that the population density of OFM does not depend primarily on the variety and time of fruit ripening in large-scale peach orchards, but more on other local conditions, e.g. surrounding area of a peach orchard play an important role.

The first record of the presence and investigation of OFM in the Goulburn valley was prepared by F.J.Gray in 1935 (Gray, 1935). The discovery of a sex pheromone secreted by female *G. molesta* (George, 1965) and the synthesis of the pheromone (Roelofs *et al.*, 1969; 1973) enabled sex pheromones to be used for monitoring populations by attracting males to the pheromone traps. Pheromone traps indicate the emergence pattern of OFM adults in the spring, as well as the general level of abundance of the pests in a locality, with greater efficiency and less labour than with bait pails. Pheromone traps may permit greater accuracy in the timing of chemical control measures early in the season, particularly where pesticides are directed at controlling adults (Rothschild *et al.*, 1984).

The possibility of the controlling OFM by mating disruption in which synthetic female pheromone was used to create artificial trails of pheromone which prevented males from finding unmated females in orchards has been demonstrated by Rothschild (1975) and Vickers *et al.* (1985). Rothschild (1975) showed that mating disruption treatments could be as effective in controlling OFM as insecticides. Further, mating disruption became more effective (Vickers *et al.*, 1985), when all orchards in a district were treated thus reducing the likelihood of mated females migrating from untreated blocks and/or orchards.

Mating disruption works most effectively in the presence of a low population density of the pest and as long as a sufficient amount of pheromone is present in the environment. Unfortunately, in most cases it is not possible to reliably estimate the population density of the target insects, nor to measure the amount of pheromone present in the volume of air to carry out the disruption of the males (Cravedi, 1992). Through the use of food traps it has been shown that mated females, albeit in small numbers, can be present even within large peach orchards where mating disruption is applied. This situation indicates the possibility that mechanisms other than pheromonal calling may allow mating (Molinari & Cravedi, 1989).

The investigation of behaviour of OFM males in overlapping sex pheromone plumes in a wind tunnel has concluded that both "false trail following", when males are repeatedly attracted to the artificial odour sources competing with the calling females and "habituation/adaptation", which is sensory overload, result in mating disruption in OFM (Arn, 1992). False trail following will work best with emission rates higher than natural emission rates of females, but probably this mechanism may not be effective at high pest populations.

In contrast, the "habituation/adaptation" mechanism is potentially independent of the initial population density of the pest and in theory should lead to effective control of OFM even at high population density (Valeur & Lofstedt, 1996).

The success of mating disruption of OFM depends on the methods of dispersing the synthetic pheromone (Rothschild, 1979; Rumbo & Vickers, 1997), as well as chemical composition, rate of release (Lacey & Sanders, 1992; Rothschild & Minks, 1974) and placement of the pheromone dispensers in the tree canopy (Baker & Haynes, 1996).

Early investigations of OFM migration in Australia concluded it is unlikely that migration was of particular importance, except when considered on a within-orchard basis (Rothschild & Vickers, 1991). Their studies on OFM movements showed that most adults do not disperse over distances greater than 200 m, although a few individuals may cover distances exceeding 1 km.

Investigations of OFM migration in Russia and Bulgaria have shown the presence of migration between fruit blocks inside of the orchard (Staneva, 1993; Atanov, 1993). To prevent this type of migration, pheromone traps "Pherocon" placed 30 metres apart on the border of peach blocks have been used. Also, the presence of migration between fruit blocks was recorded, as well as the problem of migration of mated female moths from orchards adjacent to pheromone-treated blocks. In California, almonds and plums, and occasionally prunes and apples can produce high populations of OFM, which can be the source of infestation in the orchard (Rice & Kirsch, 1988).

Recent observations in the Cobram region of Victoria has implicated migration as a factor leading to OFM damage in mating disruption blocks (Il'ichev *et al.*, 1998). An attempt was made to identify the importance of migration in the failure of mating disruption for OFM.

The investigations focused on two separate components: (1) OFM population trends and migration from non-MD pear block to MD peach block; (2) fruit and shoot tip damage assessment in peach block adjacent to pear block.

Materials and methods

Experimental Sites

In the growing season 1996/97, the field trials were laid out in W.B.C. pear and peach ("Cornish" and "Pullar") blocks on a property (property 1) at Cobram which historically always had a very high population of OFM. In the growing season 1997/98, the field trials were also laid out in the same blocks in property 1, and in another property (property 2), which also had higher number of OFM, but lower than the property 1.

Population Trends and Migration

The aim of these trails was to understand the population trends and migration of OFM between pear and peach blocks, and how this migration can influence the shoot tip and fruit damage in the peach blocks.

In 1996/97 season, the experiment was designed to check the population trends and migration pattern of OFM between a pear block under chemical control (Pear Chem), with and without a mating disruption barrier on pears (Pear MD "barrier"; ten trees deep) and an adjacent peach block with mating disruption (Peach MD).

Sets of nine food traps in three lines of three traps were placed through the interface of three blocks: peach MD, pear MD; and pear Chem. To maintain the uniformity of experimental blocks, the same distance of five trees was established in between the traps in two replications.

In 1997/98 season, two different treatments were examined:

1) Migration from a pear block under chemical control (Pear Chem), across a mating disruption barrier on pears (Pear MD "barrier"; ten trees deep), into an adjacent peach block with mating disruption (Peach MD).
2) Migration from pear block under mating disruption (Pear MD) to an adjacent peach block with mating disruption (Peach MD).

Sets of 21 food traps in 3 lines of 7 traps were placed through the interface of pears and peaches in property 1 and property 2. The same distance of five trees was established in between the traps in 2 replications.

Use of Food Traps

Standard Efecto-fly traps (Avond Pty. Ltd., Western Australia) were used to check the OFM population level and migration trend.

In 1996/97 season the experiment was started in the beginning of September and was finished in the end of May. In 1997/98 season the experiment started at the end of August and continued up to the end of April.

The traps were placed between 1.5 to 2.0 m high in the tree canopy. Each of the traps was filled to 1/3 level with 10% brown sugar solution and twelve drops of terpinyl acetate (T.A.) solution. The T.A solutions were prepared by mixing 48.5 mL of T.A. with 1.5 mL of non-ionic wetting agent and 50 mL of warm water.

The traps were monitored weekly in all blocks and the number of OFM was recorded. All collected moths were preserved in plastic container with 70% alcohol. To ensure maximum efficiency, sugar solution with T.A. was changed every week in each food trap.

The moths collected in the season 1997/98 were checked under binocular microscope to determine their sex, and number of males and females were recorded.

Damage Assessment

Oriental fruit moth damage usually manifests in two ways:

a) Tip damage to actively growing shoots. After hatching the larvae enter twigs, usually near the tip, and tunnel into the shoot for 8-10 cm. This causes the tip to die or wilt.
b) Larvae also attack developing fruits.

Shoot Tip Damage

In 1996/97 season sixty tips were counted from each tree in the three rows, where food traps were placed. For this sample each tree was divided into four different parts: north, south, east and west. From each segment 15 tips were counted randomly. All damaged tips were recorded and the percentage of damaged tips was calculated.

In 1997/98 season two tip damage assessments (16.12.97 and 21.1.98) were done. Fifty tips were counted from each tree in the rows where food traps were placed. Each tree was divided into two sides, east and west, each side again subdivided into upper and lower canopy, because upper part of the canopy had more tip damage this season. From each segment 25 tips (both from upper and lower canopy) were counted randomly. All damaged tips were recorded and the percentage of damaged tips was calculated.

Fruit Damage

A random sample of 25 peaches was taken on February 24, 1997 (2 weeks before the 1-st colour picking), from each tree of the six rows, where food traps were placed, a total of 126 trees. On April 3, 1997 (during the last picking), a random sample of 25 peaches was also taken from each of the first 10 trees (starting from the border of peaches and pears) of the rows, where food traps were placed. Infested fruits were collected in plastic bags and transported to the laboratory. Other fruits were discarded in the field. Each fruit was cut to look for larvae and to be sure that the fruits were infested with OFM. The number of damaged fruit was recorded and the percentage of damaged fruit in each tree was calculated.

In 1997/98 season, a random sample of 25 peaches was taken on January 28 1998 (4 weeks before the 1-st colour picking, because the fruit damage occurred early this season), from each tree of the rows, where food traps were placed, a total of 126 trees. This time of the year the damage fruits were concentrated mostly in upper canopy, therefore fruit damage assessment was done only in upper canopy. Only the infested fruits were collected in the plastic bags and transported to the laboratory, other fruits were discarded in the field. The number of damaged fruit was recorded and the percentage of damaged fruit in each tree was calculated.

Results

Population Trends and Migration

The average number of OFM caught per week per trap from the food traps in 1996/97 is shown in figure 1.

Three very distinct peaks of OFM populations were especially in pear blocks under chemical control.

The population in pear blocks was high in 2-nd and 4-th generations compared to peach blocks. A peak of the 1-st (overwinter generation) occurred in October and the initial level of OFM population was comparable on pears and peaches. After this peak the population declined to a very low level during November. The population of the 2-nd generation increased dramatically and reached its highest peak in the pear chem. block on December 24 , but the population in pear MD was one third and in peach MD was one fifth low. This result could show that MD started to work effectively after the first generation flight. After this peak the population again dropped, but was relatively high in 3-rd generation compared to the corresponding period after the first generation and it remained high up to the beginning of March in 4-th generation in pear chem. (Fig. 1). The population of OFM was relatively high in the beginning of the season in almost all traps in peach MD blocks, compared with later in the season. The population dropped down at the end of October and the population level fluctuated, but it was kept in peach MD relatively low throughout the season. From the beginning of April the population of OFM started to decline in all blocks and only few OFM were caught in the traps (Fig.1).

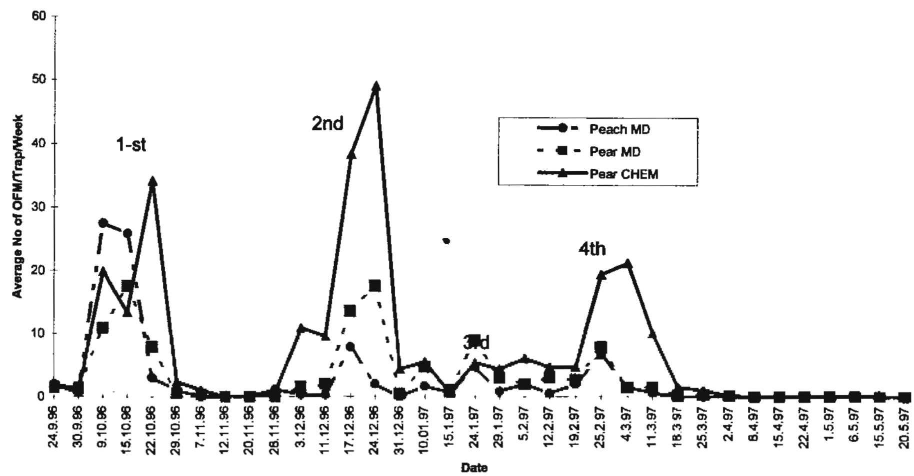

Figure 1. Comparison of OFM population trends under different treatments (Property 1).

Results of monitoring at 1997/98 season shown that OFM can concentrate in pears under chemical control and may provide a reservoir for future infestation of adjacent peaches under MD. For example, the number of OFM on the peak of the 2-nd generation flight on pears chem. was approximately five times more than that on peaches MD.

The difference between levels of OFM population in peach and pear blocks as measured with food traps recording the fluctuations of population throughout the line of traps, can at best indirectly indicates migration. For better understanding of the trend and migration pattern of OFM throughout the season the concentration places of each OFM generation could be important.

Figures 2-5 show the total number of OFM caught per trap for the whole generation. Cumulative number of OFM belongs to each food trap placed in 3 lines of 7 traps through the interface of pears and peaches shown in figures 2-5 by circles with diameter proportional to real numbers of moths. Figure 2 showed almost similar pattern of OFM number in the whole experimental plot, although the cumulative number of OFM in first generation was relatively lower in pear MD block. In the second and third generations the number was very low in pear blocks compare to peach MD block next to pear chem. (Figs. 3 - 4). High OFM number in the border of peach trees next to pear chem. may suggest the migration of OFM from pears to peaches (Fig. 4), where OFM concentrated during 2-nd and 3-rd generations and did severe damage to peach shoot tips and fruits (Figs. 6 - 7). During the 4-th generation higher concentration was observed in pear chem., which could indicate the migration of OFM from peaches to pears before winter (Fig. 5).

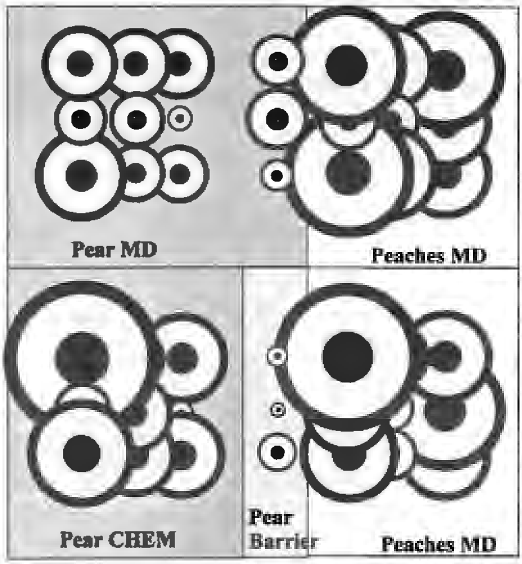

Figure 2. 1st generation of OFM (24/8-15/11/1997).

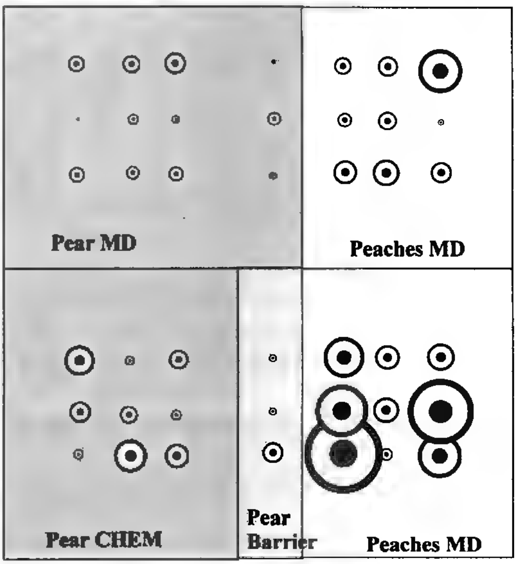

Figure 3. 2nd generation of OFM (16/11-27/12/1997).

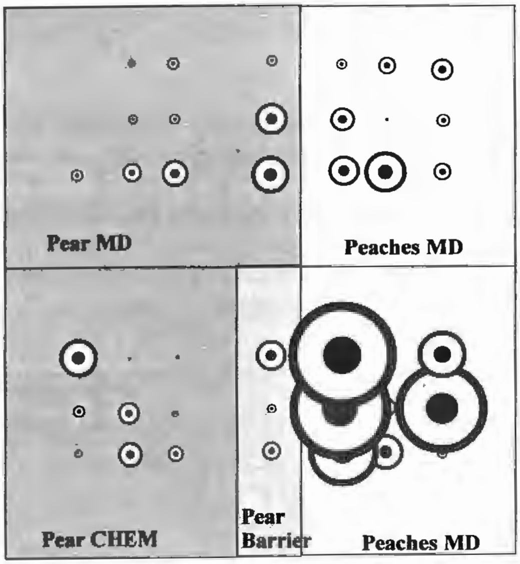

Figure 4. 3rd generation of OFM (28/12/1997-14/02/1998).

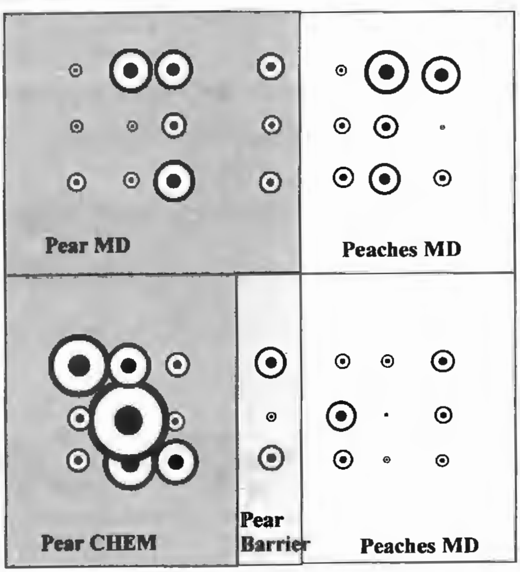

Figure 5. 4th generation of OFM (15/02-25/04/1998).

The concentration of 4-th generation in pear chem, and not in other MD treated blocks can indicate the effectiveness of MD not only in peaches, but also in pears where MD was not used normally. These changes in OFM concentration between pears and peaches during the whole season could occur due to migration, as one of the possible reasons.

Shoot Tip and Fruit Damage Assessment

Figure 6 shows the percentage of tip damage in peach block in the 1996/97 and 1997/98. In 1997/98 season results clearly showed that shoot tip damage was relatively higher in the border trees. In 1996/97, the percentage of damage fluctuated throughout the experimental block, but the damage assessment was done at the end of February, whereas in 1997/98 it was done in December. May be the mated females from the flight of the 2-nd generation oviposited mostly on the border trees of the peach block and then expanded further inside the peach block in flight of the 3-rd generation at the end of February.

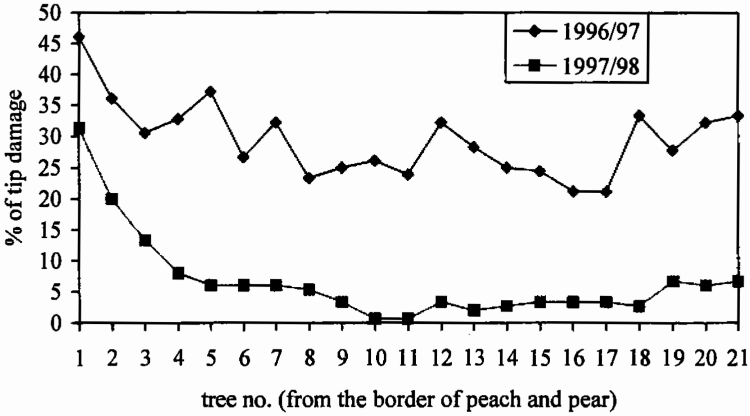

Figure 6. Tip damage assesments for 1996/97 and 1997/98 seasons.

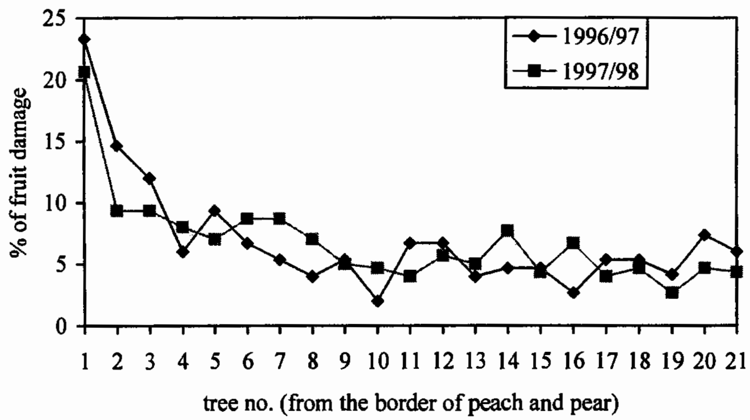

Figure 7. Fruit damage assesments for 1996/97 and 1997/98 seasons.

Figure 7 shows the percentage of fruit damage in peach block in the 1996/97 and 1997/98. Our results indicated that OFM infestation is higher in peaches in the edge bordering the pear block.

These results of shoot tip and fruit damage assessment (Figs. 6 - 7), as well as monitoring (Fig. 4) confirmed the higher level of infestation of OFM in the border of peach MD blocks next to the pear blocks. These results could support that migration of mated females from pears to peaches was able to create a problem in peach MD block.

Conclusions

1. The OFM are able to concentrate and build up the level of population in pear blocks under chemical control and may provide a reservoir for infestation of adjacent peach blocks under mating disruption.
2. Fruit damage assessments confirmed higher levels of infestation of OFM in the border of peach blocks next to the pear blocks.
3. The difference between the levels of OFM in pear and peach blocks inside the orchard during the life cycle was able to indicate migration of OFM.
4. The migration of mated OFM females from pears to peaches for oviposition could be one of the factors leading to the edge failure of mating disruption in peach blocks.

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References

Arn, H. 1992: Mating disruption on its way to perfection: some thoughts. Bulletin OILB/SROP 15, 5: 43-51.

Atanov, N.M. 1993: Optimizing the control of the Oriental Fruit Moth. Zashchita Rastenii Moskva 11: 32-33.

Baker, T.C. & Haynes, K.F. 1996: Pheromone-mediated optomotor anemotaxis and altitude control exhibited by male Oriental Fruit moth in the field. Physiological Entomology 21 (1): 20-32.

Cravedi, P. 1992: Target insects behaviour in presence of high pheromone concentration and mating disruption side effects. Bulletin OILB/SROP 15 (5): 129-134.

George, J.A. 1965: Sex pheromone of the Oriental Fruit moth (*Grapholitha molesta* Busck.). Can. Entomol. 97: 1002-1007.

Gray, F.J. 1935: The peach moth (*Cydia molesta* Busch). Investigations in the Goulburn Valley, Victoria. J.Coun. Sci. Ind. Res.(Aust). 8: 171-176.

Il'ichev, A.L., Jerie, P.H. & Hossain, M.S. 1998: Wide area mating disruption of Oriental Fruit Moth *Grapholita molesta* Busck. (Lepidoptera: Tortricidae) in Victoria. Sixth Australasian Applied Entomological Research Conference: Pest Management - Future Challenges, Brisbane, Australia, 28 September - 2 October 1998, vol. 1, p. 348-355.

Lacey, M.J. & Sanders, C.J. 1992: Chemical composition of sex pheromone of Oriental Fruit moth and rates of release by individual female moth. J. Chem. Ecol. 18 (8): 1421-1435.

Molinari, F. & Cravedi, P. 1989: Applicazione del metodo della confusione contro *Cydia molesta*. Atti XV Congr. naz. ital. Ent. L'Aquila, 13-17 giugno: 965-972.

Rice, R.E. & Kirsch, P. 1988: Mating disruption of the Oriental Fruit moth in the United States. In: Practical applications of insect pheromones and other attractants. Eds Ridgway R., Silverstein R.M. & Inscoe M., Marcel Dekker Inc., N.Y.

Roelofs, W.L., Comeau, A. & Selle, R. 1969: Sex pheromone of the Oriental Fruit moth. Nature. Lond. 224: 20.

Roelofs, W.L., Carde, R.T. & Tette, J.P. 1973: Oriental Fruit moth attractant synergist. Environmental Entomology 2: 252-254.

Rothschild, G.H.L. 1975: Control of Oriental Fruit moth (*Cydia molesta* Busck., Lep: Tortricidae) with synthetic female pheromone. Bull. ent. Res. 65: 473-490.

Rothschild, G.H.L. 1979: A comparison of methods of dispensing synthetic sex pheromone for the control of Oriental Fruit moth in Australia. Bull. ent. Res. 69: 115-127.

Rothschild, G.H.L. & Minks, A.K. 1974: Time of activity of male Oriental Fruit moth at pheromone sources in the field. Environmental Entomology 3 (6): 1003-1007.

Rothschild, G.H.L., Vickers, R.A. & Morton, R. 1984: Monitoring the Oriental Fruit moth with pheromone traps and bait pails in peach orchards in South-Eastern Australia. Protection Ecology 6: 115-136.

Rothschild, G.H.L. & Vickers, R.A. 1991: Biology, ecology and control of the Oriental Fruit moth. In: Tortricid pests their biology, natural ennemies and control. Eds. Van der Geest L.P.S. & Evenhuis H.S.. Elsevier: 389-412.

Rumbo, E.R. & Vickers, R.A. 1997: Prolonged adaptation as possible mating disruption mechanism in oriental fruit moth, *Cydia* (*Grapholita*) *molesta*. J. Chem. Ecol. 23: 445-457.

Staneva, E.M. 1993: The role of pheromones in control of Oriental peach moth. Zashchita Rastenii Moskva 9: 20-21.

Sziraki, Gy. 1979: Dispersion and movement activity of the Oriental fruit moth (*Grapholita molesta* Busck) in large scale orchards. Acta Phytopathologica Academiae Scientiarum Hungaricae 14: 209-228.

Valeur, P.G. & Lofstedt, C. 1996: Behaviour of male Oriental Fruit moth in overlapping sex pheromone plumes in a wind tunnel. Entomologia Experimentalis et Applicata 79: 51-59.

Vickers, R.A., Rothschild, G.H.L. & Jones, E.L. 1985: Control of Oriental Fruit moth at a district level by mating disruption with synthetic female pheromone. Bull. ent. Res. 75: 625-634.

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Structure of beneficial acarophages and entomophages in IPM of plums in Bulgaria - key beneficial organism and pesticides influence on them

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Abstract: The species composition of beneficial acarophauna and entomophauna on plums in Bulgaria has been established. 91 species, belonging to 11 families of 5 orders have been identified. 18 key beneficial organisms which regulate the basic pests on plums have been determined. The application of pesticides from the green list guarantees good protection of beneficial fauna in plum orchards in Bulgaria.

Key words: entomofauna, acarofauna

Introduction

Plums take third place of importance in fruit growing areas in Bulgaria and they are of great economic significance for the country. The plum agrocoenosis is rich in harmful, beneficial and indifferent species, phytopathogens and weeds. Their regulation is carried out by knowing very well the complex interrelation within the system plant - host - pest - beneficial species. The relative stability of this system determines the population density of harmful and beneficial species. A good knowledge of the quality (species composition) of the system and discovering any quantitative changes in the most important elements secure its good control. The IPM technology of plums was developed in 1995-1997 and its "logo" is shown in figure 1.

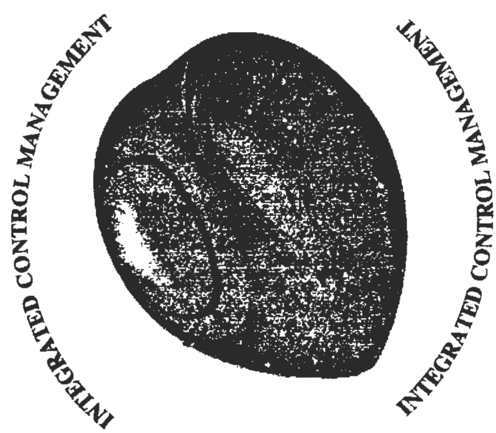

Figure 1. Logo of the IPM project in plum in Bulgaria.

The main component in the section "Plant Protection" is the complex of beneficial species of acarophages and entomophages. Farmers should know well their dynamics during vegetation and they should protect them to the highest degree in growing plums. Determination of the key beneficial species, their role and the estimation of the side effect of pesticides on them, allowed us to make the so-called "green" (Table 3), "yellow" (Table 4), and "red" lists of the applied chemicals that represent an integral part of the technology.

Material and methods

Studies were carried out in the experimental plum orchards of the Plant Protection Institute in Kostinbrod by applying the generally accepted standard methods. The species composition of the beneficial fauna was determined using material collected from all regions of the country in route tours. The collected beneficial species on plums were identified and classified in orders and families. The species identification was made by the following specialists according to the individual taxonomic groups: Acariformes: Simova S.; Coleoptera: Pelov-Krastev V.; Neuroptera: Radeva K. and Pelon-Krastev V.; Diptera: Radeva K. and Pelon-Krastev V.; Hymenoptera: Pelov-Krastev V., Balevski N. and Tomov R..

Results

The generalised results show that on plums in Bulgaria are established 91 beneficial species (Table 1). In systematic aspect they belong to 5 orders and 11 families.

Table 1. Species composition of beneficial entomofauna and acarofauna on plums in Bulgaria.

Order	**Family**	**Species**
Acariformes	Phytoseiidae	*Kampimodromus aberrans* (Oudem.)
		Amblyseius finlandicus (Oudem.)
		Ambliseius andersoni (Chant)
		Typhlodromus tibiarum (Oudem.)
		Antoseius caudigeans (Sch)
		Phytoseius plumifer (Can.et Fanz.)
		Phytoseius horridus (Ribaga)
		Phytoseius macropilis (Banks)
		Paraseiulus soleiger (Ribaga)
	Stigmaeidae	*Zetzellia mali* (Ewing)
		Zetzellia graeciana (Gonz.-Rodrig.)
		Zetzellia silvicola (Gonz.-Rodrig.)
Coleoptera	Coccinellidae	*Adalia bipunctata* L.
		Chilocorus bipustulatus L.
		Stethorus punctillum Ws.
		Coccinella septempunctata L.
Neuroptera	Chrysopidae	*Chrysopa septempunctata* Wesm.
		Chrysopa perla L.
Diptera	Syrphidae	*Episyrphus balteatus* Deg.
		Metasyrphus corrolae Fab.

Table 1 (cont.). Species composition of beneficial entomofauna and acarofauna on plums in Bulgaria.

Order	**Family**	**Species**
Hymenoptera	Aphidiidae	*Ephedrus plagiator* Nees.
		Trioxys angellicae Hal.
	Aphelinidae	*Aphytis proclia* Wik.
	Braconidae	*Acaelius erythronothus* (Foerst)
		Acaelius subfasciatus (Hal)
		Apanteles appelator (Tel)
		Apanteles arisba (Nixon)
		Apanteles ater (Rats)
		Apanteles circumacriptus (Nees)
		Apanteles evonymellae (Bouche)
		Apanteles exilis (Hal.)
		Apanteles gagates (Nees)
		Apanteles laevigatus (Ratz)
		Apanteles laspeyresiella (Papp.)
		Apanteles longicauda (Wesm)
		Apanteles nigripes (Ratz)
		Apanteles xanthostigma
		Ascogaster annularis (Nees)
		Ascogaster quadridentata Wesm.
		Ascogaster rufipes (L.)
		Colastes braconius (Hal)
		Colastes flavitarsis (Thoms)
		Gnamptodon decoris (Foerst)
		Homolobus truncator (Say)
		Macrocentrus linearis (Nees)
		Macrocentrus thoracicus (Nees)
		Meteorus ictericus (Nees)
		Micridus dimidiator (Nees)
		Microdus rufipes (Nees)
	Encyrtidae	*Blastotrix longipennis* (Howard)
	Eulophidae	*Achrysocharella chlorogaster* (Werd.)
		Achrysocharella formosa (Weastw.)
		Achrysocharoides butus (Wlk)
		Achrusocharoides cilla (Wlk)
		Achrysocharoides latreillei (Curt)
		Achrysocharoides niveipes (Thooms)
		Chrysocharis budensis (Erd)
		Chrysocharis laomedon (Wlk)
		Chrysocharis nephereus (Wlk)
		Chrysocharis orchestis (Ratz)
		Chrysocharis prodice (Wlk)
		Cirrospilus diallus (Wik)

Table 1 (cont.). Species composition of beneficial entomofauna and acarofauna on plums in Bulgaria.

Order	**Family**	**Species**
Hymenoptera	Eulophidae	*Cirrospilus lyncus* (Wlk)
		Cirrospilus elegantissimus (Westw)
		Cirrospilus pictus (Nees)
		Cirrospilus staryi (Bck)
		Cirroospilus variegatus (Masi)
		Cirrospilus viticola (Rond)
		Derostenus gemmeus (Westw)
		Euterastichus amethystinus (Ratz)
		Minotetrastichus ecus (Wlk.)
		Pediobius tetratomus (Thoms.)
		Pnigalio longulus (Zett.)
		Pnigalio nigroaeneus (Erd.)
		Pnigalio pectinicornis (L.)
		Sympiesis acalle (Wlk.)
		Sympiesis euspilapterygis (Erd.)
		Sympliesis gordius (Wlk)
		Sympliesis sericeicornis (Nees)
	Ichneumonidae	*Apophua bipunctoria* (Thunb.)
		Itoplactis maculatir (F.)
		Liotryphon punctulatus (Ratz)
		Pimpla turionellae (L)
		Pristomerus vulnerator (Parv.)
		Teleutaca striata Grav.
	Trichogrammatidae	*Trichogramma caocaecia palida*
		Trichogramma dendrolymi

The order Hymenoptera is the richest in species but most of established species occur at low density. The group of the parasitoids isolated from the plum fruit moth, the leaf rollers, leaf miners is the richest in species: 50. They are distributed in 3 families. *Ascogaster quadridentata* is the most common parasitoid from Braconidae family on the plum fruit moth, leaf rollers and some of the leaf miners from Gelechiidae; the most common parasitoid on the leaf rollers and leaf miners from Gelechiidae family is the polyembrionic endoparasite *Macrocentrus lineatus* (Nees) and on leaf miners *Apantheles xanthostigma* (Hal).

Parasitoids which have greater significance for regulating the population density of the leaf miners *Phyllonorycter cerasicolella* are: *Sympliesis sericeicornis*, *Cirrospilus starvi* and *Apanteles circumscriptus*. The most common parasitoid on *Emmetia gaunacella* is *Chrysocharis orchestis*.

Table 2 shows the key beneficial species of acarophages and entomophages which regulate the complex of phytophages on plums. The “green” list (Table n. 3) prepared on the basis of the correct choice of the applied chemicals allow achievement of very good protection of the complex of entomophages and acarophages in the plum biocoenosis

Table 2. Key beneficial species on plums in Bulgaria

Order	Family	Species
Acariformes	Phytoseiidae	*Kampimogromus aberrans* (Oudem.)
		Amblyseius finlandicus (Oudem.)
		Amblyseius andersoni (Chait.)
		Typhiodromus tiliarum (Oudem.)
	Stigmaeidae	*Zetzellia mali* (Ewing)
		Zetzellia graeciana (Gonz.-Rodrig.)
Coleoptera	Coccinellidae	*Adalia bipunctata* (L.)
Neuroptera	Chrysopidae	*Chrysopa septempunctata* (Wesm.)
		Chrysopa perla (L.)
Diptera	Syrphidae	*Epysyrphus balteatus* (DEG)
Hymenoptera	Aphelinidae	*Aphytis proclia* (Wlk)
	Braconidae	*Apanteles xanthostigma* (Hal)
	Eulophidae	*Cirrospilus staryi* (Bck)
		Sympiesis sericeicornis (Nees)
	Ichneumonidae	*Itoplactis maculator*

Table 3. "green" list of pesticides permitted for use in plum integrated production

Type	active ingredient	trade name
Fungicides		
	Hexaconazol	Anvil
	Pyrinphenox	Docado
	Dithianon	Delan
	Miklobutanyl	Systan
	Tryforin	Saprol
Insecticides & acaricides		
	Triflumuron	Alsystin
	Dyflubenzuron	Dimilin
	Fenoxycarb	Insegar
	Tephlubenzuron	Nomolt
	Hexytiazoks	Nisuran
	Amytraz	Mitac
	Kiofentezin	Apolo
	Propagrit	Omit
	Bacillus thuringiensis	Dipel, Batic, Biobit
Herbicides		
	Glifosat	Raundap, Glifodin, Sting, Guialka
	Fluasifop buthyl	Fusilat, Fusilat super
	Oxyfluorfen	Goal
	Pendimethalin	Stomp

Table 4. "yellow" list of pesticides permitted for use in plum integrated production.

Type	active ingredient	trade name
Fungicides		
	Zineb	Perozin, Aliett-Z
	Benomyl	Benlayte, Fundasol, Agrocid
	Sulphur	Thiosol, Sulphur powder
Insecticides & acaricides		
	Endosulfan	Tiodan
	Fosalon	Agria-1060, Zolon
Herbicides		
	Haloxyfopetoxyethyl	Galant, Galant super
	Imasikvin	Skepter
	Lenasil	Venzar

Conclusion

The structure of the species composition of the beneficial acarofauna and entomofauna on plums is established. It includes 91 species, which belong to 11 families of 5 orders. They regulate the basic plum pests. The application of pesticides included in the so called "green" list guarantees good protection of the complex of key beneficial organisms in the plum biocoenosis.

References

Balevski, N. & Tomov, R. 1997: Mining moths from family Buccularicidae, Gracillariidae, Lyonetiidae, Nepticulidae and Tisheriidae (Lepidoptera) as host of parasitoids from family Braconidae (Hymenoptera). Acta Entomologica Bulgarica.

Pelov, V. & Tomov, R., 1998: Chalcidid wasps (Hymenoptera,Chalcidoidea) reared from mining moths (Lepidoptera) feeding on fruit trees in Bulgaria. Acta Entomologica Bulgarica l: 56-63.

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Distribution, races and management of the european cherry fruit fly (*Rhagoletis cerasi* L.) in Norway

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Abstract: The European cherry fruit fly (*Rhagoletis cerasi* L.) is one of the main pests on sweet cherries (*Prunus avium* L.) in Europe. The species was discovered for the first time in the main sweet cherry production area in Norway in 1991, although it has been reported from southern Norway since the 1930s. By means of yellow sticky traps and examination of fruit samples the distribution and abundance of the cherry fruit fly have been recorded yearly in the main fruit growing areas in Norway since 1992. The distribution of the species is not continuos in Norway. The abundance is higher in southern Norway compared to western Norway. The abundance is also several times higher on Honeysuckle (*Lonicera* sp.) compared to sweet cherries. A crossing experiment showed that both the western and the south-eastern population belonged to the northern race of the species.

Key words: monitoring, races, control strategies

Introduction

The European cherry fruit fly (*Rhagoletis cerasi* L.) is one of the main pests on sweet cherries in central and southern Europe (Boller *et al.*, 1980). Damage is caused by the adult females laying eggs in the half-ripened sweet cherry fruits, so that the larvae can develop inside the fruits.

In 1991 the cherry fruit fly was recorded for the first time in Hardanger, western Norway, where the main sweet cherry production area in the country is located (Jaastad, 1994). In the 1930s and 40s a rather large population of the cherry fruit fly was reported from south-eastern Norway (Ausland, 1951). However, this population declined and was believed to be extinct in the 1980s (Edland, 1990).

In addition to sweet cherries the European cherry fruit fly accepts some species of Honeysuckle (*Lonicera* sp.) as host plants for laying eggs, most frequently *L. tartarica* and *L. xylosteum*.

There are two races of the cherry fruit fly in Europe, known as the southern and the northern race (Boller *et al.*, 1976). Between the races there is an unidirectional incompatibility; crosses between females from the northern race and males from the southern race are sterile, whereas the reciprocal crosses are fertile (Boller & Bush, 1974).

The objectives of this paper are:

1) to present results on the distribution and abundance of the cherry fruit fly in Norway;
2) to present data from a crossing experiment conducted to conclude on the races and origin of the cherry fruit fly populations in Norway;
3) to discuss the management strategy employed against the cherry fruit fly in Norway and possible alternative strategies.

Distribution and abundance

The distribution and abundance of the cherry fruit fly have been recorded since 1992 by using yellow sticky traps (REBELL™) (Remund & Boller, 1979) and by systematically collecting fruit samples. Traps were placed in all fruit district in Norway (more than 3000 traps each year). In Hardanger the density of traps was 1 trap per 10-20 trees and traps were placed in all fruit orchard. In other areas traps were placed in some selected fruit orchards. Traps were also placed in Honeysuckle shrubs in these areas. Traps were controlled twice, in late June and in middle/late July. Additionally, samples of 100 fruits from the southern side of both sweet cherry trees and *Lonicera* bushes were collected and examined for larvae.

The distribution of the cherry fruit fly in Norway was found to be discontinuous; two populations were found in the inner fjords of western Norway, and one population was found along the south-eastern coast (Fig. 1).

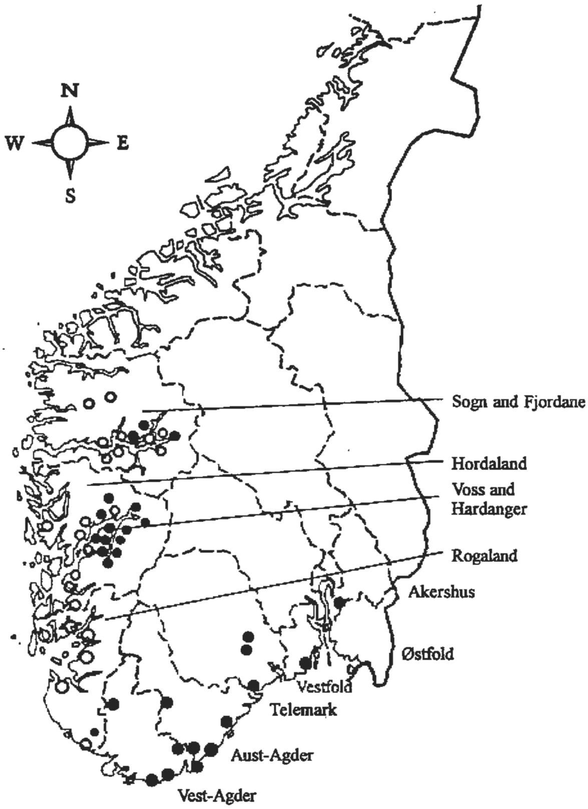

Figure 1. Distribution of *Rhagoletis cerasi* in Norway. Registration are based on recordings from yellow traps abd fruit samples of sweet cherry and *Lonicera* fruits. ❍ = no flies registered, ● = flies are present.

The abundance of flies was highest in the southern part of the country over several years (Table 1). In western Norway the distribution was locally variable in that flies was found in one orchard, while lacking in the neighbor orchard. This might be due to differences in summer temperatures, as the cherry fruit fly is dependent on temperatures higher than 16 °C to be active (Boller, 1966). Temperatures in June and July are close to 2 °C higher in southern compared to western Norway (Table 2). The abundance on Honeysuckle was several times higher than on sweet cherries (Table 3). The difference in number of flies caught per trap between western and southern Norway was highest in catches on sweet cherries, although more flies were also caught in traps on Honeysuckle in the southern area (Table 3). The infestation of the cherry fruit fly was higher in southern compared to western Norway (Table 4). In western Norway larvae were found only in Honeysuckle fruits (except from one sample in 1992).

Table 1. Mean number of cherry fruit flies caught per trap (combining catches on sweet cherries and Lonicera) in Hardanger (western Norway) and in Agder (southern Norway) (1992-1996).

Locations	1992	1993	1994	1995	1996
Hardanger	0.29	0.28	0.21	0.56	-
Agder	-	11.58	12.51	11.32	20.40

Table 2. Average daily summer temperatures in Ullensvang (western Norway) and Landvik (southern Norway), in °C.

Locations	June	July
Ullensvang	13.8	14.7
Landvik	15.0	16.2

Table 3. Mean number of cherry fruit flies caught per trap on sweet cherries and Honeysuckle in Hardanger (western Norway) and Agder (southern Norway) (1994-1995).

	Sweet cherries		Honeysuckle	
Locations	1994	1995	1994	1995
Hardanger	0.085	0.35	10.38	21.25
Agder	10.50	10.98	40.25	47.00

Table 4. Mean number of cherry fruit larvae found in samples of 100 fruits (number of samples in brackets) of sweet cherries and Honeysuckle in Hardanger (western Norway) and Agder (southern Norway) (1994-1995).

	Sweet cherries		Honeysuckle	
Locations	1994	1995	1994	1995
Hardanger	0 (66)	0 (13)	0.5 (26)	0 (7)
Agder	0.7 (17)	9.2 (11)	1.0 (2)	4.3 (3)

Races and origin of the norwegian populations

Larvae of the cherry fruit fly was discovered in imported fruits from Italy in 1991. Thus, a likely explanation for its occurrence in western Norway was that it had been introduced with imported fruits. A crossing experiment was therefor conducted to conclude on the races of the Norwegian populations (Jaastad, 1994). Unmated flies from both the western and the south-eastern populations were crossed with flies from Switzerland (the southern race) (Jaastad, 1994).

The results showed that both the western and the south-eastern population in Norway belonged to the northern race of the fly. There was a clear difference between fertile and sterile crosses (Table 5).

Table 5. Results from crossing experiment with *Rhagoletis cerasi*, presented as the proportion of eggs hatching. Flies originating from: Ne = eastern Norway, Nw = western Norway, CH = Switzerland. n = number of crossings, each between tree females and one male. From Jaastad (1994).

Crossing males x females	n	No. of eggs laid (mean)	No. of eggs hatching (mean)	Proportion hatching (mean)
Ne x CH	2	196.5	176.5	0.89
Nw x CH	2	227.5	177	0.81
CH x CH	4	538	492	0.90
CH x Ne	3	235.7	0	0
CH x Nw [1)]	2	288	0	0
CH x Nw [2)]	3	78.7	0	0

[1)] = flies from Kinsarvik, [2)] = flies from Odda.

When females from Norway were crossed with males from Switzerland (southern race) no eggs hatched, whereas the reciprocal cross (males from Norway crossed with females from Switzerland) resulted in eggs that hatched. As most of the sweet cherry fruits imported to Norway come from regions where the southern race of the cherry fruit fly is common, it is not likely that the western population originate from imported sweet cherries. It is more likely that population in western Norway has been introduced with Honeysuckle plants from areas where the northern race is common.

Management strategies employed against the cherry fruit fly in Norway and alternative strategies

As the registrations showed that the abundance of the cherry fruit fly varied from year to year and the distribution was locally variable, our management strategy has been to use traps (REBELL™) in combination with insecticides. In this way we have been able to restrict the applications of insecticides to those areas were flies have been detected in traps. Insecticides (fenthion and dimethoat) have been used in half of the recommended concentration. The threshold for using insecticides have been any catch. We might have to reconsider this threshold. However, more research is needed on the relationship between egg laying, larval infestation and climatic factors in Norway.

Management strategies that interfere with normal behavior or reproduction might be a good alternative to insecticides. Such strategies have the potential to be species specific, to not disturb the natural habitat and to not represent a threat to human health. The sterile insect technique (SIT) is a method that interferes with normal reproduction (Gilmore, 1989). However, the method is expensive and its efficiency is dependent on a rather small, not widely-distributed natural population of flies. Its success in Norway would probably be limited.

As we do have the northern race in Norway we have the possibility to use the incompatible insect technique (IIT) (Ranner, 1990). The technique is based on the release of southern race males into areas where the northern race is distributed. However, as with the sterile insect technique its success is dependent on a rather small and isolated population.

The female *R. cerasi* oviposition deterrent pheromone has been successfully used to prevent female flies from laying eggs (Katsoyannos & Boller, 1980; Aluja & Boller, 1992). It is so far not commercially used due to high production costs (E. F. Boller, pers. comm.). This would, however, be a good alternative to insecticides.

A potential management strategy for the future might be to make use of the male sex pheromone in mating disruption. Females *R. cerasi* seems to actively choose between males, but on what cues they choose males are not identified (Jaastad, 1998). Possibly the male sex pheromone is an important cue, as females are attracted to the pheromone (Katsoyannos, 1982). This is an interesting and promising topic to work with.

Conclusions

The distribution of the cherry fruit fly in Norway is discontinues, two populations are found in the inner fjords of western Norway and one along the south-eastern coast.

The population size is larger in southern Norway compared to western Norway, and more flies are found on Honeysuckle shrubs compared to sweet cherry trees. It is not likely that the western population originate from imported sweet cherry fruits. Apparently it has been imported to the area with Honeysuckle shrubs from south-eastern Norway or Scandinavia. This is supported by the high catches on Honeysuckle compared to sweet cherries.

The management strategy in Norway is to use a combination of yellow sticky traps and insecticides.

There are several alternative management strategies that might be used in Norway, however, more research is needed to reveal their effects and efficiency.

References

Aluja, M. & Boller, E.F. 1992: Host marking pheromone of *Rhagoletis cerasi*: field deployment of synthetic pheromone as a novel cherry fruit fly management strategy. Entomol. Exp. Appl. 65: 141-147.

Ausland, O. 1951: Kirsebærflua (*Rhagoletis cerasi* L.) i Norge. En orientering om dens biologi og bekjemping. Melding fra Statens plantevern. 5. 35pp. (in Norwegian)

Boller, E.F. 1966: Beitrag zur Kenntis der Eiablage und Fertilität der Kirschenfliege, *Rhagoletis cerasi* L. Mitt. Schweiz. Ent. Ges. 38: 193-202. (in German)

Boller, E.F. & Bush, G.L. 1974: Evidence for genetic variation in populations of the European cherry fruit fly, *Rhagoletis cerasi* L. based on physiological parameters and hybridization studies. Entomol. Exp. Appl. 17: 279-293.

Boller, E.F., Remund, U. & Katsoyannos, B.I. 1980: Alternatives zur konventionellen chemischen bekämpfung der Kirschenfliege, Schlussbericht der Forschungsperiode 1962-1979. 107 pp. Eidg. Forschungsanstalt Wädenswil. (in German)

Boller, E.F., Russ, K., Vallis, V. & Bush, G.L. 1976: Incompatible races of European cherry fruit fly, *Rhagoletis cerasi* (Diptera: Tephritidae). Their origin and potential use in biological control. Entomol. Exp. Appl. 20: 237-247.

Edland, T. 1990: Kirsebærflue Rhagoletis cerasi (L.) – og andre skadelige fruktfluer på kirsebær. Gartneryrket. 80 (11): 16-18. (in Norwegian)

Gilmore, J.E. 1989: Sterile insect techniqe (SIT). In: Robinson, A.S. and Hooper, G. (eds.) Fruit flies: their biology, natural enemies and control, vol 3A. Elsevier Science Publisher, Amsterdam: 353-363.

Jaastad, G. 1994: First registration of the cherry fruit fly, *Rhagoletis cerasi* (L.) in western Norway; distribution, size and origin of the population. Norw. J. Agric. Sci. 8: 203-214.

Jaastad, G. 1998: Mating behavior and distribution of the European cherry fruit fly (*Rhagoletis cerasi* L.) in Norway; applied and evolutionary research aspects on an insect pest. PhD thesis, University of Bergen, Norway. ISBN 82-992402-9-8.

Katsoyannos, B.I. 1982: Male sex pheromone of *Rhagoletis cerasi* L. (Diptera: Tephritidae): Factors affecting release and response in the mating behavior. Z. ang. Entomol. 94: 187-198.

Katsoyannos, B.I. & Boller, E.F. 1980: Second field application of oviposition-deterring pheromone of the European cherry fruit fly, *Rhagoletis cerasi* L. (Diptera: Tephritidae). Z. ang. Entomol. 89: 278-281.

Ranner, H. 1990: Untersuchungen zur Biologie und Bekämpfung der Kirschfruchtfliege, *Rhagoletis cerasi* L. (Diptera, Trypetidae) – V. Versuche zur Bekämpfung der Kirschfruchtfliege mit Hilfe der Incompatible Insect Technique (IIT). Plantzenschutzberichte 51: 1-16. (in German)

Remund, U. & Boller, E.F. 1979: Zur Negativprognose (Befallsprognose) bei der Kirschenfliege. Sweitz. Z. Obst- und Weinbau. 115: 167-170. (in German)

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Adult emergence and swarming activity of the Cherry fruit fly, related to meteorological factors (Preliminary project results).

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Abstract: The Cherry fruit fly (*Rhagoletis cerasi*) represent a serious problem in sweet cherry production in Central and Southern Europe. In Norway the evidence of this insect was not regarded as a serious threat until early 90 when larvaes of *R. cerasi* were found in fruits in the main districts of sweet cherry production in Hardanger. Then a rather comprehensive project started both to investigate the extent of the population of this insect and to develop methods and strategies for pest management.

Key words: *Rhagoletis cerasi*, model, forecasting

Introduction

The occurence of Cherry fruit fly populations in Norway is rather scattered, also in districts with relative dense and continous fields of sweet cherry trees. The appearence of the flies also vary greatly from one year to another in the same garden, and it is obvious related to climate and weather condition. Earlier investigations in other countries demonstrate this relationship in the different stages of the life cyclus of the fly. The emergence from the pupae in the soil and the start of eclosion is depending on soil temperature. The adult flies are not very mobile and the swarming activity - and the oviposition, is strongly dependent on the weather conditions. In the Norwegian summer climate there are frequently days with weather conditions that limit the activity of the flies, and that may to a great extent explain the varying appearence of the insect. But in most of the actual districts, and in most years, the weather conditions are obviously sufficient for emergence, swarming and multiplying of this fly (Ullensvang Research Center, 1994; Baker, 1991; Baker & Miller, 1978; Ravn & Rasmussen, 1997; Jaastad, 1998).

The sweet cherry production in Norway is limited to the fjord districts in the south-western part (80%) and to some smaller areas in the southernmost part. The climate favourable for this production is mild winters, no frost in the flowering period and relative warm and humid summers with little wind. On the steep hillsides on both sides of a fjord the radiation heating is great and by night the fjord is acting like an effective heat reservoir. As the topography thus plays an important role on climate, the variations of the climate may be great over relatively short distances.

As a part of the national project, one garden at Landvik Research Center (58.19'N,8.30'E), (Fig. 1), was selected for more detailed studies of the behaviour of the Cherry fruit fly, 1996 - 98. Here 11 traps were placed within a rather small area and the number of trapped flies were counted every 2 or 3 day. The nearest automatic weather station is about 500 m from the field and in 1998 another automatic station is placed within the actual garden with measurements of temperature, humidity and wind. In addition there are measurements of temperatures at 3 levels in 3 of the trees with traps.

The main purpose of this work is to find relations between measured weather parameters and the behaviour of the Cherry fruit fly, to be able to forecast a best possible time for optimum effect of a management. The basic information for this forecast is ment to be registrations from a network of automatic weather stations and some few observations of traps in the earliest orchards.

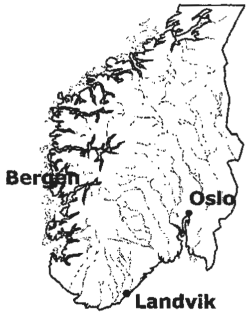

Figure 1. Schematic map of Southern Norway

Theory

A change of state in the annual cyclus of both plant and insect species, is within a population observed as a process that last for some time, and the length of the period is often varying with climate. For instance, in our country between 58 and 72 deg.NL, the occurance of a given biological or zoological phenomena may last for weeks in Southern Norway while it is all done in a few days in the northern part. The distribution of the occurance of new events within the actual time scale may often be presented, within significant limits, as a normal probability distribution with the general expression:

$$\varphi(x) = c \cdot e^{-\frac{1}{2}x^2}$$

This general distribution is shown in figure 2.

In modelling the emergency of the Cherry fruit fly, the optimum number of flies one particular day depends on a) how many larvae there are in the soil, b) the time of start of emergence, and c) the length of the period of oviposition.

a) This is perhaps the most difficult parameter to determine. From a practical point of wiew however, this will not have a decisive affect on the programme for pest management.
b) The time of the start of emergence is predicted from calculated heatsums of soil temperatures and of origin of the population. The time of emergence of the adult flies from soil is dependent on temperature conditions in the uppermost layer in the soil during spring and early summer. Using temperature measurements at 10 cm level and a basic temperature of 5.0 °C, the emergence appear at temperature sums of 400-430 degree-days.
c) The lifetime of the Cherry fruit fly is about one month. It is assumed that temperature more or less affects the activity and development in the different periods, but the preoviposition period usually last 7-10 days.

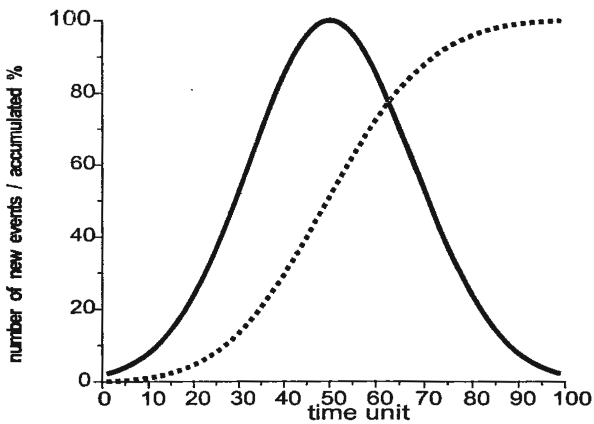

Figure 2. A normal probability distribution.

For most gardens the conditions of the local climate has to be judged from the measurements at the nearest weather station. The actual weather conditions within a fruit garden may be different from what is measured at a station in an open field. Situations with rain or no rain is usually common for a larger area, but estimates of actual wind and temperature may be rather dubious. Therefore additional informations about local variations of climate are necessary most places.

The swarming and the oviposition activity of the flies is affected by temperature, wind and rain. The temperature has to be more than 16 °C and that means that the flies are active only some few hours in the middle of the day. Wind is perhaps the most indeterminable parameter because in this low layer it varies much both in time and space. The trees in a fruit garden usually shield the lower part very effective from wind, and estimates based on measurements from a distant location has to be done very carefully.

From the start of emergence, the model calculate for every day the number of new insects and the accumulated number of flies in the population. Number of new flies one particular day is given by the formula:

$$\varphi(x) = n_{max} \cdot e^{-\{(x-\mu)/\sigma\}^2}$$

In this expression x gives the number of days from the start of the emergency, n_{max} is an estimated maximum number of new flies emergenced on one day, σ is a number that express how the daily numbers of emergencies is distributed from the mean value, and 2μ is the total number of days in the period.

The actual number of swarming flies one particular day is a result of the total number of hatched flies and the weather conditions. And if the possibility for being trapped is directly correlated to the number of swarming flies, the daily number of trapped flies can be estimated by the formula:

$$F(x) = \Sigma(\varphi(x) \cdot I_x), \quad \text{where} \quad I_x = c \cdot \Sigma(I_{tx} \cdot I_{vx} \cdot I_{rx} \cdot I_{qx})$$

I_x is a multiplicative climate-index composed of hourly temperature-, wind- , precipitation- and radiation indexes. How the limits for the indexes are set depends on local conditions, and below is given as an example the numbers used in this project.

Temperature index (I_{tx}):		Wind index (I_{vx}) :	
$T < 12$	0	$WS > 3$	0
$12 \leq T < 16$	0.5	$3 \geq WS > 2$	0.5
$T \geq 16$	1	$WS \leq 2$	1

Rainfall index (I_{rx}) :		Radiation index (I_{qx}) :	
$RR > 0$	0	$Qrel \leq 0.6$	0.5
$RR = 0$	1	$Qrel > 0.6$	1

Data

In the two years 1996 and 1997, the weather conditions in spring and early summer were very different. In 1996 the temperature was on average below normal in April, May, June and greater part of July. In 1997 the temperatures were, except for May, above the normal in this period. The differences in temperature conditions between the two years are given in the table 1, and it is also clearly demonstrated by figure 3 which gives daily means of 10 cm soil temperatures in the period April - July 1996 and -97.

Table 1. Temperature and precipitation, Landvik

	1996						1997				
	Apr.	May	June	July	Aug.		Apr.	May	June	July	Aug
Temp.	4.8	8.4	13.9	15.3	16.9		5.4	9.4	15.2	18.1	19.9
ΔNorm	-.3	-2.0	-.8	-.9	1.5		0.3	-1.0	0.5	1.9	4.5
Prec.	8	135	68	27	128		21	40	97	71	6
%Norm.	14	165	96	29	113		36	49	137	77	7

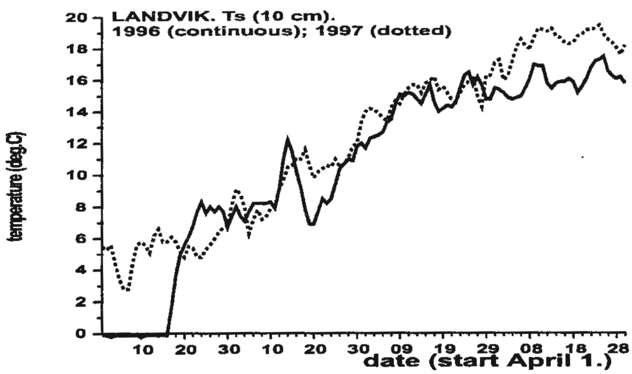

Figure 3. Daily means of soil temperatures April - July, 1996 (continuous line) – 97 (dotted line). LANDVIK Ts(10 cm).

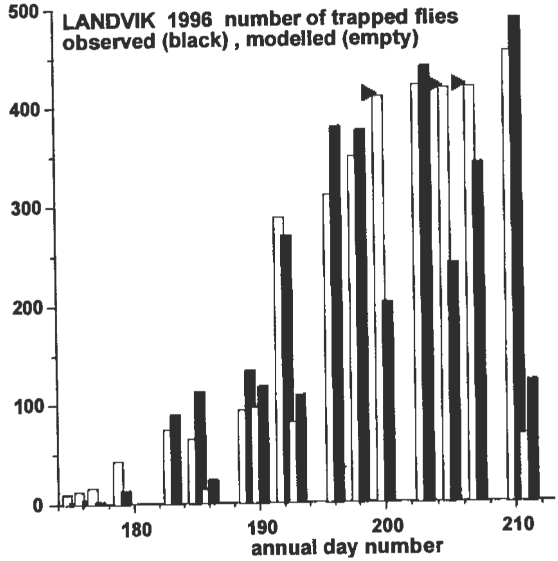

Figure 4. Number of trapped flies and modelled catchings 1996

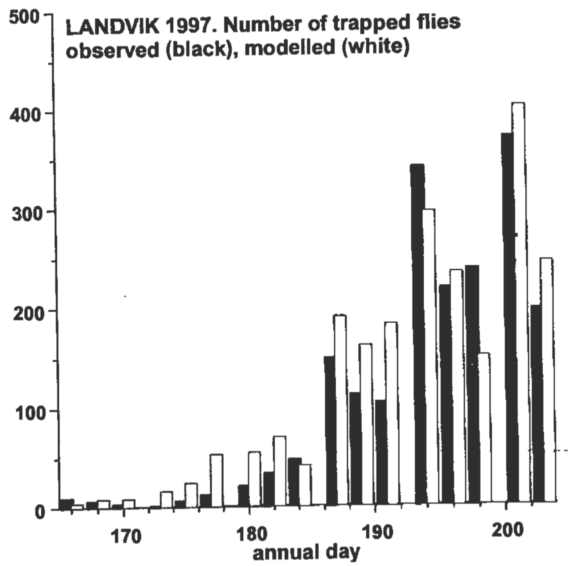

Figure 5. Number of trapped flies and modelled cathings 1997

From figure 3 it is seen that in 1996 there was a rather late start of the soil heating (snow cover), and in the rest of the year the soil temperature is partly much lower than in the next year. The first findings of Cherry fruit flies were on day no.176 and 167 in the two years resp., but despite less favourable weather conditions, the total number of trapped flies was 30 % higher in 1996 than in 1997 (3450 and 2665).

Figures 4 and 5 give the numbers of flies counted on every inspection of the traps (black columns) and the corresponding numbers calculated by the model (red coulumns), 1996 and 1997 resp. The total number of both trapped and modelled catchings are the same each year, but the observations of flies stopped both years at the end of July and therefore there is no «complete» ending of the theoretical distribution.

Discussion

This project is running also this year (1998). An extra automatic weather station in the actual garden will give a more precise measure of actual weather parameters, and hopefully it also will be possible to get more knowledge about how the actual weather parameters affect and limit the swarming and oviposition activity. The observations of the traps will this year continue until end of August to include the decline of this part of the life cyclus of the fly.

In the results from 1996 and 1997 given by figures 4 and 5, there are some greater deviations between observed and modelled catches (marked by arrows) which will be given special attention in the further analysis. In the next run, to decide the optimum time for a management, the model results has to be compared to knowledge about phenological development of the cherry trees.

References

Baker, C.R.B & Miller, G.W. 1978: The effect of temperature on the post-diapause development of four geographical populations of the European Cherry Fruit Fly (*Rhagoletis cerasi*). Ent.Exp. & Appl. 23: 1-13.

Baker, C.R.B. 1991: The validation and use of life-cycle simulatin model for risk assessmenet of insect pests. OEPP/EPPO Bulletin 21: 615-622.

Jaastad, G. 1998: Mating behaviour and distribution of the European cherry fruit fly (*Rhagoletis cerasi* L.) in Norway; applied and evolutionary research aspects on an insect pest. Dr. scient. thesis, Dep. of Zoology, Univ. of Bergen.

Ravn, P.R. & Rasmussen, A.N. 1997: Kirsebærfluen, (Grøn Viden nr. 102) (in Danish)

Ullensvang Research Station 1994: Kirsebærfluge (information leaflet, in Norwegian)

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Sympatric speciation via diverging host preferences? Planned experiment with European cherry fruit fly, *Rhagoletis cerasi* (Diptera: Tephritidae).

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Abstract: Experimental testing of host plant preference in *Rhagoletis cerasi* will be conducted in June/July 1999. Naive colormarked flies collected as larvae from each of the two hosts, sweet cherry, *Prunus avium* and *Lonicera tartarica* will be introduced to one of four choice situations for host plants in field cages. The choice situations are; both sweet cherry and *Lonicera* with fruits for oviposition, sweet cherry with fruits and *Lonicera* without and vice versa and neither with fruits. The position and behaviour of flies will be recorded by predetermined criteria. The hypothesis is that host preference in adult *R. cerasi* is affected by larval adolescence.

Key words: *Prunus avium, Lonicera tartarica*

Host choice in European cherry fruit flies; a basis for sympatric speciation?

The objective of this study is to test whether there exist, on the basis of host choice, two partly reproductively isolated populations of *R. cerasi* in southern Norway. The result is of interest in relation to sympatric speciation and integrated pest control, since *Lonicera* plants now are common in sunexposed parks and gardens in Europe where the phenology of the fruits coincide with sweet cherry (Boller *et al.*, 1998, Jaastad pers. comm.).

Sympatric speciation in animals has been controversial ever since Darwin. Some doubt its occurrence (Mayr, 1963; Futuyma & Mayer, 1980), and others rely on better established alternatives (Carson, 1987; Coyne & Barton, 1988). The key obstacle in sympatric speciation is the homogenising effect of recombination (Felsenstein, 1981; Tauber & Tauber, 1989). However, several biologists have presented conditions under which sympatric speciation is possible (Bush, 1975; White, 1978; Bush & Howard, 1986; Kondrashov & Mina, 1986; Rice, 1987; see Tauber & Tauber, 1989), and several models have also been suggested (Rosenzweig, 1978; Rice, 1984; Slatkin, 1982; Rausher, 1984; Diehl & Bush, 1989; Johnson *et al.*, 1996). For example, Bush (1969; 1975) proposed that herbivorous insects can speciate sympatrically during host shifts. This process includes an intermediate stage of host-races (host-race criteria see: Jaenike ,1981; Diehl & Bush, 1984; Bush, 1992). If mating occurs in association with the host, assortative mating within subpopulations can result due to host preference (Rice, 1984; Price, 1980; Diehl & Bush, 1984). The best studied case of host-race formation is that of the Apple maggot fly, *Rhagoletis pomonella* (Bush, 1969; Feder *et al.*, 1988; McPheron *et al.*, 1988; Prokopy *et al.*, 1988; Smith, 1988).

Whether there exist host-races of the European cherry fruit fly, *Rhagoletis cerasi*, on *Lonicera* and sweet cherries in central Europe is a matter of controversy (Boller & Prokopy, 1976). In their natural shady habitats, *Lonicera* have a slower development of fruits than sweet cherries. The phenology and the cooler habitat influence the flight period of *R. cerasi* (Wiesmann, 1932; 1937). By planting Lonicera in sunny habitats as gardens, parks and along superhighways, the phenology of the plants have become more equal to that of sweet cherries (Boller *et al.*,1998). It has been shown that learning in adults affected oviposition behaviour (Boller *et al.*, 1998). But it still remains to confirm whether host races exist.

In 1991 *R. cerasi* was discovered in Hardanger (Hesjedal & Jaastad, 1993), the main sweet cherry production site in Norway. The fly might have been imported to the area together with *Lonicera* plants used in gardens and parks (Jaastad, 1998). Jaastad (1998) observed that mainly *Lonicera* spp. was infested by *R. cerasi*, but small numbers were also found on sweet cherries. If the fly was imported together with *Lonicera* plants, the observed individuals on sweet cherries have shifted host. In south-eastern Norway, 500 km east of Hardanger, *R. cerasi* has existed since the 1930s (Ausland, 1951) on both *Lonicera* and sweet cherries.

Planned research

R. cerasi oviposit on several species of *Lonicera*, where the most important ones are *L. tartarica* and *L. xylosteum*. Also several cultivated varieties of sweet cherries are used as host plants. In my experiment I will only use flies collected from *L. tartarica* and *P. avium*.

Collected pupa from each population will be hatched under laboratory conditions as described by Boller (1984). The newly hatched adults will be colormarked (for technique see Bonduriansky & Brooks, 1997) according to host origin. 25 naive females and males of each origin (a total of 100 flies) will then be released into each of four field cages (2x2x2 meters) with one *P. avium* and one *L. tartarica* plant. In each field cage, the flies are presented to a choice situation. The four choices are:

1) both sweet cherries and *Lonicera* with fruit,
2) sweet cherries with fruit and *Lonicera* without and
3) vice versa
4) neither with fruits.

Washed fruits are fastened to the plants and changed each day to prevent altered behaviour and floor-ceiling effects due to female oviposition pheromone. After introduction to the field cages the position (on which plant and where on the plant) and behaviour (copulation, oviposition) of the flies will be registered according to predetermined criteria. Two sampling methods are used (Altman, 1974); scan sampling and focal sampling. Scan sampling is used in ten minute sessions every hour. Focal sampling, following one individual, preferentially females, for a given period is used to quantify the activity level. This will in second turn be used to determine the dependence between the hourly scan samplings. The registration will take place during peak activity, 7-9 hours after sunrise (Katsoyannos, 1982). The experiment will terminate approximately after one month, when cohort has died.

I will use chi-quadrat statistics and Correspondance analysis to analyse data.

References

Altmann, J. 1974: Observational study of behaviour: Sampling methods. Behaviour 46: 227-267.

Ausland, O. 1951: Kirsebærfluga (*Rhagoletis cerasi* L.) i Norge. En orientering om dens biologi og bekjemping. Melding fra Statens plantevern. 5. 35pp.

Boller, E.F. 1984: *Rhagoletis cerasi* and *Ceratitis capitata*. 2: 135-144. In Singh, P. & Moore, R.F. eds. Handbook of insect rearing. Elsevier Science Publishers.

Boller, E.F. & Prokopy, R.J. 1976: Bionomics and management of *Rhagoletis*. Ann. Rev. Entomol. 21: 223-246.

Boller, E.F., Katsoyannos, B.I. & Hippe, C. 1998: Host races of *Rhagoletis cerasi* L. (Dipt., Tephritidae): Effect of prior adult experience on oviposition site preference. J. Appl. Ent. 122: 231-238.

Bonduriansky, R. & Brooks, R.J. 1997: A technique for measuring and marking live flies. Canad. Ent. 129: 827-830.

Bush, G.L. 1969: Sympatric host race formation and speciation in frugivorous flies of the genus *Rhagoletis* (Diptera: Tephritidae). Evolution 23: 237-251.

Bush, G.L. 1975: Sympatric speciation in phytophagous parasitic insects. In: Price, P.W. ed. Evolutionary strategies of parasitic insects. Plenum, London: 187-206

Bush, G.L. 1992: Host race formation and sympatric speciation in *Rhagoletis* fruit flies (Diptera:Tephritidae). Psyche 99: 335-357.

Bush, G.L. & Howard, D.J. 1986: Allopatric and non-allopatric speciation ; assumtions and evidence. In: Karlin, S. & Nevo, E. eds. Evolutionary processes and theory. Academic press, New York: 411-438.

Carson, H.L. 1987: The genetic system, the deme, and the origin of species. Annu. Rev. Genet. 21: 405-423.

Coyne, J.A. & Barton, N.H. 1988: What do we know about speciation? Nature (London) 331: 485-486.

Craig, T.P., Itami, J.K., Abrahamson, W.G. & Horner, J.D. 1993: Behavorial evidence for host-race formation in *Eurosta solidaginis*. Evolution 47: 1696-1710.

Diehl, S.R. & Bush, G.L. 1984: An evolutionary and applied perspective of insect biotypes. Ann. Rev. Entomol. 29: 471-504.

Diehl, S.R. & Bush, G.L. 1989: The role of habitat preference in adaptation and speciation.. In: Otte, D. and Endler, J.A. eds. Speciation and its consequences. Sinauer, Sunderland, Mass: 345-365.

Feder, J.L., Chicolite, C.A. & Bush, G.L. 1988: Genetic differentiation between sympatric host races of the apple maggot fly *Rhagoletis pomonella*. Nature 336: 61-64.

Felsenstein, J. 1981: Scepticism towards Santa Rosalia, or why are there so few animals? Evolution 35: 124-138.

Futuyma, D.J. & Mayer, G.C. 1980: Non-allopatric speciation in animals. System. Zool. 29: 254-271.

Hesjedal, K. & Jaastad, G. 1993: Registrering og bekjemping av kirsebærfluge i Hardanger. Rapport frå utryddingsprogrammet 1992 og plan for arbeidet 1993. 7 pp.

Jaastad, G. 1998: First registration of the cherry fruit fly, *Rhagoletis cerasi* (L.) in western Norway; distribution, size and origin of population. Norw. J. Agri. Sci. 8: 203-214.

Jaenike, J. 1981: Criteria for ascertaining the existence of host races. Am. Nat. 117: 830-834.

Johnson , P.A., Hoppensteadt, F.C., Smith, J.J. & Bush, G.L. 1996: Conditions for sympatric speciation: a diploid model incorporating habitat fidelity and non-habitat assortative mating. Ecology 10: 187-205.

Katsoyannos, B.I. 1982: Male sex pheromones of *Rhagoletis cerasi*, L.(Diptera: Tephritidae): factors affecting release and response and its role in the mating behaviour. Z. ang. Ent. 94: 187-198.

Kondrashov, A.S. & Mina, M.V. 1986: Sympatric speciation: When is it possible? Biol. J. Linn. Soc. 27: 201-223.

Mayr, E. 1963: Animal species and evolution. Belknap press of Harvard University Press, Cambridge, MA.

McPheron, B.A., Smith, D.C. & Berlocher, S.H. 1988: Genetic differences between host races of *Rhagoletis pomonella*. Nature 336: 64-66.

Price, P.W. 1980: Evolutionary biology of parasites. Princeton University press, Princeton, N.J.

Prokopy, R.J., Diehl, S.R. & Cooley, S.S. 1988: Behavioural evidence for host races in *Rhagoletis pomonella* flies. Oecologia 76: 138-147.

Rausher, M.D. 1984: The evolution of habitat preference in subdivided populations. Evolution 38: 596-608.

Rice, W.R. 1984: Disruptive selection on habitat preference and the evolution of reproductive isolation: a simulation study. Evolution 38: 1251-1260.

Rice, W.R. 1987: selection via habitat specialisation: the evolution of reproductive isolation as a correlated character. Evol. Ecol. 1: 301-314.

Rosenzweig, M.L. 1978: Competitive speciation. Biol. J. Linn. Soc. 10: 275-289.

Slatkin, M. 1982: Pleiotropy and parapatric speciation. Evolution 36: 263-270.

Smith, D.C. 1988: Heritable divergence of *Rhagoletis pomonella* host races by seasonal asynchrony. Nature 336: 66-67.

Tauber, C.A. & Tauber, M.J. 1989: Sympatric speciation in insects: Perception and perspective. In: Otte, D. & Endler, J.A. eds. Speciation and its consequences. Sinauer, Sunderland, Mass: 307-344.

White, M.J.D. 1978: Modes of speciation. Freeman, W.H. San Fransico.

Wiesmann, R. 1933: Untersuchungen über die Lebensgeschichte und Bekämpfung der Kirschfliege *Rhagoletis cerasi* Linné. 1. Mitteilung. Landw. Jb. Schweiz. 47: 553.557.

Wiesmann, R. 1937: Das Wirtspflantzeproblem der Kirschfliege, *Rhagoletis cerasi* L. Landw. Jb. Schweiz. 51: 1031-1044.

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Further data on the flight activity of cherry fruit fly (*Rhagoletis cerasi* L.)

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Abstract: During the observations on the flight activity of cherry fruit fly in 1997 and 1998 it was found that the catches of traps placed on the south or on the west side of the tree canopy were not consequently higher than of those placed on the north or east side. The air temperature on the place of traps is not consequently higher on the north or West Side; the light intensity is varying widely on the place of the traps. Our opinion is further experiments should be done to determine the flight activity of *Rhagoletis cerasi* L. and the affection of abiotic factors.

Key words: monitoring, temperature, distribution

Introduction

One of the most important insect pests of cherry growing in Hungary is the cherry fruit fly (*Rhagoletis cerasi L.*). This insect infects almost all Hungarian orchards. In spite of the fact that research on cherry fruit fly has been well practised and its damage is known for a long time everywhere in Europe several aspects of the pest biology have to be cleared. One of them is the flight biology of the insect.

Materials and methods

Previous investigations were done in 1995-1996. The results of these years were just the same as it could be found in the literature: the imagoes of cherry fruit fly like to sit on the south side of the tree canopy with pleasure (Voigt, 1997).

The observation of the flight activity of *R. cerasi* was continued in 1997 and 1998.

The investigations were carried out on three experimental fields (with trees of 10-12 years): 1) sweet cherry hybrid orchard; 2)sour cherry genebank; 3) sour cherry hybrid orchard.

On the above fields each tree is of different varieties, including early, medium and late ripening ones.

Soil, exposition and warming up of the experimental fields were the same thus they could not influence emergence from the pupae.

The yellow sticky traps have been used for monitor of the flight activity of the cherry fruit fly for many years (Prokopy & Boller, 1971; Remund & Boller, 1975; Jenser & Tóth, 1976; Remund *et al.*, 1983; Stamenkovich *et al.*, 1996; Voigt, 1996; Voigt, 1997).

In our experiments the traps were always yellow sticky traps with glue on one side (vertical rectangular traps). They contained no baits. In our trial "Csalomon" trap (Hungarian trap designed) was used having the same colour and size as the "Rebel" trap of Switzerland.

Experiments of 1997

The previous literature says: the cherry fruit fly has poor flight activity, it prefers to remain on the sunny parts of the tree canopy. In our experiments carried out in 1997. The traps were placed 150 – 160 cm above the ground on the south and north side of the tree canopy in four replicates. In every case we measured the temperature of the air in tree canopy several times in a day on the place of the traps. In this investigations we wanted to know whether the lower or the higher temperature is the reason of the phenomenon that the flies like to sit on the south side of the tree.

Experiments of 1998

Searching of other abiotic factor influencing the behaviour of cherry fruit fly adults not only the temperature was measured on the surface of the traps but the light intensity as well, and the traps were placed not only on the north and the south side of the tree canopy, but on the east and the west side as well. The temperature and the light intensity were measured several times in a day.

Results

The results of 1997 show the same tendencies as we had in the previous experiments (Voigt, 1997) (Figs. 1 - 2). The traps placed on the south side of the tree canopy caught more flies than the same traps placed on the north side. The situation was the same in the three experimental fields (sweet cherry hybrid, sour cherry hybrid, and sour cherry genebank orchard). Selected data on the .temperature measured on the surface of the traps are summarised in table 1.

These results are surprising because there was no difference between the south side of the canopy and the north side of the canopy. If the weather was cloudy, the temperature was similar on both sides. At sunshine in the morning the temperature of the south (east) side was higher and in the afternoon on the contrary the north (west) side. But the difference was only one degree in both cases.

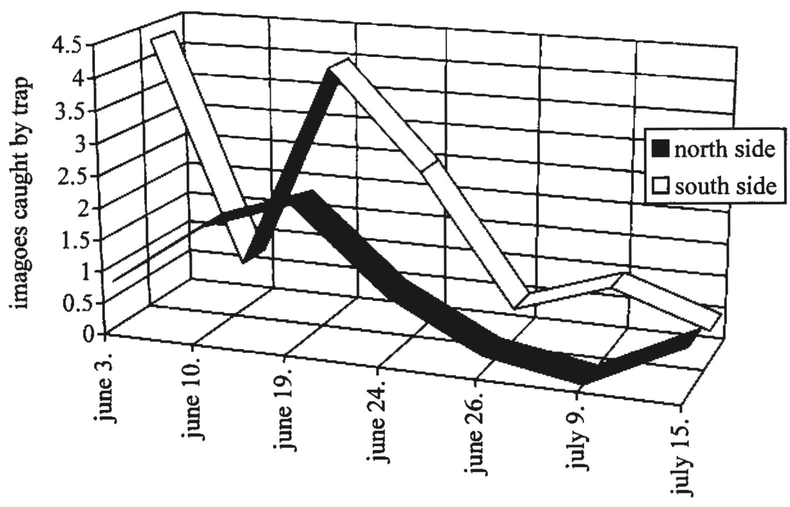

Figure 1. Flight of *Rhagoletis cerasi* L. in sweet cherry orchard in 1997.

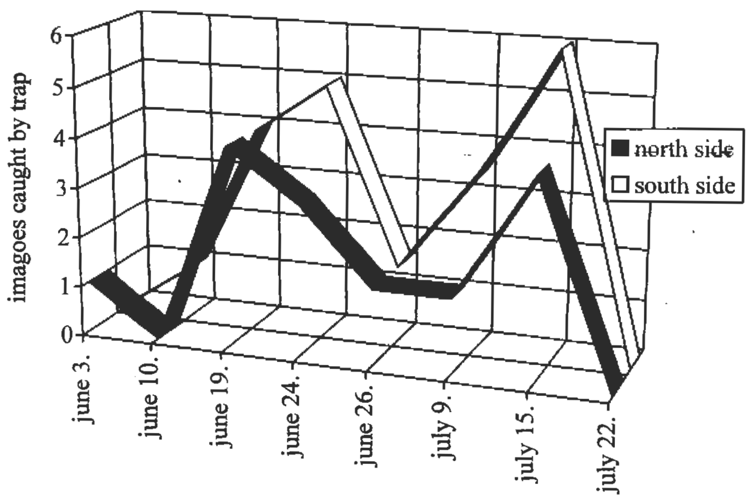

Figure 2. Flight of *Rhagoletis cerasi* L. in sour cherry genebank in 1997.

Table 1. Temperatures measured on the surface of the traps in 1997.

Orchard	Date	Time	North side	South side	
Sour cherry genebank					
	June 10	12 a.m.	22° C	23° C	sunshine
		03 p.m.	26° C	26° C	
Cherry hybrid					
	June 10	01 p.m.	24° C	25° C	sunshine
Sour cherry genebank					
	June 21	10 a.m.	21° C	21° C	cloudy
		04 p.m.	26° C	26° C	cloudy
Cherry hybrid					
	June 21	12 a.m.	20° C	20° C	cloudy
		04 p.m.	25° C	25° C	Cloudy
Sour cherry genebank					
	July 15	04 p.m.	25° C	24° C	sunshine
Cherry hybrid					
	July 15	04 p.m.	26° C	25° C	sunshine

The imagoes of the cherry fruit fly can be observed (flying or sitting) during the day either on the fruits or on the leaves.

In 1997 we did not find any reason of the old observation: the imagoes of *Rhagoletis cerasi* L. generally remain on the sunny part of the canopy.

In the experiments of 1998 we have got rather surprising results (Figs. 3 - 4).

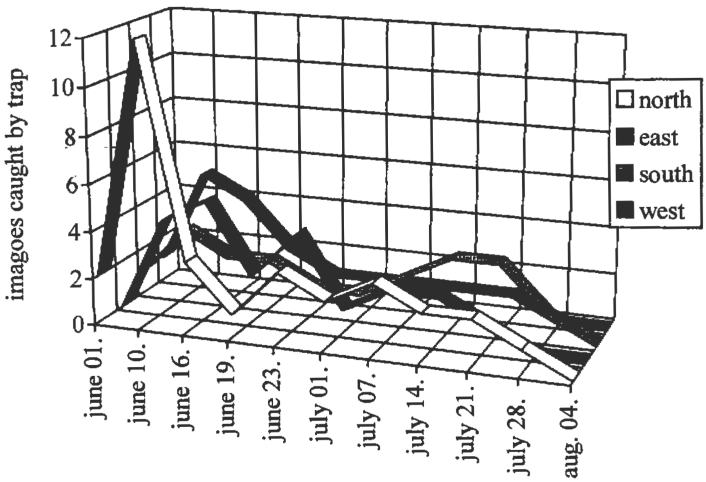

Figure 3. Flight of *Rhagoletis cerasi* L. in sweet cherry orchard in 1998.

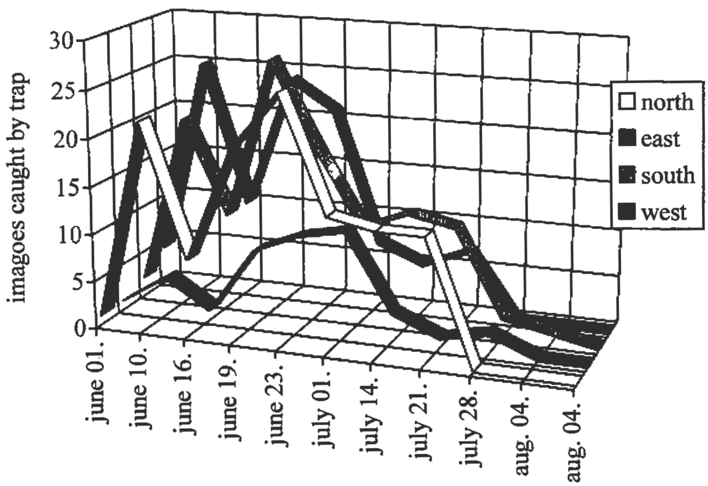

Figure 4. Flight of *Rhagoletis cerasi* L. in sour cherry genebank orchard in 1998.

The catches of the traps placed on the south or on the east side were not significantly higher than on the north or west side. (See the data of the traps in the sweet cherry or sour cherry orchard).

As the temperature of the air on the surface of the traps concerned the situation was the same as it was in 1997. There was only one-degree difference between the two sides of the canopy. (south – north in the morning, or north - south in the afternoon).

The situation of the light intensity is rather complicated. The degree of light intensity measured on the surface of the trap in a given moment is summarised in table 2. As the traps can move very quickly from the sunshine to the shadow or from the shadow to the sunshine data on light intensity varied between 2 000 and 11 000 lux (which is wide range).

This year a statistical analysis of data was done to get better knowledge of the tendencies of the behaviour of the insect. The results are represented in table 3, 4 and figure 5. (The tables contain all the data got in the experiments of 1998).

Table 2. Light intensity (in lux) on the place of the traps

Orchard	Date	Time	north side	east side	south side	west side	
Sour cherry genebank	June 10	10 a.m.	1700	5200	8000	5500	sunshine
Cherry hybrid	June 10	11 a.m.	8 000	5 000	15 000	4 000	sunshine
Sour cherry genebank	June 16	09 a.m.	1 800	2 500	1 500	1 800	cloudy
Cherry hybrid	June 16	10 a.m.	600	2 000	3 000	4 000	cloudy
Sour cherry genebank	June 10	02 p.m.	8 600	6 400	6 400	9 200	sunshine
Cherry hybrid	June 10	03 p.m.	5 400	9 600	11 000	11 000	sunshine

Table 3. Multiple range analysis for flight of *R. cerasi* in 1998 by cardinal points (* denotes a statistically significant difference)

Method: 95 Percent LSD					
Level	**Count**	**LS Mean**	**Homogenous groups**		
East	44	3.4090909	X		
North	44	6.2500000	XX		
West	44	6.6363636	X		
South	44	7.2272727	X		
Contrast				Difference +/-	Limits
north-east				2.84091	2.95945
north-south				- 0.97727	2.95945
north-west				- 0.38636	2.95945
east-south				- 3.81818	2.95945 *
east-west				- 3.22727	2.95945 *
South-west				0.59091	2.95945

Table 3. shows that data of the cardinal points can be divided into two homogenous groups. North from these is homogenous with two of the all groups. There is significant difference in case of east-south and east-west.

Data of table 4 show that in case of dates there is significant difference at 5 % significance level. Significant difference could be shown between cardinal points only at 10 % significance level.

Distribution of data given by traps is shown by figure 5.

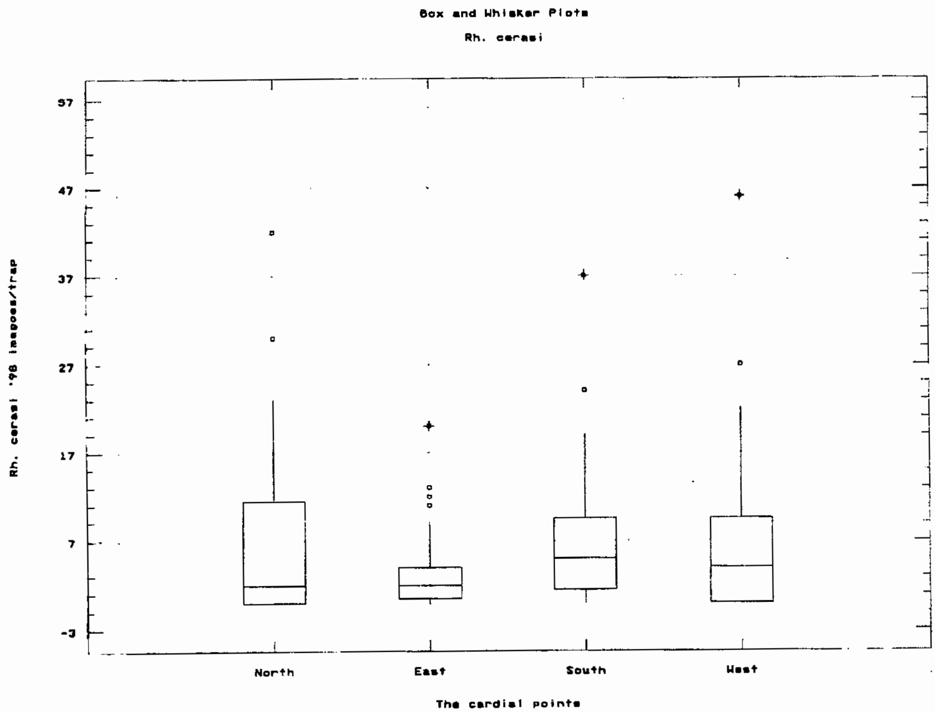

Figure 5. Distribution of data given by traps

Conclusions

- the flight activity of *R. cerasi* was longer than four weeks in each cases, it lasted from the beginning of June till the middle of July,
- there are differences between the catches of the traps at different places of the tree canopy according to the cardinal points, but they are not consequently higher on the south side,
- there is no correlation between the flight of *R. cerasi* and the air-temperature and the light intensity measured several times a day on the place of the traps,
- the air-temperature on the place of the traps is not consequently higher on the south or east

side of the tree canopy,

- The light intensity is varying widely on the place of the traps because they can move from the shadow to the sunshine or from the sunshine to the shadow and so on.

Further experiments should be done to determine the flight activity of *R. cerasi* and the influencing abiotic factors.

Table 4. Analysis of variance for flight of *R. cerasi* Type III. Sums of Squares.

Source of variation	**Sums of squares**	**d.f.**	**Mean square**	**F ratio**	**Sig. Level**
Main effects					
A: cardinal points B: date	379.6989 3346.1818	3 10	126.56629 334.61818	2.571 6.789	.0569 .0000
Interactions AB	483.36364	30	16.112121	.327	.9996
Residual	6497.2500	132	49.221591		
Total (corrected)	10706.494	175			

0 missing values have been excluded

All F ratios are based on the residual mean square error

Bibliography

Jenser, G. & Toth, E. 1976: A színcsapdás cseresznyelégy elrejelzési módszer alkalmazhatóságnak vizsgálata több fajtából álló cseresznyeültetvényben (Analysing the applicability of colour traps for *Rhagoletis cerasi* forecasting in an orchard consisting of several varieties of cherry). XXIII: Növényvédelmi Tudományos Értekezlet: 235-239.

Prokopy, R.J. & Boller, E.F. 1971: Response of European cherry fruit flies to coloured rectangles. J. Econ. Entomol. 64: 1444-1447.

Remund, U. & Boller, E.F. 1975: A new visual trap capturing *R. cerasi* L. and other fruit flies. Z. angew. Entomol. 77: 348-353.

Remund, U., Boller, E.F. & Cavalloro, R. 1983: Visual traps for biotechnical control and negative forecasting of the cherry fly *Rhagoletis cerasi* L. In: Proceeding of the CEC/IOBC, International Symposium, Athens, Greece, 16-19 X. 1992: 490-494.

Stamenkovic, S., Milenkovic, S. & Stamenkovic, T. 1996: Population dynamics of *Rhagoletis cerasi* L. (Diptera, Tephritidae) in Western Serbia. Proc. Int. Cherry Simp., Acta Hort. 410: 561-566.

Voigt, E. 1996: Cseresznyelégy rajzásmegfigyelése színcsapdával (Flight observation of *Rhagoletis cerasi* L. by mean of coloured trap) Agrofórum, 7 (1): 46-47.

Voigt, E. 1997: Monitoring cherry fruit fly (*Rhagoletis cerasi* L.) using yellow traps. IOBC wprs Bulletin. 20 (6): 50-53.

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Temperature-dependent functional response of *Bracon hebetor* parasitising larvae of *Adoxophyes orana* in the laboratory

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Abstract: The functional response of *Bracon hebetor* (Say) attacking fifth instar larvae of *Adoxophyes orana* (Fischer von Rosslerstamm) was measured at three constant temperatures (20, 25 and 30 °C) each at six densities. A type II functional response model was fit separately at each temperature both with respect to number of dead larvae and number of parasitised larvae. Temperature was incorporated into functional response equation by substituting handling time (Th), as a function of temperature. The composite model fit the data as well as the separate equations; R^2 were 0.96 (dead larvae) and 0.71 (parasitised larvae). Maximum number of dead larvae ranged from 7.4 to 33.5, while for parasitised larvae ranged from 1.1 to 6.4.

Key words: *Bracon hebetor*, functional responses, *Adoxophyes orana*

Introduction

Adoxophyes orana (Fischer von Rûslerstamm) is a serious pest of peaches causing significant damage on leaves and fruits in peach orchards in Greece. It was mentioned for the first time in the region of Naoussa in Macedonia in 1985, as a pest of peach and cherry orchards (Savopoulou-Soultani *et al.*, 1985). Although, control can be achieved by chemical treatments, development of integrated control programs has prompted the research for biological control agents.

Bracon hebetor (Say) is a gregarious larval ectoparasitoid of many Lepidoptera species. It was recovered from parasitised larvae of *A. orana* that have been collected from peach orchards in northern Greece. Since now it has not been reported to parasitise larvae of *A. orana* (Evenhuis & Vlug, 1983). A *B. hebetor* female first paralyzes its host by stinging and then lays a variable number of egg on the ventral surface of the larva (Antolin *et al.*, 1995). *B. hebetor* has shown a high fecundity and rate of increase, which makes it a promising natural enemy against *A. orana* (Unpublished data).

The changes in the number of attacks per parasitoid as a function of host density has been described as a functional response (Solomon, 1949). Apart from the quantitative data on life history characteristics (fecundity, development rate, progeny sex ratio) the study of functional response is essential for the evaluation of the parasitoid as an effective biological control agent against *A. orana*.

There are several studies investigating the effect of temperature on parasitoid functional response (Flinn, 1991; Enkegaard, 1994; Smith, 1994; Runjie *et al.*, 1996). Temperature affects parasitoid life history characteristics (Smith, 1992). Search rate as also handling time are expected to be affected by temperature (Mack *et al.*, 1981).

The objective of the present work was to determine the functional response of *B. hebetor* on larvae of *A. orana* at three different temperatures.

Materials and methods

Larvae of *A. orana* used in all experiments were obtained from a laboratory culture. They were maintained on an artificial diet that has been developed for rearing of *Lobesia botrana* (Denis and Schiffermueller) (Lepidoptera: Tortricidae) (Savopoulou-Soultani *et al.*, 1994). The laboratory colony was established from larvae collected from infested shoots of peach trees. Adults were maintained in truncated transparent plastic cups covered with a transparent plastic sheet. A hole in the bottom of cups was punched and plugged with dental roll wick which provided the adults with a 5% sucrose solution. The egg masses collected from the plastic sheet were placed on pieces of the artificial diet in new cups.

Parasitoids were obtained from a laboratory culture which was established with adults that have been recovered from collected parasitised larvae of *A. orana*. In the laboratory, larvae of *Plodia interpunctella* (Hb.) (Lepidoptera: Pyralidae) were used for rearing *B. hebetor*. The adults in this study originated from the third or fourth generation.

The functional response of *B. hebetor* was examined with laboratory experiments, by exposing individual wasps to six host density levels (2, 4, 6, 8, 10 and 15) of *A. orana* larvae for 24h at three constant temperatures (20 °C ±1, 25 °C ±1 and 30 °C ±1). Only fifth instar host larvae were used as functional response is possibly affected by the instar of *A. orana*. All female parasitoids used in this experiments were 48—72 h old and had been kept with males since emergence. Larvae of *A. orana* were placed in glass Petri dishes (7.0 cm diameter) with cherry leaves, and that was 24 hours before one female parasitoid to be placed as well, in order to allow the larvae to make a web. Females of *B. hebetor* were separated from the Petri dishes 24 hours later. After the removal of the parasitoids from the dishes the number of parasitised hosts (i.e. hosts with one or more eggs on their exterior) and 'dead' hosts (i.e. paralysed hosts with and without eggs) as well as the number of eggs laid by the parasitoid on each parasitised larva was recorded.

The functional response of *B. hebetor* was analysed with respect to the number of parasitised hosts and the number of dead hosts. A type II disk equation for parasitoids (Rogers, 1972) was used to fit the data within each temperature:

$$N_a = N_t[1-\exp\{-\frac{aTP_t}{1+aT_hN_t}\}] \qquad (1)$$

where N_a is the number of hosts attacked, N_t is the number of hosts available, a is the instantaneous search rate, T is the total time of the experiment, P_t is the number of parasitoids and T_h is the parasitoid handling time. A nonlinear least squares program (Statsoft, 1993) was used to estimate the coefficients a and T_h, using a quasi-Newton method.

Results

Functional response; dead larvae.

The functional response of *B. hebetor* to fifth instar larvae of *A. orana* at the three experimental temperatures is shown in figure 1, along with the curves obtained by applying equation 1 to the data. The estimates of search rate (a) and handling time (T_h) are listed in table 1. The model fits the data extremely well at the three temperatures (Fig. 1), resulting in high r^2 values (Table 1). The search rate was the lowest at 20 °C and the highest at 25 °C. The lowest value for handling time was observed at 30 °C resulting in a maximum paralyzation rate of 33.5 larvae per day (Table 1).

Table 1. Estimates of instantaneous search rate (a) and handling time (Th) for *B. hebetor* with respect to dead larvae from (A) fitting eq. 1 separately for each temperature and (B) from fitting the temperature dependent model for all data.

A		Separate models		
Temperature	a (d^{-1}) ± SE[a]	Th (day) ± SE	Max. no. dead larvae[b]	R^2
20	2.57 ± 2.8	0.09 ± 0.04	7.4	0.97
25	17.8 ± 41.6	0.05 ± 0.01	12.9	0.97
30	5.87 ± 5.6	0.02 ± 0.01	33.5	0.97
B		Temperature dependent model		
	a	b		R^2
	5.64 ± 2.12	3.84 ± 0.63		0.96

[a] Asymptotic standard error
[b] Computed by dividing total time (0.66 d) by T_h

The inverse of handling time, $1/T_h$, was plotted against temperature, giving a straight line, that intercepted the x-axis at 18.1 °C, which is considered as the minimum threshold for paralyzation of *B. hebetor*. In order to describe temperature mediated functional response, handling time in 'Rogers' equation, was substituted by the equation $1/T_h = b(C-18)$, where b is a constant and C is the temperature to which the parasitoids were exposed:

$$N_a = N_t[1-\exp\{-\frac{aTP_t}{1+aN_t/(b(C-18))}\}] \qquad (2)$$

Handling times by applying the above equation to all data were 0.13, 0.04 and 0.02 at 20 °C, 25 °C and 30 °C, respectively.

Functional response; parasitised larvae.

The functional response of *B. hebetor* with respect to parasitised larvae, along with the curves obtained from applying the equation 1 is shown in figure 2. The model fits the data relatively poor resulting in low r^2 values and large standard errors of the estimates of search rate and handling time (Table 2).

The equation incorporating the temperature-dependent handling time was also applied to all data giving the estimated parameters shown in table 2. Although, the model fit the data relatively well with an r^2 of 0.71, it fails to give a realistic estimate of search rate. Handling times estimated from the model were 0.582, 0.166 and 0.097 at 20 °C, 25 °C and 30 °C, respectively. The maximum number of larvae per day that one *B. hebetor* is able to parasitise is 1.15, 4.03, and 6.09 at the three temperatures which are in accordance with those estimated from the type II equations (Table 2).

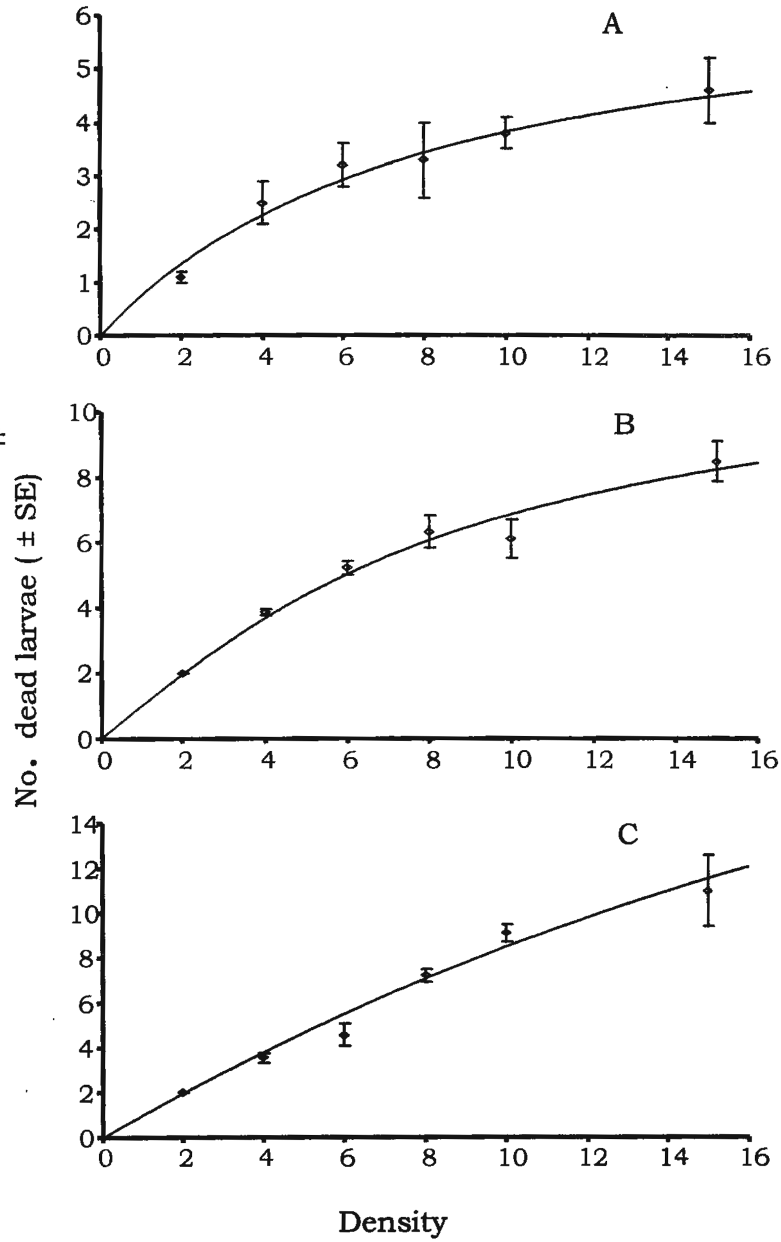

Fig.1. Functional response of *B. hebetor* expressed as number of dead larvae in relation to density of *A. orana* at 20°C (A), 25°C (B) and 30°C (C), respectivily.

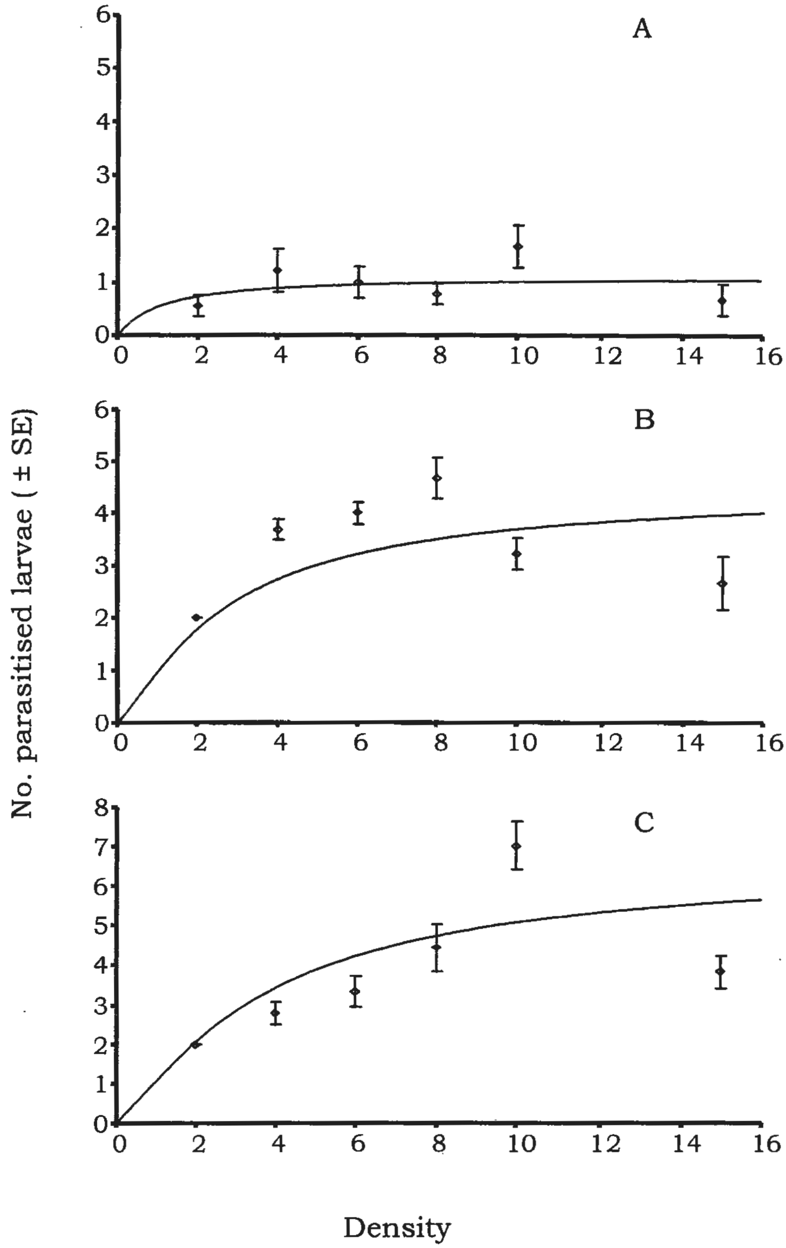

Fig. 2. Functional response of *B. hebetor* expressed as number of parasitised larvae in relation to density of *A. orana* at 20°C (A), 25°C (B) and 30°C (C), respectivily

Table 2. Estimates of instantaneous search rate (a) and handling time (Th) for *B. hebetor* with respect to parasitised larvae from (A) fitting eq. 1 separately for each temperature and (B) from fitting the temperature dependent model for all data.

A		Separate models		
Temperature	a (d^{-1}) ± SE[a]	Th (day) ± SE	Max. No. parasitised[b]	R^2
20	3.7 ± 19.6	0.6 ± 0.27	1.1	0.11
25	540201	0.14 ± 0.02	4.8	--
30	172794	0.11 ± 0.02	6.4	0.48
B		Temperature dependent model		
	a	b		R^2
	815546	0.86 ± 0.89		0.71

[a] Asymptotic standard error
[b] Computed by dividing total time (0.66 d) by T_h

The number of eggs per parasitised larva laid by a female parasitoid was ranged from 1.8 to 0.6 at 20°C, 6.8 to 1.3 at 25 °C and 7.1 to 1.6 at 30 °C (Fig. 3). At 25 °C and 30 °C there was a gradual decrease on the number of eggs per parasitised larva from low to high densities, while at 20 °C it was kept at low levels for all densities

Discussion

This study indicated that parasitism by *B. hebetor* was affected both by temperature and host density. The model of type II functional response fitted the data satisfactorily at all three temperatures tested. This acts in accordance with Taylor (1988) who reported a typical type II functional response of *B. hebetor* to different host densities of *P. interpunctella* and *Anagasta kühniella* (Zeller).

It is most likely that a general reduction in the activity of the parasitoid as well as reduced rate of oogenesis with decreasing temperature, affected the functional response of *B. hebetor* to *A. orana* larvae. The overall pattern of decrease in rate of parasitism is similar to the one found for other species such as *Cephalonia waterstoni* (Gahan), *Anisopteromalus calandrae* (Howard) and *Telenomus reynoldsi* (Gord & Coker) (Flinn, 1991; Smith, 1994; Case & Gaylor, 1989). The effect of temperature was incorporated into the model of type II functional response by substituting Th as a function of temperature. Handling time determines the host density at which the asymptote is reached, while the shape of the curve at low density is primarily affected by search rate (a) (Flinn, 1991; Smith, 1994). Theoretically, the relationship between Th and temperature should be U-shaped because there should exist an optimum and 2 temperature extremes at which handling time is infinite (Mack *et al.*, 1981). However, in this study a simple relationship was used, as there was not observed any high-temperature inhibition, probably because the highest temperature tested was at or below the optimum.

Functional response could be affected by other factors such as host species, parasitoid age and host age (Guo, 1990; Taylor, 1988). Morales-Ramos & Cate (1992) reported temperature as the third most important factor (after host density and parasitoid age) affecting parasitism rates of *Catolaccus grandis* (Burks). Taylor (1988) pointed out that host characteristics could be tremendously important affecting *B. hebetor* parasitisation.

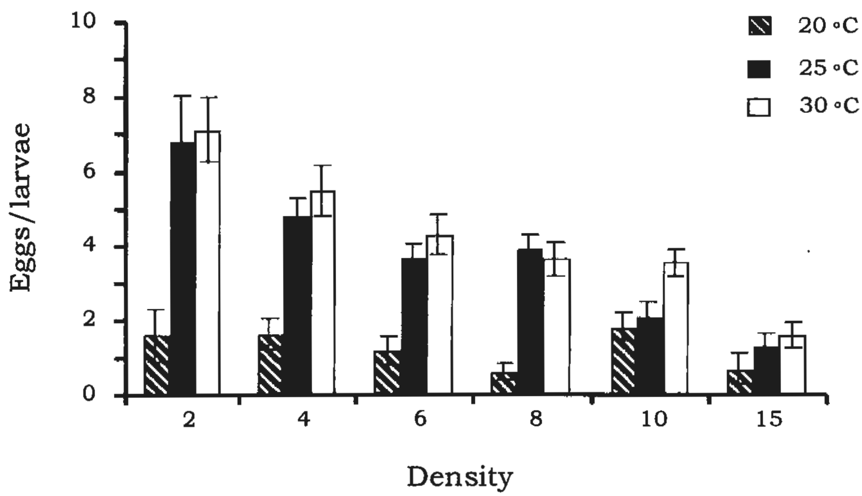

Fig. 3. Number of eggs laid per parasitised larva by a female *B. hebetor* in relation to density of *A. orana* at 20°C (A), 25°C (B) and 30°C (C), respectivily.

This parasitoid can paralyse and feed upon its host without oviposition, and females can paralyse much more hosts than can lay eggs on. Hosts that are paralysed but not killed by host feeding may contribute to the overall stability of the system (Flinn, 1991). Paralysed larvae could remain available for oviposition and thus offering a chance for the parasitoid to survive periods of low host availability. *B. hebetor* is known to exhibit a type of self-provisioning parasitising *Ephestia cautella* (Walker) (Hagstrum, 1983). However, this is not a profitable strategy against *A. orana* as dehydration of paralysed larvae proceeds very quickly and they are not available for oviposition for a long time.

Huffaker & Messenger (1976) claimed that the effectiveness of a parasitoid depends upon its ability to locate hosts at low densities and to parasitise large numbers of hosts at high densities. Hagstrum & Smittle (1977) reported a relatively high host finding ability for *B. hebetor* which is confirmed form this study as well. Our results indicate that this parasitoid could be an effective biological control agent against *A. orana* as it increases host mortality by attacking and feeding on all instars and its generation time is half that of its host (unpublished data).

References

Antolin, M.F., Ode, P.J. & Strand, M.R. 1995: Variable sex ratios and ovicide in an outbreeding parasitic wasp. Anim. Behav. 49: 589-600.

Case, R.D. & Gaylor, M.J. 1989: Functional response of *Telenomus reynoldsi* (Hym.: Scelionidae) at five constant temperatures and in an artificial plant area. Entomophaga 34: 3-10.

Enkegaard, A. 1994: Temperature dependent functional response of *Encarsia formosa* parasitizing the poinsettia-strain of the cotton whitefly, *Bemisisa tabaci*, on poinsettia. Entomol. Exp. Appl. 73: 19-29.

Evenhuis, H.H. & Vlug, H.J. 1983: The hymenopterous parasites of leaf-feeding apple tortricids (Lepidoptera: Tortricidae) in the Netherlands. Tijdschrift voor Entomologie 126: 109-135.

Flinn, P.W. 1991: Temperature-dependent functional response of the parasitoid *Cephalonia waterstoni* (Gahan) (Hymenoptera: Bethylidae) attacking rusty grain beetle larvae (Coleoptera: Cucujidae). Environ. Entomol. 20: 872-876.

Guo, Yu-Jie. 1990: Larval parasitisation of rice leaf-folders (Lepidoptera: Pyralidae) under field and laboratory conditions. Ph.D. dissertation, University of the Philippines, Los Banos.

Hagstrum, D.W. & Smittle, B.J. 1977: Host-finding ability of *Bracon hebetor* and its influence upon adult parasite survival and fecundity. Environ. Entomol. 6: 437-439.

Hagstrum, D.W. 1983: Self-provisioning with paralyzed hosts and age, density, and concealment of hosts as factors influencing parasitisation of *Ephestia cautella* (Walker) (Lepidoptera: Pyralidae) by *Bracon hebetor* Say (Hymenoptera: Braconidae). Environ. Entomol. 12: 1727-1732.

Huffaker, C.B. & Messenger, P.S. 1976: Theory and practice of biological control. Academic Press, Inc., New York.

Mack, T.P., Bajusz, B.A., Nolan, E.S. & Smilowitz, Z. 1981: Development of temperature-mediated functional response equation. Environ. Entomol. 10: 573-579.

Morales-Ramos, J.A. & Cate, J.R. 1992: Functional response of *Catolaccus grandis* (Burks) (Hymenoptera: Pteromalidae) in field cages. Biolog. Control 2: 193-202.

Rogers, D. 1972: Random search and insect population models. J. Anim. Ecol. 41: 369-383.

Runjie, Z., Heong, K.L. & Domingo, I.T. 1996: Relationship between temperature and functional response in *Cardiochiles philippinensis* (Hymenoptera: Braconidae), a larval parasitoid of *Cnaphalocrocis medinalis* (Lepidoptera: Pyralidae). Environ. Entomol. 25: 1321-1324.

Savopoulou-Soultani, M., Hatzivassiliadis, A., Vlug, H.J., Minks, A.K. & Tzanakakis, M.E. 1985: First records of the summerfruit tortricid, *Adoxophyes orana* F.v.R., in Greece. Entomol. Hellenica 3: 65-66.

Savopoulou-Soultani, M., Stavridis, D.G., Vassiliou, A., Stafilidis, J.E. & Iraklidis, I. 1994: Response of *Lobesia botrana* (Lepidoptera: Tortricidae) to levels of sugar and protein in artificial diets. J. Econ. Entomol. 87: 84-90.

Smith, L. 1992: Effect of temperature on life history characteristics of *Anisopteromalus calandrae* (Hymenoptera: Pteromalidae) parasitizing maize weevil larvae in corn kernels. Environ. Entomol. 21: 877-887.

Smith, L. 1994: Temperature influences functional response of *Anisopteromalus calandrae* (Hymenoptera: Pteromalidae) parasitizing maize weevil larvae in shelled corn. Ann. Entomol. Soc. Am. 87: 849-855.

Solomon, M.E. 1949: The natural control of animal populations. J. Anim. Ecol. 18: 1-35.

Statsoft, 1993: Statistica, version 4.5, statistical procedures. Statsoft, Tulsa, OK.

Taylor, A.D. 1988: Host effects on functional and ovipositional responses of *Bracon hebetor*. J. Anim. Ecol. 57: 173-184.

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White peach scale phenology and climatic parameters

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Abstract: A relationship between degree-days and pheromone traps catches for the male of *Pseudaulacaspis pentagona* has been discovered and statisically analysed. In each of the two annual flight of the males of this pest this relationship is statistically significant. More over a verification of this relationship has been carried out with indipendent data. The non-parametric Kolmogorov-Smirnov test shows that data collected and those forecast agree very well.

Key words: White Peach Scale, degree day, monitoring, forecast

Introduction

Pseudaulacaspis pentagona (Targioni Tozzetti) (Homoptera: Diaspididae) (White Peach Scale – WPS) is a very important pest in many Italian peach orchards. The reasons of this are in the intrinsic capability of this specie to cause damage and also in the well-known difficulties in the control of this insect.

The use of pheromone traps proved to be a good tool to monitor the swarming of the males of the white peach scale (Kozár *et al.*, 1997).

Studies carried out by the authors on grape moths, *Eupoecilia ambiguella* (Cravedi & Mazzoni, 1990a), and above all on *Lobesia botrana* (Cravedi & Mazzoni, 1990b, 1990c) shown that exist a relationship between the number of males catched by pheromone traps and temperature accumulations. These ratios are held to be valid strictly in the local surroundings where they have been determined and if they have been obtained using a sufficiently long-term series of data (Pennacchio & Tremblay, 1991). However the relationship proved to be statistically significant also when it was verified in the field with independent data (Cravedi & Mazzoni, 1994).

As during the past years a quite long series of data of catches with WPS pheromone traps was collected (Cravedi & Mazzoni, 1993; Kozár *et al.*, 1997), it was decided to analyse data to see if the relationship catches-temperature accumulation is valid also for this pest.

Materials and methods

The emergence of the males of *P. pentagona* was checked by using pheromone traps ("Scale Trap" model) according to the procedure described elsewhere (Kozar *et al.*, 1997).

The dates of the beginning and end of the emergence periods of each generation were discovered. The catches carried out between these two extremes were converted into a percentage of the total catches in the period. The percentages were then turned into probit.

To determine the temperature of the lower developmental threshold, literature data where analysed and several available data on *P. pentagona* development at different constant temperatures were found (Ball, 1980; Park & Kim, 1990; Erkiliç & Uygun, 1997). According to these data, together with data collected by the authors (Mazzoni & Cravedi, unpublished data) the relationship between temperature and developmental rate was determined and the lower temperature threshold was calculated using the regression line (Fig. 1). So a minimun temperature of 6.3 °C degrees was adopted to calculate temperature accumulations by applying the formulas proposed by Allen (1976).

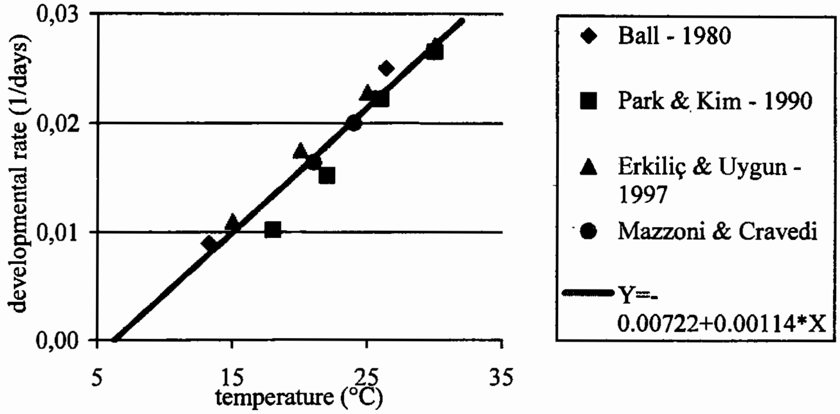

Figure 1. *P. pentagona* developmental rate, according to literature data.

Meteorological data were supplied by the "Agri-meteorological Network" of the Province of Piacenza. Logarithms of the temperature accumulations were then matched to the catch probits. 1st January was fixed as the starting date for the calculation.

Data from 1987 to 1993 were processed and a regression line for each flight was obtained for the first and the second flight. Then the results obtained were statistically verified, using the non-parametric Kolmogorov-Smirnov test (Teng *et al.*, 1980), by comparing the probits of the males of the WPS trapped in 1994 end 1996 with those of the catches forecast on the basis of the ratios previously discovered.

Results

Each year, from 1987 to 1996, two periods of emergence were identified (Fig. 2). Nonetheless for some emergences it was not possible to determine the dates of the beginning and/or end, and so these cases were not used. On the whole 11 set of data were available; 4 of them refer to the first flight and 7 to the second one (Table 1).

The degree-day accumulation values, on reaching which the beginning and end of the 11 capture curves were found, are recorded in table 1. The amount of degree days to complete each flight is reported also. On the average the first flight lasted about 443 degree days and about 586 degree days the second one.

The distribution of percentages of catches vs temperature accumulations shown clearly a linear relationship between them, confirmed by the statistical analysis as, in both cases, the first and the second flight, the r^2 is statistically significant (Table 2).

Table 1. Temperature accumulation values for the beginning, end and total lenght of the two flights of *P. pentagona* near Piacenza (northern Italy).

Flight	first			second		
Year	start	end	lenght	start	end	lenght
1987	758	1113	355	1794	2359	565
1988	716	1104	388	1782	2288	506
1989	-	-	-	1837	2316	479
1990	-	-	-	1743	2329	586
1991	769	1341	572	1831	2586	755
1992	765	1220	455	1785	2349	564
1993	-	-	-	1726	2376	650

Table 2. Equations of the log-probit regression lines which express, for each of the two emergences, the ratio "temperature accumulation / catches of *P. pentagona* males with pheromone traps" in the province of Piacenza from 1987 to 1993.

Flight	"log-probit" line	df	r^2
1	$Y_{probit(\% catches)} = -73.06 + 26.50 * Log(degree - days)$	50	0.952
2	$Y_{probit(\% catches)} = -104.00 + 32.95 * Log(degree - days)$	92	0.865

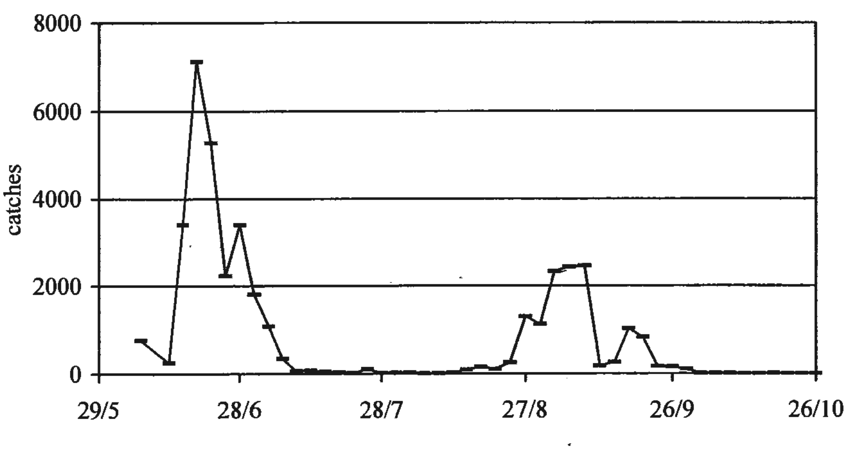

Figure 2. Average of catches of males of *P. pentagona* using pheromone traps, from 1987 to 1993.

In 1994 and 1996 the monitoring of *P. pentagona* was carried out again and data collected were used to verify the relationships between catches and degree days previously discovered. In 1994 and 1996 two flight of *P pentagona* males were recorded (Fig. 3).

The distribution of the percentage of catches vs the temperature accumulation, in comparison with the "log-probit lines" for the first and the second flight are shown in figure 4.

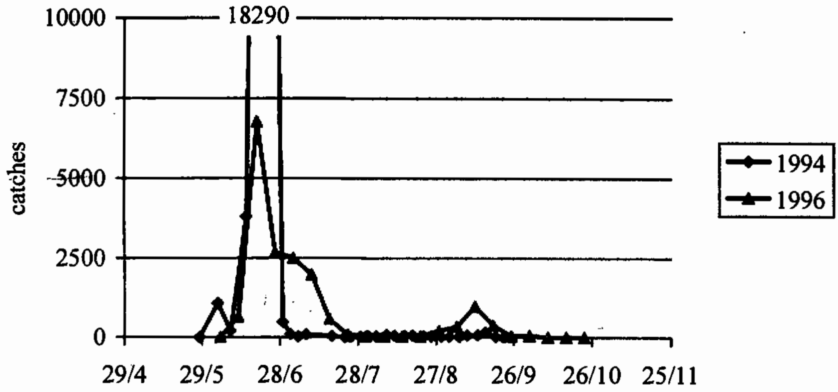

Figure 3. Catches of males of *P. pentagona* using pheromone traps, in 1994 and 1996.

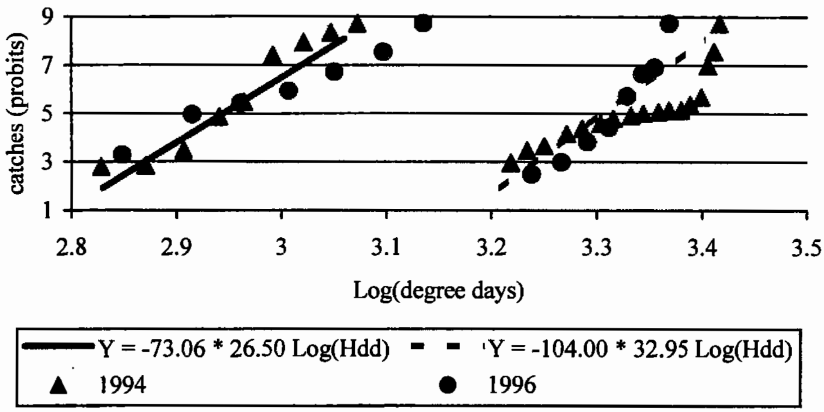

Figure 4. Distribution of probits of the catch percentages, both forecast and registered in the years 1994 ad 1996, according to the degree-days logarithm, calculated from 1st January. The continuous lines represent the emergences forecast using the equation $Y = -73.06 + 26.50X$ (for the first flight) and $Y = -104 + 32.95X$ (for the second flight), while the symbols represent the emergence figures registered.

From a preliminary observation of the plot a quite good concordance between forecast and observation can be inferred. Using the non-parametric Kolmogorov-Smirnov test it was cheched the statistical significance of the comparison between the probits of the catch percentages and the probits of those forecast, calculated according to the equations of table 2.

The results of such analysis are reported in table 3.

In none of the 4 situations analysed, was the difference statistically significant even if the figures registered during the second emergence in 1994, were seen to follow those forecast not so well as in the other cases studied, mainly in the second part of the flight.

Table 3. Results of comparison between the probits of the emergence percentages forecast and those registered with the non-parametric Kolmogorov-Smirnov test. The differences between the forecast and registered figures are statistically significant for levels of $p < 0.05$ (n: number of figures on which the comparison is based; D: coefficient of the Kolmogorov-Smirnov test; p: probability).

Year	Flight	D	p	n
1994	1	0.33	0.99	9
	2	0.35	0.24	17
1996	1	0.25	1	8
	2	0.38	0.99	8

Conclusions

Degree days have been proved to be a good tool as they can forecast quite accurately *P. pentagona* males emergences. More over, there is a great opportunity of using degree days with the white peach scale males because they are short living. This is important because, in comparison with lepidopteran males that can spent a significant amount of time after the emergence before respondig to pheromone traps, so catches and emergences can be biassed by all the events, mainly meteorological ones that reduce flight activity, in *P. pentagona*, males must respond immediately and so catches in the traps shown only new emerged males and not the previous ones. This forecasting method, after the necessary adaptation to the local situation, can be a useful tool to improve monitoring of this pest helping to find more precisely the crawler emergence.

References

Allen, J.C. 1976: A modified sine wave method for calculating degree days. Environ. Entomol. 5 (3): 388-396.

Ball, J.C., 1980: Development and fecundity of the white peach scale at two constant temperatures.Fla. Entomol. 63:189-194.

Cravedi, P. & Mazzoni, E. 1990a: Relazioni fra la somma delle temperature giornaliere e le catture con trappole a feromoni degli adulti di *Eupoecilia ambiguella* (Hbn.) (Lepidoptera Tortricidae). Bollettino di Zoologia agraria e Bachicoltura – Serie II 22 (2): 121-138.

Cravedi, P. & Mazzoni, E. 1990b: Somme termiche per la previsione degli sfarfallamenti di *Lobesia botrana* Den. & Schiff. (Lepidoptera Tortricidae). Redia LXXIII: 17-40.

Cravedi, P. & Mazzoni, E. 1990c: Relazioni fra la somma delle temperature giornaliere e le catture con trappole a feromoni degli adulti di *Lobesia botrana* Den. & Schiff. (Lepidoptera Tortricidae). Redia LXXIII: 213-222.

Cravedi, P. & Mazzoni, E. 1994: Verification of the relation between degree-days and pheromone trap catches of *Lobesia botrana* (Den. & Schiff.) (Lepidoptera Tortricidae). Redia 77 (1): 109-122.

Erkiliç, L.B. & Uygun N., 1997: Development time and fecundity of the white peach scale, *Pseudaulacaspis pentagona*, in Turkey. Phytoparasitica 25(1): 9-16.

Kozár, F., Mazzoni, E. & Cravedi, P. 1997: Comparison of flight periods of male *Pseudaulacaspis pentagona* in Hungary and northern Italy. IOBC wprs Bull. 20 (6): 43-49.

Park, D.J. & Kim, K.C., 1990: Effect of temperatures on development and distribution of mulberry scale, *Pseudaulacaspis pentagona*, within trees. Korean J. Appl. Entomol. 29 (4): 238-243.

Pennacchio, F. & Tremblay, E. 1991: I gradi-giono e il loro uso nel controllo integrato degli insetti dannosi in agricoltura. Proc. of the meeting "Modelli euristici e operativi per la difesa integrata in agricoltura", Caserta 27-29 settembre 1990: 80-102.

Teng, P.S., Blackie, M.J. & Close, R.C. 1980: Simulation of the barley leaf rust epidemic: structure and validation of BARSIM-I. Agricoltural Systems 5 (2): 85-103.

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Contrôle de la fécondité apparente d'*Encarsia berlesei* (Howard) (Hymenoptera, Aphelinidae) parasitoïde de *Pseudaulacaspis pentagona* (Targioni -Tozzetti) (Homoptera, Diaspididae).

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Résumé: *Encarsia berlesei*, principal ennemi naturel de *Pseudaulacaspis pentagona*, semble être en cause dans la recrudescence de son hôte en verger de pêcher. En effet, le contrôle de sa fécondité apparente en laboratoire laisse à supposer que les traitements chimiques (au mithidation en particulier) tendent à nuire au développement du parasitoïde.

Mots-clés: Lutte biologique, Cochenille blanche, parasitoïde, fécondité, *Encarsia berlesei*

Introduction

Au début du siècle, *Pseudaulacaspis pentagona* (*Homoptera*, *Diaspididae*) provoquait d'importants dégâts sur mûrier. Pour lutter contre cette cochenille, les chercheurs italiens ont introduit un micro-hyménoptère aphelinidé *Encarsia berlesei* du Japon et des Etats-Unis. Cette acclimatation fût un des premiers succès de lutte biologique (Clausen, 1978). Toutefois, en verger de pêchers, la Cochenille continue à provoquer des dégâts depuis les années 1950. L'échec de la lutte biologique est en partie due à l'utilisation intempestive des pesticides (Bénassy, 1958). Depuis une dizaine d'années, une stratégie de lutte intégrée en verger de pêchers tend à se développer, diminuant le nombre de traitements, choisissant des produits plus spécifiques et utilisant des techniques de luttes alternatives comme la confusion sexuelle notamment contre *Cydia molesta* (Busk). Malgré la présence de *E. berlesei* et celle d'autres entomophages recensés récemment (Kreiter & Dijoux, 1998), la Cochenille blanche du pêcher, jusqu'alors ravageur plus ou moins secondaire selon les régions, connaît depuis une dizaine d'années une importante recrudescence dans toutes les zones productrices de pêches en France. L'efficacité de *Encarsia* semble diminuer, aussi afin de vérifier cette hypothèse, nous avons mesuré la fécondité apparente des parasitoïdes provenant d'échantillons ~~prélevés sur~~ le terrain, puis élevés en laboratoire.

Techniques et méthodes

Nous avons prélevé des échantillons de branches et d'écorces de vieux mûriers, infestés par la Cochenille blanche parasitée par des larves et des nymphes de *E. berlesei,* dans la région de Pégomas (06). Ces mûriers avoisinent des vergers de pêchers mais ne sont pas en contact direct avec les traitements chimiques. Ces échantillons sont ensuite placés dans des éclosoirs, d'où émergent des adultes de *E. berlesei.* Ces individus sont récoltés par phototropisme positif tous les jours. *E. berlesei* se reproduit par parthénogénèse thélytoque, aussi chaque individu récolté est immédiatement isolé dans une boîte (∅ = 106 mm et h = 80 mm) en plastique transparent contenant un tubercule de pomme de terre (variété Monalisa) infestée par des jeunes femelles de *P. pentagona*. Cette boîte est percée de trois ouvertures de 30 mm de diamètre recouvertes d'une grille très fine permettant une parfaite aération du végétal et évitant le passage des insectes. Trente trois *Encarsia* sont testés. Nous appellerons la génération prélevée sur le terrain M0. Au bout de 28 jours en moyenne, nous commençons à récolter les premiers individus issus de M0. Ces individus sont dénombrés boîte par boîte. Trente individus sont tirés au hasard et placés dans les mêmes conditions que leurs parents ; cette génération est appelée M1.

Nous avons recommencé cette opération en prélevant des morceaux de branches de pêchers infestés par *P. pentagona* parasité par *E. berlesei*. Ce verger venait d'être traité au mithidation. Trente individus sortant de l'éclosoir sont mis dans les mêmes conditions que précédemment. Cette génération s'appellera P0. Les descendants sont dénombrés et remis dans les mêmes conditions pendant trois générations. Nous aurons donc successivement P0, P1, P2, P3.

La fécondité totale comprend les individus éclos et les individus morts à tous les stades préimaginaux. Ces derniers, après un contrôle préalable, ne représentent que 1 à 2 % de la fécondité totale. Aussi compte tenu de la somme de travail que cela représente, nous nous sommes intéressés uniquement à la fécondité apparente c'est à dire le nombre de parasitoïdes émergeant.

Nous avons comparé certaines générations entre elles avec le test de Mann-Whitney du logiciel Statbox® afin de voir s'il y avait une différence significative entre les supports végétaux d'origine et entre les générations.

L'expérimentation s'est déroulée dans une pièce climatisée à 25°C, 62 % d'humidité relative et 1700 lux d'intensité lumineuse.

Résultats

Nous avons regroupé par classe le nombre de descendants obtenus par femelle de *E. berlesei* en fonction du végétal et de la génération. Le tableau suivante donne la répartition en pourcentage de la population observée entre les différentes classes.

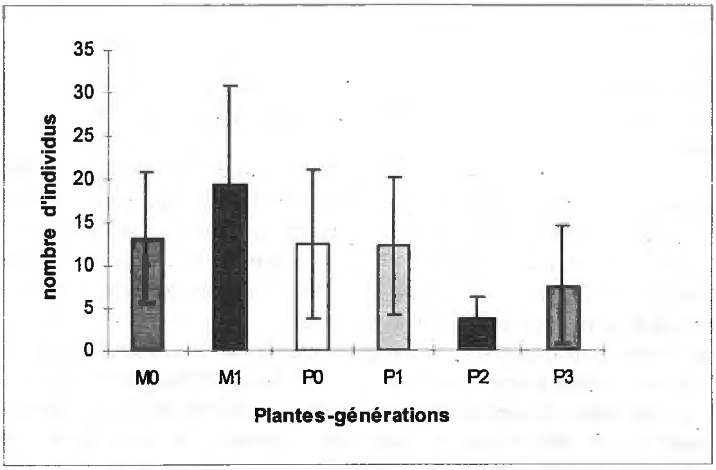
Le nombre de femelles stériles (classe 0) reste relativement constant quel que soit le végétal ou la génération expérimentée. Toutefois, on constate une forte augmentation en P3 où le taux de femelles n'ayant pas pondu s'élève à 46 %. Plusieurs hypothèses peuvent être émises. Nous sommes en droit de penser qu'il s'agit d'une conséquence liée aux conditions de laboratoire (température constante, hygrométrie, végétal) ou encore à une action à retardement du traitement chimique effectué avant la récolte de P0. Il nous est encore impossible de donner un explication, mais nous constatons un phénomène qui pourrait être lié à la baisse d' efficacité de parasitisme de *E. berlesei* observée sur le terrain.

En M0, le plus grand nombre de femelles réparties en fonction de leur ponte se situe dans la classe [11-15]. La moyenne des *Encarsia* émergés est égale à 13,2 ± 7,6. En revanche, on constate en M1, une augmentation de la descendance, (la moyenne $\bar{x}$ =19,4 ± 11,5), la classe la plus fréquente étant la classe ≥ 21. Nous avons vérifié par le test de Mann-Whitnney, l'hypothèse d'égalité entre ces deux échantillons indépendants et nous obtenons une différence significative à α = 0,05 (Z= 1,97). Il y a bien une augmentation du taux d'émergence de la génération qui est née en laboratoire.

Nous avons vérifié si la fécondité apparente de la génération P0 ($\bar{x}$ = 12,4 ± 8,7) était semblable à celle de M0 et nous avons pu observer qu'il n'existait pas de différence significative à un seuil de 5% (Z = - 0,50). Nous pouvons en déduire que le végétal d'origine n'a pas d'influence sur la fécondité ou du moins que les individus s'y sont bien adaptés. De plus, le traitement sur des individus au stade nymphal ne semble pas avoir un impact immédiat sur la fécondité des femelles de première génération.

Tableau 1. Distribution (en %) et variation de la fécondité apparente des femelles de *E berlesei* en fonction de la plante-hôte d'origine et de la génération.

	Mûrier		Pêcher			
Descendants par classe	M0 (%)	M1 (%)	P0 (%)	P1(%)	P2 (%)	P3 (%)
0	18.2	20	16.6	28	25	46
1-5	9	10	23.3	12	50	23
6-10	24.2	13.3	20	28	25	19.2
11-15	30.3	3.3	6.6	8	0	0
16-20	3	23.3	23.3	12	0	7.7
≥ 21	15.1	30	10	12	0	3.8
N	33	30	30	25	24	26



Graphique 1. Nombre moyen de descendants par femelle pour chaque condition expérimentale

Afin de vérifier si la fécondité variait sur plusieurs générations, nous avons renouvelé l'opération sur trois générations. En observant le tableau 1, nous remarquons qu'entre P0 et P1 ($\bar{x}$ = 12,2 ± 8) les femelles ont une moyenne très proche mais ne sont pas réparties de la même façon par classe de nombre de parasitoïdes éclos. Nous avons tout de même émis l'hypothèse d'égalité de ces deux échantillons. On observe qu'il n'y a pas de différence significative (u = 0,

086) à un seuil $\alpha = 0,05$. Nous pouvons observer ici que les conditions de laboratoire n'altèrent pas la fécondité apparente de P1.

En P2, l'ensemble de l'effectif se situe dans les classes [1-5] et [6-10] et la moyenne n'excède pas 3,8 ± 2,4. Nous avons comparé cet échantillon de P2 à celui de P1 afin de voir si la différence observée dans le tableau 1 et dans le graphique 1 était significative. Le test de Mann-Whitney pour échantillons indépendants met en évidence une différence significative à un seuil de 5% (u = 46).

Comme pour le nombre de femelles stériles, nous pouvons émettre plusieurs hypothèses qui seraient une action tardive des conditions de laboratoire, une action du traitement chimique sur le patrimoine génétique des femelles de *Encarsia* en P0 qui ne se manifesterait qu'en troisième génération après le traitement.

La moyenne de la génération P3 tend à augmenter par rapport à P2, mais elle reste tout de même encore très faible. Comme pour P2, à l'exception de trois individus, les fécondités des individus se situent dans les classes [1-5] et [6- 10] et il n'y a pas de différence significative entre ces deux échantillons (p2 et p3) (u = 155,5). Toutefois comme nous l'avons signalé le nombre de femelles stériles augmente considérablement. On constate ici, malgré trois individus ayant une fécondité apparente supérieure à seize individus, une autre forme de dégénérescence qui au final s'ajoute à la baisse d'efficacité de *E. berlesei*.

Conclusion

La fécondité apparente de *E. berlesei* en conditions de laboratoire n'excède pas en moyenne 20 individus. Ce chiffre reste nettement inférieur à la fécondité mesurée par Bénassy (1958) qui était de 40 œufs dans les mêmes conditions de laboratoire.

Toutefois, cet auteur a mesuré la fécondité totale de *E. berlesei* en considérant les individus morts aux différents stades préimaginaux. Mais ceci, ne représentant qu'un faible pourcentage, n'explique pas une telle différence entre les résultats que nous avons obtenus et ceux de cet auteur.

Il semble qu'il n'y ait pas de différence significative entre les première génération (P0 et M0) des souches issues d'un mûrier sans traitement chimique et d'un verger de pêcher soumis à tous les pesticides rencontrés dans une conduite phytosanitaire raisonnée. En revanche, la descendance conçue et née en laboratoire (P1 et M1) semble se comporter différemment. La deuxième génération de *Encarsia* provenant de mûrier et n'ayant pas reçu de produit chimique reste nettement supérieure à toutes les autres modalités.

Sur pêcher, nous assistons à une baisse progressive du taux d'émergence. Ceci pourrait être dû aux derniers traitements coccicides à base d'organophosphorés ou aux conditions expérimentales constantes. Cependant, pour discriminer sûrement l'action des pesticides de celles des conditions de laboratoire, il aurait été intéressant de poursuivre l'élevage de la souche "mûrier" jusqu'en M3 (pour que l'on puisse comparer génération par génération). Il serait aussi nécessaire de savoir à quel niveau agissent les pesticides, est-ce sur les ovogonies à la fin du stade nymphal ayant reçu le traitement ou est-ce sur les hormones induisant l'ovogénèse. De plus, d'autres contrôles devront être effectués pour démontrer la baisse effective d'efficacité de *E. berlesei* qui est semble-t-il un des facteurs de la recrudescence de *P. pentagona*. A l'avenir l'effet non intentionnel des pesticides utilisés en verger de pêcher sur les auxiliaires devront être étudiés, afin d'aménager la stratégie de lutte dans un but de se rapprocher d'une lutte intégrée limitant de plus en plus le nombre de traitements chimiques.

Références bibliographiques

Benassy, C. 1958: Etude bio-écologique de *Pseudaulacaspis pentagona* Targ. et de son parasite spécifique *Prospaltella berlesei* Howard, en France. Ann. Epiphyties 4: 425-496.

Clausen, C. 1978: Introduced parasites and predators of arthropod pests ans weeds. A world review. Agriculture Handbook n° 480 - Agric. Res. Serv, U. S. Dept. Agric., Washington D. C., 545 pp..

Kreiter, Ph. & Dijoux, L. 1998: La cochenille blanche du mûrier en verger de pêcher Un exemple de lutte dans les Alpes-Maritimes. Phytoma La défense des végétaux. 501: 36-40.

Studies on the fecundity of *Encarsia berlesei* (Howard) (Hymenoptera, Aphelinidae) parasitoid of *Pseudaulacaspis pentagona* (Targioni - Tozzetti) (*Homoptera, Diaspididae*).

Abstract: The efficiency of *Encarsia berlesei* against the white peach scale is decreasing in peach orchard. We tested in laboratory its fecundity and it would seem that pesticides (like mithidation) induce a negative effect.

Key words: Biological control, White scale, parasitoïds, fecundity, *Encarsia berlesei*

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Différentes techniques de lutte utilisées contre la cochenille *Pseudaulacaspis pentagona* (Homoptera, Diaspididae) (Targioni-Tozzetti) en verger de pêchers

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Résumé: La cochenille blanche du mûrier cause à nouveau d'importants dégâts dans les vergers de pêchers du Sud-Est de la France. Des observations ont été réalisées pendant 3 ans pour positionner au mieux les traitements chimiques. Toutefois, la diminution de l'action des traitements homologués nous ont amenés à éprouver l'efficacité d'autres moyens de lutte mécanique et biologiques notamment le décapage des arbres à l'eau sous haute pression et l'action des ennemis naturels indigènes et exotiques.

Mots-clés: *Pseudaulacaspis pentagona*, cycle biologique, périodes de traitements, décapage à haute pression, ennemis naturels.

Introduction

Ravageur majeur des cultures de mûrier en France au début du siècle, la cochenille blanche du mûrier, *Pseudaulacaspis pentagona* (Targioni-Tozzetti), est un insecte polyphage originaire d'Extrême-Orient qui cause d'importants dégâts dans les vergers de pêchers en France dès les années 1950. La succession des générations de cochenilles aboutit à la formation d'encroûtements sur les troncs et les branches envahis. Par injection de salive phytotoxique, l'insecte provoque le dessèchement des charpentières voire la mort de l'arbre en deux ans. En cours d'été, la cochenille peut également se fixer sur les fruits, principalement dans la cuvette pédonculaire. Elle entraîne alors une augmentation du nombre de fruits écartés au tri. L'introduction d'un micro-hyménoptère *Encarsia berlesei* Howard en culture de mûrier (Clausen, 1978) puis, à partir des années 1970, l'application de nouvelles stratégies de traitement en verger de pêchers ont alors permis de limiter la prolifération de la cochenille. Toutefois, depuis deux à trois ans, l'application des produits homologués et l'action des ennemis naturels semblent insuffisants pour enrayer une nouvelle augmentation des populations constatées notamment en région Provence-Alpes-Côte-d'Azur. Devant l'ampleur du phénomène, la Chambre d'Agriculture des Alpes Maritimes et le G.R.C.E.T.A. de Basse ont saisi le L.N.P.V. et l'I.N.R.A. d'Antibes afin d'envisager différentes méthodes de lutte.

En cours de végétation, réduction des effectifs par des traitements mieux ciblés.

La lutte traditionnelle contre *P. pentagona* est une lutte chimique. Pour une efficacité maximale, les traitements sont dirigés contre le stade le plus vulnérable du cycle, la larve de premier stade, une larve mobile qui ne présente pas encore le bouclier protecteur caractéristique des stades ultérieurs. Afin de positionner au mieux les traitements, une des premières tâches a été d'établir le cycle biologique de la cochenille.

Matériel et méthodes

Un verger infesté par la Cochenille a servi de site d'expérimentation en 1996. Situé dans la vallée de la Siagne à Pégomas (Alpes-Maritimes), il est composé de 496 pêchers de variété Anita, Daisy et July Lady sur porte-greffe pêcher-amandier G.F. 677 et Damas. Les observations ont été réalisées tous les 15 jours de mars à décembre. A chaque date d'observation, des rameaux ou des fragments d'écorce infestés par la cochenille sont prélevés sur 5 arbres désignés au hasard de façon à disposer d'une quantité suffisante de cochenilles vivantes. Sur les rameaux issus d'un même arbre, 5 surfaces unités de 0.8 cm^2 chacune sont examinés sous loupe binoculaire. Toutes les cochenilles femelles présentes sur ces 4 cm^2 sont comptées et, en soulevant le bouclier, leur état (morte ou vivante), leur stade de développement ainsi que le nombre d'œufs pondus (à l'exception des chorions vides) sont déterminés. Pour chaque date, les effectifs totaux des différents stades sont calculés. Exprimés en fréquence de chaque stade observé par rapport au nombre total de formes femelles vivantes, ces résultats sont présentés en figure 1.

Résultats - discussion

Dans la vallée de la Siagne (Fig. 1), *P. pentagona* présente trois générations par an ainsi que le signalait Bénassy (1958). La femelle hiverne à l'âge femelle fécondée.

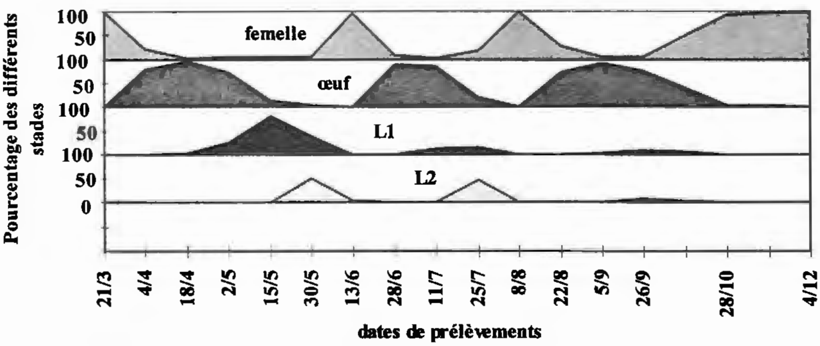

Figure 1. Cycle biologique de *P. pentanona* en parcelle biologique

Trois périodes de traitements coïncidant avec la présence des larves de 1[er] stade doivent donc être retenues : la première se situant vers la mi-mai, la seconde du début juillet à la mi-juillet et la troisième période vers la mi-septembre. Ces périodes d'intervention varient en fonction de la situation géographique des vergers et les conditions climatiques annuelles (Kreiter, 1997). Un examen de chaque verger s'avère donc nécessaire pour positionner judicieusement les traitements. Comme l'indiquait Benassy (1983), sous réserve de disposer d'un modèle de développement de la cochenille de la fécondation à l'émergence des larves, l'utilisation de la phéromone sexuelle de *P. pentagona* permettrait de substituer à l'observation des larves la surveillance d'un piège de capture des mâles. La phéromone sexuelle de *P. pentagona* est commercialisée en Italie. Des essais sont en cours pour estimer les possibilités d'emploi de ces pièges notamment dans des secteurs soumis au mistral.

Le calendrier théorique à 3 périodes d'intervention défini par ces observations est rarement appliqué en totalité. Les exploitants cherchent avant tout à limiter le nombre de cochenilles de deuxième génération responsables de dégâts sur fruits. Dans ce but, l'action contre les larves de première génération est courante car elle permet de limiter le nombre de femelles susceptibles de donner une deuxième génération. Par contre, les dates de récolte, les délais d'emploi des produits avant récolte et l'échelonnement des sorties de larves en automne limitent la lutte chimique directe contre les larves de deuxième et troisième génération.

Les fortes infestations constatées sur certaines parcelles et ces contraintes d'emploi des produits agro-pharmaceutiques nous ont conduits à envisager d'autres moyens de lutte, mécaniques et biologique susceptibles de compléter l'action des pesticides.

Réduction de l'effectif hivernal : un nettoyage des arbres à l'eau sous pression

En début d'expérimentation, 80 % des arbres du verger de Pégomas précédemment décrit présentaient des encroûtements de plus de 10 cm de longueur sur plusieurs charpentières. Afin de diminuer ces infestations, un nettoyage des arbres à l'eau sous haute pression a été choisi. Une moitié du verger a ainsi été traitée, l'autre moitié, non nettoyée, servant de témoin.

Observations
Après intervention, une nouvelle notation de tous les arbres a été réalisée. De plus, nous avons cherché à évaluer l'effet du décapage sur la composition des agrégations de cochenilles en considérant qu'un encroûtement est constitué par les cochenilles femelles mortes, vivantes ou parasitées enchevêtrées. Pour comparer la population restante à celle de la partie non décapée, quinze arbres de chaque partie ont fait l'objet d'un prélèvement. Ces échantillons ont été observés en utilisant la technique adoptée pour l'étude du cycle biologique.

Résultats
On constate que l'utilisation de cette technique est extrêmement efficace. En effet, les arbres soumis au décapage ne présentent plus que des agrégations longues de 0,5 à 5 cm. Dans les encroûtements (Fig. 2), une majorité de femelles mortes demeure et on constate également une diminution des populations de femelles vivantes. Les femelles parasitées sont aussi décapées. Toutefois, si elles ne sont pas prédatées, le parasitoïde peut encore émerger et jouer un rôle dans la limitation de *P. pentagona.*

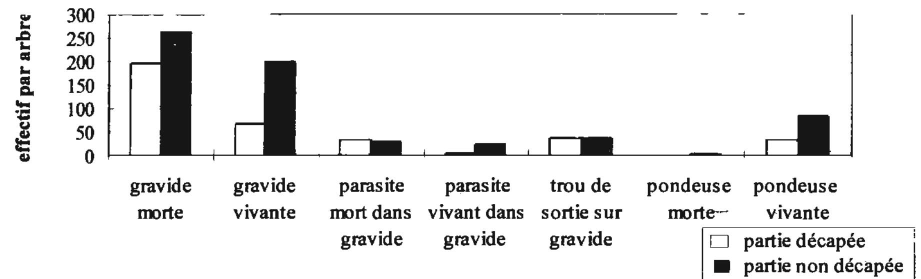

Figure 2. Comparaison des structures de population femelle

Eventuellement remplacé par un brossage des foyers au moment de la taille en cas d'attaques plus localisées, le décapage des arbres permet ainsi de baisser les populations de cochenilles en réduisant les encroûtements. Il rend les cochenilles plus vulnérables aux traitements chimiques mais également aux auxiliaires dont les possibilités d'action sont à prendre en compte lorsqu'on examine l'ensemble des moyens de lutte.

Les moyens de lutte biologique contre *P. pentagona*

Actuellement, les phéromones sexuelles utilisées en confusion ou pour un piégeage massif figurent au premier plan d'un nombre croissant de programmes de lutte contre des ravageurs. En France, les travaux préliminaires à de telles utilisations de la phéromone de *P. pentagona* ont été initiés en 1998. Dans l'attente des résultats, l'utilisation des auxiliaires demeure l'outil de lutte biologique majeur.

En préalable, un inventaire des ennemis naturels

Un inventaire a été réalisé en 1996 sur le site de Pégomas. Après le dénombrement, les rameaux sont disposés dans des éclosoirs à 25°C dans le but de récolter d'éventuels auxiliaires. La récolte est faite de façon quotidienne. Chaque individu est immédiatement isolé et identifié.

Les différentes catégories d'ennemis naturels de *P. pentagona* sont représentées:

- prédateur : *Rhizobius lophantae* (Blaisd.) (*Coleoptera, Coccinellidae*)
  Chilocorus bipustulatus (L.) (*Coleoptera, Coccinellidae*).
- parasite : *Encarsia berlesei* (Howard) (*Hymenoptera, Aphelinidae*)
  Aphytis proclia (Walker) (*Hymenoptera, Aphelinidae*),

Très présent en fin de saison, un hyperparasite *Ablerus perspeciosus* (Girault) (*Hymenoptera, Aphelinidae*) peut limiter l'action de ces deux parasitoïdes.

Comparaison entre la lutte chimique et la lutte biologique

Cette diversité dans les espèces d'auxiliaires ainsi que les effectifs conséquents observés nous ont conduits à penser qu'une lutte biologique contre *P. pentagona* était envisageable. Aussi après le décapage à l'eau sous haute pression et une application d'huile blanche, une partie de la parcelle (appelée "parcelle biologique") ne recevait aucun traitement visant la cochenille pendant la suite de la saison culturale tandis que des traitements coccicides à base d'organophosphorés dirigés contre le stade larve mobile étaient appliqués à chaque génération sur l'autre partie de la parcelle dite "parcelle chimique". L'impact de ces deux stratégies sur l'évolution des populations femelles vivantes est résumé en figure 3.

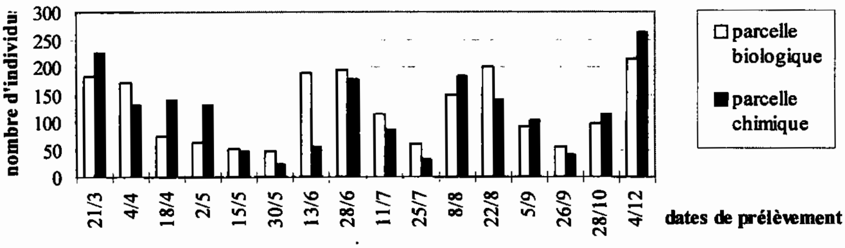

Figure 3. Effet des traitements sur les populations femelles

Dans la parcelle chimique, en première génération, le niveau de population des femelles vivantes est supérieur à celui du bloc mené en lutte biologique. En deuxième génération, compte tenu des traitements, la population de la parcelle chimique croît plus tardivement pour atteindre cependant un seuil équivalent à la parcelle biologique. Il est intéressant de voir qu'ensuite les populations des deux parcelles, avec ou sans traitement, suivent une même évolution et que même, la concentration de femelles hivernantes est supérieure en parcelle chimique. Dans la parcelle biologique, les populations sont plus ou moins régulées par l'entomofaune locale sans y avoir lâché d'auxiliaires.

Renforcer l'action des auxiliaires

Deux types d'expérimentation sont en cours en 1998 dans cet objectif :

- à l'instar d'expériences précédentes (Clausen, 1978), des lâchers d'un prédateur local de *P. pentagona*, *R. lophantae*, ont été effectués pour compléter une entomofaune faible et constituée en majorité de parasitoïdes
- un parasitoïde de mâles de *P. pentagona*, *Arrhenophagus chionaspidis* Aurivillius (*Hymenoptera, Encyrtidae*) a été introduit. En effet, contrairement à d'autres cochenilles, *P. pentagona* a besoin d'être fécondée pour assurer une descendance. Une lutte contre les mâles pourrait avoir un effet concluant en supprimant la descendance chez les femelles.

Conclusion.

Afin de conserver son efficacité à la lutte chimique traditionnellement pratiquée contre *P. pentagona*, des traitements dirigés contre les larves mobiles, le stade le plus sensible, s'imposent. Pour mieux cerner les périodes de traitements appropriées à chaque région, l'étude du cycle biologique demeure l'outil indispensable en attendant la mise au point d'un modèle prédictif lié à l'observation du vol des mâles. Des travaux sur les techniques de piégeage employant la phéromone sexuelle de *P. pentagona* sont en cours. Ce cycle indique que dans les vergers suivis dans le Sud-Est de la France, le pêcher abrite deux générations complètes de la cochenille et une troisième partielle auxquelles correspondent trois périodes d'intervention. Etant donné les dates de récolte, les délais d'emploi des produits agro-pharmaceutiques et l'échelonnement des sorties de larves mobiles en automne, les deuxième et troisième générations sont difficiles à combattre par les moyens chimiques. L'option d'intervenir mécaniquement sur les populations hivernantes et de favoriser l'action des auxiliaires tout au long de l'année a semblé intéressante. Ainsi, en diminuant de façon conséquente les populations de cochenilles, le nettoyage des arbres à l'eau sous haute pression en hiver rend les cochenilles plus accessibles aux pesticides et aux auxiliaires. Après ce décapage, dans des situations où les différentes catégories d'ennemis naturels de *P. pentagona* étaient en effectif conséquent, en l'absence de traitements coccicides, le contrôle biologique semble donner satisfaction. Lorsque l'entomofaune est moins riche, le recours au renforcement des populations d'auxiliaires indigènes ou exotiques est à l'étude tout comme l'emploi d'autres solutions biologique telles que les phéromones.

Références bibliographiques

Benassy, C. 1958: Etude bio-écologique de *Pseudaulacaspis pentagona* Targ. et de son parasite spécifique *Prospaltella berlesei* Howard, en France. Ann. Epiphyties, 4: 425-496.

Benassy, C., Bianchi, H. & Einhorn, J. 1983: La cochenille du mûrier en vergers de pêchers : perspectives nouvelles de lutte. Phytoma-LdV n° 351: 28-30.

Clausen, C. 1978: Introduced parasites and predators of arthropod pests ans weeds. A world review. Agriculture Handbook n° 480 - Agric. Res. Serv, U.S. Dept. Agric., Washington D.C., 545 pp..

Kreiter, P. 1997: Cochenille Blanche du Mûrier: suivi des populations en verger de pêcher non traité dans le secteur de Crau en 1997. InfoARBO n° 17, 1.

Different *Pseudaulacaspis pentagona* (Homoptera, Diaspididae) (Targioni-Tozzetti) control strategies in peach orchards

Abstract: In recent years, the white peach scale has caused again serious damage in peach orchards in South-Eastern France. The development of infestations was monitered over a period of 3 years to improve the use of insecticides. Poor results following the application of registered insecticides prompted us to test other mechanical and biological methods such as the cleaning of the trees with high-pressure water and the action of local or exotic natural enemies.

Key words: *Pseudaulacaspis pentagona*, life story, periods of treatments, cleaning with high pressure water, natural ennemis.

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Scale insects on stone fruits in Afghanistan and Iran

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Abstract: In the survey of scale insect species, which has been done on different fruit plants in different regions of Afghanistan, 6 species of scale insects were found. From which five species belong to the family of Diaspididae and one species to the family of Coccidae. Our investigation resulted 8 species of scale insect species in Iran, from which six species belong to the family of Diaspididae and two species to the family of Coccidae. Our survey and literature data resulted 43 scale insect species in 3 families on stone fruits in Afghanistan and Iran.

Key words: Diaspididae, Coccidae

Introduction

Fruit-infesting scale insects were studied in Central Asia by Archangelskaya (1937), Borchsenius (1966) and in Afghanistan Siddiqi (1966), Siddiqi (1981), Talhouk (1975). They mention that some species are of great importance, such as *Diaspidiotus prunorum*, *Suturaspis archangelskyae*, *Didesmococcus unifasciatus*, etc., in different parts of Central Asia. All these data show, that the scale insect fauna is scarcely studied in Afghanistan, and it needs more intensive survey and studies.

No contemporary published summary of scale insects of Afghanistan known, but there are some surveys investigating the neighbouring areas. A survey in study of scale insects have been done by Konstantinova *et al.* (1981), in Middle Asia (Kazakhstan, Kirghizia, Tadjikistan, Turkmenia and Uzbekistan). Samples were also collected in several other regions of fruit growing areas like Sakhalin, Armenia, Azerbajdzhan and Georgia.

The scale insect fauna of the Irano-Turanian Region only in some countries and in some families was studied in detail. According to the last analyses in this region, 302 scale insect species were found (Kozár & Walter, 1985; Kozár & Drozdják, 1987). Lots of them are important pests.

The main aims of this work are the following:

- to study the composition of scale insect fauna in Afghanistan, Iran and the rate of the infestation, parasitisation, predation, on different fruit trees species and ornamental plants.
- to know and identify the composition of scale insects and prepare an up-to-date list of the scale insect species on stone fruits in Afghanistan, and Iran.

Materials and methods

Survey in Afghanistan

Twig and bark samples were collected from September to October (1991), following the method of Kozár & Viktorin (1978). The samples were 10 cm long, taken from 2-3 years old branches. The samples were collected on almond (7), on apple (7), on apricot (4), on peach (4), on pear (10), on sweet cherry (2), and on *Elaeagnus angustifolia* (wild-olive) (1) with a total of 35 samples from 4 regions. Microscopic slides were prepared for the determination of the species by standard method (Kosztarab & Kozár, 1988). Material was collected in the NE region of Afghanistan on about more than 1800 m above the sea level, mostly in state farm and home orchards.

Survey in Iran

For studying the scale insects on fruit trees in N-Iran, twig, and bark samples were collected from the 14th to 30th of September 1992, following the method of Kozár (1990), and Kozár & Viktorin (1978). The samples were 10 cm long, taken from 2-3 years old branches. The 25 samples were collected on apple (3), on apricot (2), on pear (2), on peach (3), on plum (4), on sweetcherry (4), on lemon (3), and on rose (4), from 4 North regions of Iran. Material was collected in the small scale backyard orchards.

Scale insect fauna of Afghanistan and Iran

To prepare an up to date and modern list of the species names of scale insects on stone fruits recorded from these countries, we used different monographs and papers published in different countries (Ben-Dov, 1993, Borchsenius, 1966; Danzig, 1993)

Results

In the survey in Afghanistan 6 species of scale insects were found (Table 1). From which five species belong to the family of Diaspididae and one species to the family of Coccidae. The highest number of species was found on pear than on apricot, peach, almond and apple. *P. oleae* was found on most of the studied plants, but *S. archangelskyae* and *L. rubri* were found only on one plant species. Also the highest infestation rate occurred on almond and *Elaeagnus angustifolia*, which was followed by peach, pear, sweet cherry, apple and apricot. The density of *D. unifasciatus*, was the highest on almond, while on peach *P. oleae* was the most common on branches. The infestation by *D. prunorum* was approximately similar both on the trunk and on branches of sweetcherry. However, on the other fruit trees mentioned the infestation on branches was heavier than on the trunks.

Our investigation resulted 8 species of scale insects in Iran (Table 1), from which six species belong to the family of Diaspididae and two species to the family of Coccidae. *A. aurantii* was found on apricot, lemon and rose in Mashhad province and Minodasht, *D. prunorum* was found on apricot, peach, sweetcherry and rose in Mashhad and Tehran. M. *halli* was detected on peach in Mashhad. *P. oleae* and P. *crypta* was found on apple, plum and rose, and *P. pentagona* was found on pear in Tehran. *P. corni* was found on apricot, pear, plum, sweetcherry and rose in Mashhad and Tehran, and *S. prunastri* on peach in Mashhad.

Our survey resulted 43 scale insect species in 3 families on stone fruits in Afghanistan and Iran. The scale insect fauna of Iran on stone fruits is relatively better known (41 species) than the fauna of Afghanistan on stone fruits that is especially under explored (14 recorded scale insect species).

Acknowledgement

The project was supported by OTKA (No. 22005)

Table 1. Species list of scale insects living on stone fruits in Afghanistan (A) and Iran (I). According to literature records, some more species could be present, but till now not recorded.

Suborders, families, genera and species	Occurrence (literature data)		Collected in	
	A	I	A	I
Coccoidea				
Pseudococcus comstocki (Kuwana, 1902)		+		
Coccidae				
Ceroplastes floridensis Comstock, 1881		+		
Ceroplastes rusci (Linnaeus, 1758)	+	+		
Coccus hesperidum (Linnaeus, 1758)	+	+		
Didesmococcus unifasciatus (Archangelskaya, 1923)	+	+	+	
Eulecanium rugulosum (Archangelskaia, 1937)		+		
Eulecanium (*Lecanium*) *tiliae* (Linnaeus, 1758) (coryli Linnaeus, 1758)		+		
Palaeolecanium (*Eulecanium, Lecanium*) *bituberculatum* (Signoret, 1868)	+			
Parthenolecanium (*Eulecanium*) *corni* (Bouché, 1844)		+		+
Parthenolecanium (*Eulecanium, Lecanium*) *persicae* (Fabricius, 1776) (*cecconii* Leonardi, 1908)	+	+		
Rhodococcus turanicus (Archangelskaya, 1923)	+	+		
Saissetia coffeae (Walker, 1852) (*hemisphaerica* Targioni-Tozzetti, 1867)		+		
Saissetia oleae (Olivier, 1791)		+		
Sphaerolecanium (*Eulecanium*) *prunastri* (Fonscolombe, 1834)		+		+
Diaspididae				
Aonidiella aurantii (Maskell, 1879)		+		
Aonidiella citrina (Coquilett, 1891)	+	+		+
Aspidiotus destructor (Signoret, 1869)		+		
Aspidiotus nerii (Bouché, 1833) (*hederae* Signoret, 1868)		+		
Chrysomphalus dictyospermi (Morgan, 1889)		+		
Chrysomphalus pinnulifera (Maskell, 1891)		+		
Diaspidiotus (*Quadraspidiotus*) *ostreaeformis* (Curtis, 1843)		+		
Diaspidiotus (*Aspidiotus, Quadraspidiotus*) *perniciosus* (Comstock, 1881)		+		
Diaspidiotus (*Aspidiotus*) *prunorum* (Laing, 1931)	+	+	+	+
Diaspidiotus (*Aspidiotus, Quadraspidiotus*) *pyri* (Lichtenstein, 1881)		+		
Dynaspidiotus (*Diaspidiotus*) *amygdalicola* (Borchsenius, 1952)		+		
Epidiaspis leperii (Signoret, 1869) (*betulae*)		+		

Table 1 (cont.). Species list of scale insects living on stone fruits in Afghanistan (A) and Iran (I). According to literature records, some more species could be present, but till now not recorded.

Suborders, families, genera and species	Occurrence (literature data)		Collected in	
	A	I	A	I
Hemiberlesia lataniae (Signoret, 1869)		+		
Hemiberlesia rapax (Comstock, 1883) (*camelliae* Signoret, 1869)		+		
Lepidosaphees ulmi (Linnaeus, 1758)		+		
Lepidosaphes malicola Borchsenius, 1947		+		
Lepidosaphes rubri (Thiem, 1931)	+		+	
Meleanaspis (*Aonidiella*) *inopinata* (Leonardi, 1913)		+		
Mercetaspis halli (Green, 1923)	+	+		+
Mycetaspis personata (Comstock, 1883)		+		
Neochionaspis (*Childaspis, Chionaspis, Tecaspis, Voraspis*) *asiatica* (Archangelskaya, 1930) (*prunorum* Borchsenius, 1939; *adlei* Balachowsky & Kaussari, 1955)	+	+		
Parlatoreopsis (*Parlatoria*) *chinensis* (Marlatt, 1908)		+		
Parlatoreopsis longispina (Newstead, 1911)		+		
Parlatoria camelliae Comstock, 1883		+		
Parlatoria crypta (McKenzie, 1943)	+	+	+	+
Parlatoria oleae (Colvée, 1880)	+	+	+	+
Parlatoria theae Cockerell, 1896		+		
Pseudaulacaspis pentagona (Targioni-Tozzetti, 1886)		+		+
Suturaspis (*Leucaspis, Salicicola*) *archangelskyae* (Lindinger, 1929)	+	+	+	
Species number	**14**	**41**	**6**	**8**

References

Archangelskaya, A.D. 1937: Scale insects of Central Asia, Izd. Kom. Nauk UzSSR, Tashkent, 159 p.

Ben-Dov, Y. 1993: A systematic Catalogue of the soft scale insect of the World. Sandhill Crane Press, Inc., Gainesville and Leiden, 536 p.

Borchsenius, N.S. 1966: Catalogue of the armoured scale insects (Diaspidoidea) of the World, Nauka, Moscow-Leningrad, 449 p.

Danzig, E.M. 1993: Scale insects (Coccinae) families Phoenicoccidae and Diaspididae. Fauna of Russia and neighbouring countries. Rhynchota. Vol. X. (In Russian), Nauka, St. Petersburg, 452 p.

Konstantinova, G.M., Kozár, F., Yasnosh, V.I. Matesova, G. Reznikova, E.M., Bazarov, B., Benke, G.Y., Gummel, E., Gura, N.A. & Knyazatova, V.J. 1981: Scale insects on deciduous fruit trees in eastern part of USSR. Verh. Sieec X. Budapest, 350-352.

Kosztarab, M. & Kozár, F. 1988: Scale insects of Central Europe. Akadémiai Kiadó. Budapest, 456 p.

Kozár, F. 1990: Forecasting and monitoring infestations. In: D. Rosen-The armoured scale insects, their biology, natural enemies and control, Vol. B: 341-347.

Kozár, F. & Drozdják, J. 1987: Some questions concerning the knowledge of Palaearctic Coccoidea (Homoptera). Boll. Lab. Ent. agr. Filippo Silvestri 43 (Suppl.): 97-105.

Kozár, F. & Viktorin, R.A. 1978: Survey of scale insect (Homoptera: Coccoidea) Infestation in European orchards, changes in the scale infestation levels in Hungarians orchards. Acta Phytopathologica Acad. Sci. Hung. 13 (3-4): 391-402.

Kozár, F. & Walter, J. 1985: Check-list of the Palaearctic Coccoidea (Homoptera). Folia Entomologica Hungarica 46: 63-110.

Siddiqi, Z.A. 1966: Crop Pest in Afghanistan, Plant Protection Association of Afghanistan Kabul, Publ. No. 1: 4-5.

Siddiqi, P.M. 1981: Major Agriculture pests in Afghanistan and methods for their control. Faculty of Agriculture, Kabul University. Kabul: 172-180.

Talhouk, A.S. 1975: Contributions to the knowledge of almond pests in East Mediterranean countries II. *Didesmococcus unifasciatus* (Arch.). Z. für angew. Entomol. 78 (4): 409-414.

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IPM in stone fruit production in Norway

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Abstract: Data on the importance of stone fruit, main pests and diseases and IPM application in Norway are presented.

Key words: plum, cherry, pests

Production of stone fruits in Norway

Due to a short growing season and rather low summer temperatures sweet cherries, sour cherries and plums are the only stone fruits produced in Norway. The main districts for stone fruits in Norway are located in the western part of the country. More than 80% of the sweet cherry production and 85% of the plum production are found in western Norway.

In 1997 the total area of sweet cherry production was 2255 daa. The yearly yield varies mainly due to climatic factors, but the average marketable yield is approximately 500 tons. The total area of plum production was 3400 daa in 1996, and the average yearly yield is 1900 tons. The production of sour cherries in Norway is small and mainly located at home gardens.

As a part of the Norwegian governmental policy both sweet cherry and plum production are increasing in Norway. Due to a delayed season compared to other European countries, there is now increasing interest among Norwegian fruit growers to expand this industry aiming at the export market.

Main problems

In cherries the main problems are the cherry black fly (*Myzus cerasi*) and different fungi causing fruit rot, the most important being *Monilia laxa*. There is also a growing problem with the cherry moth (*Argyresthia pruniella*). The cherry fruit fly (*Rhagoletis cerasi*) may become a major problem as the production now is increasing in areas were the fly is abundant. However, in western Norway the population of the cherry fruit fly is small.

Attack on leaves and fruits by mites (*Panonychus ulmi* and *Aculus fockeui*) is the main problem in plums. The bird bullfinch can remove a large proportion of the buds in some years on some cultivars. Both the plum saw fly (*Hoplocampa flava* and *H. minuta*) and the plum moth (*Cydia funebrana*) are increasing problems in southern and eastern Norway.

IPM in stone fruits

IPM has had a great influence on the development of pest management strategies in both stone fruits and pome fruits in Norway. The process to reduce the number of pesticide applications started in the 1960s with a more fully investigation of pest lifecycles and distributions to be able to adjust treatments to make them more effective. In the 1980s economic thresholds for important pests and forecasting systems for the most important insects and fungi pests were developed. An advisory system has been developed in all fruit districts. Farmers are offered courses in how to monitor the pest situation in their own orchard, and how to decide when treatments are necessary.

The experimental work and the advisory system have resulted in a reduction from 6-8 to 0-3 treatments with pesticides against insects and mites, and from 8-16 to 3-5 treatments against fungus. The concentrations of pesticides in a treatment have also been reduced to reduce harmful effects on predatory insects and mites.

Presently there is no IPM label on Norwegian stone fruits. However, from 1998 only apples grown under IPM will be sold with the "Godt Norsk" label. There is a need for an IPM production and control system in stone fruits.

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The current status of Integrated Stone Fruit Production in Greece

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Abstract: The situation of IPM application in Greece is reported, together with the list of main problem for stone fruit.

Key words: pests, diseases

Introduction

Stone fruits are cultivated in Greece and especially in its northern part. The area they cover and the amount of fruit produced are shown in table 1.

Table 1. Cultivated area (hectares) and production (tons) of stone fruits

Plant species	Hectares	Tones
Peach	65000	2.000.000
Apricot	6000	80.000
Cherry	8500	40.000

The peach trees cultivated belong to the following varieties: Spring Crest, May Crest, Red Haven, Cardinal, while the apricot trees belong to the varieties Tyrinthos Bebekou, Diamandopoulou, Luiset. Cherry trees are Biggarreau Burlet, B. Stark Hardy Giant, Tragana Edessis, and plum trees Agen, Scopelou, Stanley and Angelino.

Pests of Stone Fruits

Stone fruit trees are good hosts for several pest species and severe damage can rapidly occur if effective control is not maintained. The most important pests of peach trees are the microlepidopterous species *Adoxophyes orana (F.v.R.)* (Lepidoptera: Tortricidae) (Savopoulou-Soultani *et al.*, 1985; Savopoulou-Soultani & Hatzivassiliadis, 1991), *Anarsia lineatella* (Zeller) (Lepidoptera: Gelechiidae), *Grapholitha (Cydia) molesta (Busck)* (Lepidoptera: Tortricidae). They complete 3-4 generations per year in northern Greece. The most serious damage caused is that on fruit. *A. orana* is the most damaging pest recorded in each of the last four years in northern Greece. Overwintering larvae cause damage to blossom and young leaflets followed by three more generations. First generation larvae in June initially feed on leaf rolls in shoots and the on fruit whereas a second generation larvae cause damage to fruit. The last generation of larvae develop on leaves, because fruit has already been harvested. High numbers of moths were recorded in traps from mid May to mid June, early

July to early August and late August to late September.

Parasitoids such as *Colpoclypeus florus* (Walker) (Hymenoptera: Eulophidae), *Brachymeria rugulosa* (Forster) (Hymenoptera: Chalcididae) and *Bracon hebetor* (Say¡) (Hymenoptera: Braconidae) were found to parasitise on *A. orana* larvae or pupae.

Aphids also cause serious problems in spring especially those belonging to the *Myzus persicae* complex in peach trees, and *Myzus cerasi* in cherry trees. The most important predator of aphids is *Coccinella septempunctata* (Coleoptera: Coccinellidae).

Tetranychus urticae and *Panonychus ulmi* (Tetranychidae) are the most common mite species in the orchards of northern Greece. The most frequently observed Eriophyidae are *Vasates (Aculus) cornutus* on peach trees, *V. fockeui* on cherry trees in the same geographic area (Savopoulou-Soultani & Koveos, 1995). Beside the phytophagous mites, some of their most well-known predators, especially Phytoseiids are already found.

The problems with the apricot are fewer in number than those of the peach and do not lead to serious difficulties. The aphid *Hyalopterus pruni* (Geoff.) is more to be feared as a vector of Sarka than for any direct damage that it causes. The cultivated with plum trees area is limited, so our knowledge about its most important pests is still incomplete. *Cydia funebrana* (Treitschke) (Lepidoptera: Tortricidae) cause damage to plums but it has not yet been studied . *A. orana* and *Rhagoletis cerasi* L. are the most important pests of cherry trees.

Up to 1994 only chemical control was used for fruit protection. The widespread use of synthetic pesticides drastically upset the existing balance between different species and their natural enemies. From that year on, a serious attempt started for Integrated Fruit Production (IFP) in the orchards of northern Greece within the scope of a pilot project. It has been developed by researchers of the Aristotle University of Thessaloniki and the Institute of Pomology of Naoussa. IFP is defined as the production of high quality fruit, giving priority to ecologically saver methods, minimising the undesirable side effects and use of agro-chemicals, to enhance the safe guards to the environment of human health.

In IFP, decision for control of orchard pests was made on the basis of information gained from orchard monitoring, which is based on defined thresholds. The timing of insecticide sprays for *A. orana,* for example, was based on threshold pheromone trap captures (>10 moths/trap/week). Pesticide use is restricted and only those products which are least toxic, least persistent, most selective and with minimal side effects on beneficial organisms are used. Alternative strategies for control of *A. orana* includes the use of granulosis virus, the juvenile hormone analogue insect growth regulators and chitin synthesis inhibitors. Mathematical models are on construction, driven by daily temperature records and field observations and moth trapping in pheromone traps. The system will provide information on the optimal timing for monitoring and pesticide applications, which will be most effective because the development of pest populations will be known. Based on data from laboratory experiments, we have established the rates of development of the various stages of *A. orana* at different temperatures. The prepared model will be validated next year by comparing the predictions with observations of the field population.

Diseases of stone fruits

The following diseases cause serious damage to stone fruits (Thanassoulopoulos, 1996).

A. Peach trees:

Clasterosporium carpophilum (*Coryneum beijerinckii)*
Taphrina deformans during spring on fresh leaves

Sphaerotheca pannosa
Monilinia (Sclerotinia)

B. Cherry trees:
Monilinia laxa, either during spring or later if the weather is rainy.

C. Apricot and Plum trees:
Monilinia laxa, during blooming in spring.

Fungicidal treatment is applied against these diseases. Dormant sprays are applied after the leaf fall in autumn-winter and then protective sprays during growing season. Control recommendations include cultural measures except the spray treatments. Unfortunately the level of control offered by the fungicides is not sufficient enough to guarantee a satisfactory protection, especially when weather conditions are very favourable to the development of the diseases.

We believe that using a more careful and rational pest and disease control management it will be possible, at least in part, to re-establish a balance in the agro-ecosystem. The use of integrated pest management involves an increased cost of production. But when deciding on a correct method of protection for stone fruit cultivation, the cost of chemical treatments is no longer considered from a strictly economic point of view, but rather from an ecological and social aspect. In Greece this has also been the basis of much research to obtain further information about all the species associated with stone fruits during the last four years, and we hope that this trial will be continued in the following years.

References

Milonas, P.G. & Savopoulou-Soultani, M. 1997. Parasitoids of *Adoxophyes orana* (F.v.R.) (Lepidoptera: Tortricidae) in northern Greece. 7th Greek Entomol. Congress, Kavala, 21-24 October 1997 (in Greek, english abstract).

Savopoulou-Soultani, M., Hatzivassiliadis, A., Vlug, H.J., Minks, A.K. & Tzanakakis, M.E. 1985: First records of the summerfruit tortricid, *Adoxophyes orana* F.v.R., in Greece. Entomol. Hellenica 3: 65-66.

Savopoulou-Soultani, M. & Hatzibassiliadis, A. 1991. Seasonal development and flight period of *Adoxophyes orana* (F.v.R.) (Lep., Tortricidae) in the Naoussa area of northern Greece. Anz. Schadlingskde., Pflanzenschutz, Umweltschutz, 64: 61-62.

Savopoulou-Soultani, M. & Koveos, D.S. 1994. Identification of three species of Eriophyid mites and population fluctuation of two of them on apple and peach trees in northern Greece. 4th Greek Entomol. Congress, Volos, 14-17 October 1991 (in Greek, english abstract).

Thanassoulopoulos, K. 1996. Diseases of Fruit Trees and Grape Vine. Thessaloniki, Ziti Publ.

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Major pest and disease problems in stone fruit production in Northern Victoria, Australia

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Abstract: The use of Integrated Pest Management (IPM) systems has been standard practice in stone fruit production in Goulburn-Murray Valley, Victoria for many years. The major pests of stone fruit are the follow: Oriental Fruit Moth (OFM) (*Grapholita* (*Cydia*) *molesta* Busck., Lep: Tortricidae) is the major pest of peaches, nectarines, apricots, quinces, plums, cherries, as well as pome fruit such as pears and apples, where damage has recently been observed. Lightbrown Apple Moth (LBAM), (*Epiphyas postvittana* Walker., Lep: Tortricidae) is a serious pest on stone and pome fruit, berries and ornamentals. Carpophilus Beetles (CB) (*Carpophilus* spp., Coleoptera: Nitidulidae) or Dried fruit beetles [*Carpophilus hemipterus* (L.), *C. mutilatus* (Erichson), *C. davidsoni* (Dobson)] are major pests of ripening stone fruit such as peaches, nectarines, plums and apricots. The major diseases of stone fruit are the follow: Fungal diseases, such as Root rot caused by *Phytophthora* spp. can result in the die back of many stone fruit trees, particularly, peaches. Armillarea root rot, causing a decline in tree health, may occur in stone fruit trees. Silverleaf disease, caused by *Chondrostereum purpureum*, is a serious disease of stone fruits. Brown rot is a continuous problem in peaches, nectarine, cherries, apricots and occasionally in plums. It may be caused by *Monilinia fructicola* and/or, *Monilinia laxa*. The important bacterial diseases that cause concern in stone fruits are Bacterial gummosis (*Pseudomonas syringae*) and Bacterial spot (*Xanthomanas capestris*).

Key words: Stone fruit, pests, diseases, IPM, mating disruption

Introduction

Australia produces approximately 1.16% of the world's stone fruit and contributes to 0.5% of the world's export market. Twenty-five percent of Australia's total stone fruit production is based in the Goulburn Valley, Victoria, of which 60% comprises of peaches for the processing (canning) industry and 15% of this product is exported (The Australian Horticultural Statistics Handbook 97/98).

The use of integrated pest management (IPM) systems with supplementary sprays has been standard practice in stone fruit production for many years. A Pest Management survey conducted in 1996-97, clearly indicated a significant increase in the overall understanding and adoption of IPM by the Goulburn Valley growers compared with a similar survey conducted in 1991-92. There has been a significant increase in number of growers practicing IPM (66%) in orchards compared to 42% in 1991-92. Maximum adoption of IPM has been achieved in controlling two spotted mite and Oriental Fruit Moth (OFM) by using mating disruption on stone fruit. Most growers surveyed (89%) were satisfied with the use of IPM and have shown interest in its use in the future (Singh, 1998).

Organophosphate (OP) insecticides, such as parathion (ethyl & methyl), azinphos-methyl and chlorpyrifos, have traditionally been used to control the primary pests: Oriental Fruit Moth (OFM) (*Grapholita molesta* Busck., Lepidoptera: Tortricidae), Light Brown Apple Moth (LBAM) (*Epiphyas postvittana* Walker., Lepidoptera: Tortricidae) and *Carpophilus* beetles (CB) (*Carpophilus* spp., Coleoptera: Nitidulidae), but now with the availability of sex pheromones, mating disruption techniques and biological control agents, the role of OP sprays have decreased dramatically (Brown & Il'ichev, 1998).

Since 1995, industry surveys have recorded a declining trend in the effectiveness of OP sprays with 1-7% pest damage levels in both canning and fresh peach crops. In comparison, areas treated with pheromone based mating disruption (MD) for OFM have reduced average damage levels to 0.1% - 0.2%. It is well known, however, that MD is less effective when the population density of pests is very high. Therefore, applications of OP sprays have been necessary to treat these areas to reduce pest population and minimise subsequent OFM damage. The prolonged over-use of OP sprays are considered disruptive to IPM systems.

Major pests of stone fruit and their control

*Oriental Fruit Moth (OFM), (*Grapholita *(*Cydia*)* molesta *Busck., Lepidoptera: Tortricidae)*

OFM is the major pest of peaches, nectarines, apricots, quinces, plums, cherries, as well as pome fruit such as pears and apples, where damage has recently been observed. Wilting lateral tips on peaches and nectarines are the first sign of infestation.

After hatching, the larvae will tunnel to the shoot tips and a cream to pale pink caterpillar up to 12mm long could be found at the end of the tunnel. The larvae will often leave the shoot tip to wilt and enter another, or tunnel into a fruit. Later maturing varieties are generally most seriously affected by fruit infestation, where injury can lead to brown rot infection. Infestation can occur any time from late September and continue throughout the season (Orchard Pest and Disease Handbook, 1996-98). OFM has 4-5 generations per season in Victoria. The first flight of overwintering generation starts during the beginning of September and the last flight finishes in April (Rothschild & Vickers, 1991).

Mating disruption is now a cornerstone of IPM in Australian orchards. OFM has been controlled with MD for some years. In the Murray-Goulburn Valley, shoot tip and fruit damage has more recently occurred in peach blocks with MD. Some orchardists have reported more damage may occur in the border of peach blocks adjacent to fruit blocks where chemical control is used (Il'ichev, 1997). Migration of OFM between blocks could be a cause of this problem.

The possibility of the control of OFM at a district-wide level by MD with synthetic female pheromone has been demonstrated by Rothschild (1975) and Vickers *et al.*(1985) in peach orchards in Victoria and NSW. Rothschild (1979) showed that disruption treatments could be as effective in controlling OFM as insecticides. It was suggested (Vickers *et al.*, 1985) that MD may be more effective than insecticides, when all orchards in a district are treated, so as to reduce the likelihood of mated females migrating from untreated blocks.

An effective method for reducing OFM population densities to levels below economic threshold is the adoption of Wide Area Mating Disruption (WAMD). This strategy involves treating an entire fruit production area with MD including all stone and especially pome fruit trees, where MD is not normally used. The Victorian Department of Natural Resources and Environment (DNRE) is currently evaluating the strategy in the Cobram region. The WAMD research project, covered about 800 ha in 1997/98 and more than 1,100 ha in 1998/99. This area was large enough to minimise any edge effects and migration of mated OFM females. Preliminary results of monitoring more than 230 OFM traps and damage assessments showed that the WAMD approach was effective (Il'ichev *et.al.*,1998).

Lightbrown Apple Moth (LBAM), (**Epiphyas postvittana** ***Walker., Lepidoptera: Tortricidae)***
LBAM is a serious pest on stone and pome fruit, berries and ornamentals. Very active light green caterpillars up to 25mm long can be found inside folded leaves, rolled over, usually near tips of lateral growth. Leaf damage may commence in late October and continue through until late autumn. Later in the season, shallow irregular-shaped areas eaten in fruit where two or more fruit are touching or where a leaf is fastened to a fruit by webbing. Some early fruit damage may be seen in November, but not generally until well into summer (Orchard Pest and Disease Handbook, 1996-98).

The native Australian insect LBAM, which damages fruit and can feed on a wide range of broad-leaved weeds, has a complex of natural predators including wasps, spiders and flies. These are only effective if broad-spectrum insecticides are avoided. Mating disruption for LBAM is available and the introduced egg parasite, *Trichogramma* spp. has been evaluated as a biological control agent (Thwaite, 1998). To reduce the use of OP sprays for LBAM and other pests it is possible to substitute with biological methods, such as application of *Bacillus thuringiensis* and *Trichogramma carverae* (Brown & Il'ichev, 1998).

Carpophilus Beetles (CB) (**Carpophilus spp.,** ***Coleoptera: Nitidulidae)***
Dried fruit beetles [*Carpophilus hemipterus* (L)., *C. mutilatus* (Erichson)., *C. davidsoni* (Dobson)] are major pests of ripening stone fruit such as peaches, nectarines, plums and apricots. These dark brown, thickset beetles about 3mm long with shortened wing covers are strongly attracted to rotting fruit and can migrate long distances to attack ripening fruit and aid in spreading brown rot spores. Normally CB only enter fruit which has been damaged or with split stones, but they also able to attack sound fruit and move into trees from fallen, rotting fruit. The ability to identify and synthesise the aggregation pheromones has resulted in the development of a system of monitoring and proposals for control based on mass-trapping in stone fruit orchards using synthetic aggregation pheromones and host-related co-attractants (James *et. al.*, 1998).

Other stone fruit pests
Black (*Brachycaudus persicae* (Passerini) HEM: Aphididae) and Green (*Myzus persicae* (Sulzer) HEM: Aphididae) peach aphids, Cherry Aphid (*Myzus cerasi* (Fabricius) HEM: Aphididae) and Frosted Scale (*Eulecanium pruinosum* (Coquillett) HEM: Coccidae), Fruit-tree Moth Borer (*Maroga melanostigma* (Wallengren) LEP: Oecophoridae) and Peach Silver Leaf Mite (*Aculus cornutus* (Banks) ACAR: Eriophyidae), Rutherglen Bug (*Nysius vinitor* (Bergroth) HEM: Lygaeidae) and European Earwig (*Forficula auricularia* (L) DERM: Forficulidae) are stone-fruit pests in Victoria, but IPM and biological control methods could successfully control their level below economical threshold to prevent any severe damage and outbreaks.

Major diseases of stone fruit and their control

Fungal diseases
Root rot caused by *Phytophthora* spp. can result in the dieback of many stone fruit trees, particularly, peaches. Affected trees may show signs of chlorosis and wilt even when there is sufficient water available. Integrated management using careful irrigation management and good soil drainage is recommended for the control of *Phytophthora*. In Victoria, the chemicals

metalaxyl and fosetyl-Al are registered for the control of this disease but this form of control may not always be cost-effective.

Armillarea root rot, causing a decline in tree health, may occur in stone fruit trees. Symptoms are often seen on groups of trees or radiating from an infected area. There are no fungicides available for the disease and a management practice which involves the complete removal of the tree is recommended. All affected plant parts must be burnt and the area cleared.

Silverleaf disease, caused by *Chondrostereum purpureum*, is a serious disease of stone fruits. Peach trees are highly susceptible to silverleaf. The disease limits tree performance, causes the silvering of leaves, defoliation of limbs and reduces canopy cover. In severe cases, the tree looses limbs and prematurely dies. In severely affected orchards, up to 10% of trees may be infected. There are currently no fungicides available for the control of the disease but several wound dressings are available for disease prevention. In addition, a major education program is currently underway to help growers understand the importance of orchard hygiene, pruning techniques and timing on reducing the spread of silverleaf disease.

Brown rot is a continuous problem in peaches, nectarine, cherries, apricots and occasionally, in plums. It may be caused by *Monilinia fructicola* and/or, *Monilinia laxa*. Blossoms, leaves, fruit stalks, shoots and leaves can be attacked. The disease occurs when the weather is mild and showery. Brown rot in fruit is often associated with carpophilus beetles which may be a vector of the disease. A thorough spray program including copper fungicides before pink bud followed by a range of fungicides if necessary is recommended for disease control. It is recommended that chemicals should be rotated to reduce the risk of resistance (Orchard Pest and Disease Handbook, 1996-98).

Scab (*Ventura carpophila*), Rust (*Transzchelia discolor*) and Shot Hole (*Stigma carpophila*) may appear on peaches, apricots and nectarines. Symptoms of these diseases are seen on fruit and leaves. Copper sprays at budswell and subsequent cover sprays with recommended fungicides can reduce the severity of disease.

Bacterial diseases

The important bacterial diseases that cause concern in stone fruits are Bacterial gummosis (*Psuedomonas syringae*) and Bacterial spot (*Xanthomanas capestris*). These diseases affect all parts of the tree. In both cases, the bacteria enter through leaf scars and pruning scars. Infected limbs may form cankers which spread quickly along branches. Sometimes blossoms may be blighted. In recent years, Bacterial spot in plums has become increasingly important because highly susceptible varieties such as Autumn Giants and Friars are favoured by growers for the lucrative fresh market. Currently, copper spray programs are recommended for these diseases from petal fall through to winter until early budswell. However, if favorable conditions for infection occur after fruit set, much production losses may occur. Alternative fungicides are currently being trialed in Australia to give more durable protection against these diseases.

References

The Australian Horticultural Statistics Handbook 97/98. Australian Horticultural Corporation, 1998.

Brown, D.J. & Il'ichev, A.L. 1998: The potential for the removal of organo-phosphate insecticides from stone fruit production in the Goulburn valley, Australia. Acta Horticulturae (in press).

James, D.G., Bartelt, R.J. & Moore C.J. 1996: Mass-trapping of *Carpophilus* spp. (Col: Nitidulidae) in stone fruit orchards using synthetic aggregation pheromones and a coattractant: development of a strategy for population suppression. J. Chem. Ecology, 22:1541-1556.

Il'ichev, A.L. 1997: Problems with mating disruption of Oriental Fruit Moth. Abstracts of the 28-th AGM and Scientific Conference of the Australian Entomological Society, Melbourne: 37.

Il'ichev, A.L., Jerie, P.H. & Hossain, M.S. 1998: Wide area mating disruption of Oriental Fruit Moth *Grapholita molesta* Busck. (Lepidoptera: Tortricidae) in Victoria. Sixth Australasian Applied Entomological Research Conference: Pest Management-Future Challenges, Brisbane, Australia, 28 September - 2 October 1998, vol.1: 348-355.

Orchard Pest and Disease Handbook 1996-98: Victoria-all regions and South Australia. Northern Victoria Fruitgrowers' Association Ltd.,1996.

Rothschild, G.H.L. 1975: Control of Oriental Fruit moth (*Cydia molesta* Busck., Lep: Tortricidae) with synthetic female pheromone. Bull. ent. Res. 65: 473-490.

Rothschild, G.H.L. 1979: A comparison of methods of dispensing synthetic sex pheromone for the control of Oriental Fruit moth in Australia. Bull. ent. Res. 69: 115-127.

Rothschild, G.H.L. & Vickers, R.A. 1991: Biology, ecology and control of the Oriental Fruit moth. In: Van der Geest L.P.S., Evenhuis H.S. (Eds.), 1991. Tortricid pests their biology, natural enemies and control. Elsevier: 389-412.

Singh, M. 1998: Pest management survey to measure adoption of IPM in the Murray Goulburn Valley. Northern Victoria Fruitgrowers Association-Technical Bulletin, N.1: 2.

Thwaite G. 1998: Integrated pest management in apples and pears and its adoption by growers. 1998 Deciduous Fruit Spray Schedule. Published by Stephen Tancred Pty.Ltd.: 3-7.

Vickers, R.A., Rothschild, G.H.L. & Jones, E.L. 1985: Control of Oriental Fruit Moth at a district level by mating disruption with synthetic female pheromone. Bull. ent. Res. 75: 625-634.

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Status of Stone Fruit Integrated Pest Management in the United States

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Abstract: Integrated pest management for stone fruits in the United States in not widely practiced at a high level. The most advanced integrated pest management is practiced in California, where the production of stone fruits is most intensive. Research has been done and continues to be done to refine pest management programs and to make monitoring and thresholds more reliable. Proposed guidelines for sweet cherry production are available in New York, and organic and biological control options for pest control are available in California for peaches and plums. The greatest obstacles for further development of pest management are the zero tolerance for cherry fruit fly in exported fruit and the need for calendar based sprays for cat-facing insects on peach in the East.

Key words: peach, plum, apricot, cherry

Introduction

Stone fruit production is distributed throughout the United States, and the pest problems vary, especially between the West Coast (California, Oregon and Washington) and the East. Integrated pest management, in general, is not as advanced for stone fruit crops as it is in many crops, partly because of the size of the production and the type of pests. Stone fruits are considered a minor crop in most states and therefore do not have as much research effort into developing pest management strategies as do crops with greater production. In many regions, the most serious pests do not have reliable monitoring methods and do not have experimentally determined treatment thresholds.

The most developed integrated pest management program has been developed in California for peaches, where the majority of peaches are produced and nearly all nectarines, plums and apricots are grown. Production data reported for the various stone fruits are for 1997 and are from the National Agricultural Statistics Service, U. S. Department of Agriculture, from their web page on the internet (http://www2.hqnet.usda.gov/nass/pubs/crank97.htm). There is production of nectarines, plums, and apricots in states other than those listed in the statistics below, but the production level is too low to be included in national statistics, and most of this fruit is produced for local fresh market sales.

Peaches

Production of peaches is divided into freestone peaches, which account for most of the fresh production, and clingstone peaches, which are used for processing. Freestone peach production was 682,257 metric tons in 1997, and clingstone peach production was 521,077 metric tons. Freestone peaches were grown in over 30 states, and in 1997, 49% was produced in California, 11% in Georgia, 11% in South Carolina, 5% in Pennsylvania, 4% in New Jersey, 3% in Washington and the remaining 17% from other states. All of the commercial production of clingstone peaches was from California, giving California 71% of the total peach production in the United States. Commercial nectarine production was 239,660 metric tons in 1997, all from California.

California has a progressive integrated pest management program for peach production. The University of California at Davis provides guidelines for pest management that can be accessed through their web page (www.ipm.ucdavis.edu). In these guidelines the standard chemical control program is presented, also organic options and biological control are also discussed. Mating disruption is the recommended method for control of oriental fruit moth, *Grapholita molesta* (Busck) (Tortricidae), and peach twig borer, *Anarsia lineatella* Zeller (Gelichiidae). The use of organo-phosphorus insecticides is being reduced with dormant application of oil and *Bacillus thruingiensis* at bloom time for peach twig borer. An organo-phosphorus application is used for San Jose scale, *Quadraspidiotus perniciousus* (Comstock) (Diaspididae), only if needed based on results from monitoring (usually in less than 10% of the orchards). The majority of growers do use monitoring and treatment thresholds for their insect pests in peaches in California.

Peach production outside of California is primarily in the southeastern part of the country, from Georgia and South Carolina north to Pennsylvania and New Jersey. In this region the major pests are borers, *Synanthedon pictipes* (Grote & Robinson) and *Synanthedon exitiosa* (Say) (Sesiidae), oriental fruit moth, plum curculio, *Conotrachelus nenuphar* (Herbst) and cat-facing insects (those insects that damage the expanding fruit, causing a deformity as the undamaged part of the fruit keeps growing around the damage) such as Pentatomidae and *Lygus lineolaris* (Palisot de Beauvois). The private company Gerber, a manufacturer of baby food, has begun to initiate more advanced integrated pest management on processing peaches in the South and in Michigan because of the demands for less insecticide use in baby food. Cat-facing insects require calendar based sprays in the East because they do not feed in the orchard except as adults flying through the orchard, feeding on the fruit in transit. Monitoring for the cat-facing insects is generally not reliable. Calendar spraying with organo-phosphorus or carbamate insecticides is the general pest management method for oriental fruit moth and cat-facing insects. Mating disruption has been tested for oriental fruit moth and the borers but is not used because of economic reasons. Monitoring methods for most of the pests and economic thresholds are available, but few have been rigorously validated, and these methods are not in common use by the majority of growers. Crop rotation and resistant rootstocks are the recommended treatments to reduce problems with nematodes.

Plums

Commercial plum production was 218,780 metric tons in 1997 with 88% in California, 5% in Oregon, 3% in Washington, 2% in Michigan, and 2% in Idaho. The University of California at Davis web page mentioned earlier also has integrated pest management guidelines with organic and biological control options for plum pests. Plum pests are similar to those of peach in California, with aphids being more of a problem and generally controlled with dormant oil sprays. In some regions of California, codling moth, *Cydia pomonella* (L.), has been a problem. Mating disruption has been tested and found effective in plum orchards for codling moth control.

Apricots

Apricot production in 1997 was 125,276 metric tons with 96% in California, 4% in Washington, and a very small amount in Utah. Pest problems and integrated pest management in California are similar to what has been presented for peaches in California.

Cherries

Sweet cherry production was 202,439 metric tons in 1997. Most of the production of sweet cherries was in the West with 41% in Washington, 22% in Oregon, 22% in California, 12% in Michigan, and some production in Idaho, Montana, Pennsylvania, New York, and Utah. Sour cherry production was 131,132 metric tons with 81% in Michigan, 6% in Utah, 5% in New York, 4% in Wisconsin, 2% in Pennsylvania, 1% in Oregon, and 1% in Colorado. The major limiting factor for integrated pest management for cherries in the West is the zero quarantine tolerance for cherry fruit fly, *Rhagoletis cingulata* (Loew) (Tephritidae), in any fruit from orchards producing fruit for export. Because of this zero tolerance for fruit fly, there is a heavy reliance on organo-phosphorus insecticides. A phenological model is used to predict adult fly emergence and has reduced the number of insecticide applications needed. It is also recommended to remove wild hosts to minimize the immigration of fruit flies into the orchard. Mating disruption is in use for oriental fruit moth and peach twig borer in the West. In Michigan, organo-phosphorus sprays are used for cherry fruit fly control with spray timing determined with yellow emergence traps. Plum curculio is a serious problem for cherry production in Michigan and other eastern states. Degree-day models and weekly reporting and crop alerts on the internet are used to time sprays for most pests in Michigan. Yellow emergence traps for cherry fruit fly and phenology models for plum curculio and fruit diseases are used in New York. Cornell University has a draft of integrated pest management guidelines for sweet cherries, accessed through the web (www.nysaes.cornell.edu/ipmnet/ny/vegetables/elements/e198/sw.cherr.html). The guidelines include all aspects of cherry production. Insect management guidelines are based on use of phenology models and monitoring.

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