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 RÉUNION

at/à

Zaragoza (Spain)
24-26 September 1996

Edited by
P. CRAVEDI, C. HARTFIELD & E. MAZZONI

IOBC/WPRS Bulletin
Bulletin OILB/SROP Vol.20(6) 1996

The IOBC/WPRS Bulletin is published by the International Organization for Biological and Integrated Control of Noxious Animals and Plants, West Palaearctic Regional Section (IOBC/WPRS)

Le Bulletin OILB/SROP est publié par l'Organisation Internationale de Lutte Biologique et Intégrée contre les Animaux et les Plantes Nuisibles, section Régionale Ouest Paléarctique (OILB/SROP)

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ISBN 92-9067-091-6

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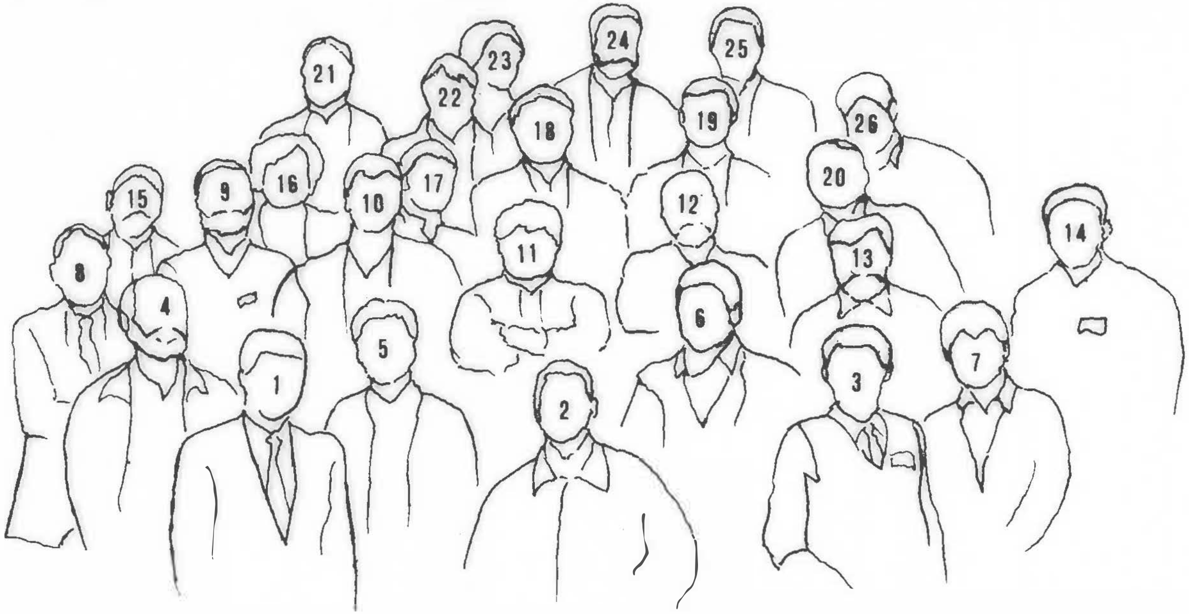
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INTRODUCTION

The Biennial meeting of the Working Group "Stone Fruit" was held in September 1996 in Zaragoza (Spain), where a meeting on the same subject had already been held in 1990. Once again, the meetings and the greatly appreciated tours of the town were impeccably organised by Rafel Balduque.

One of the subjects which emerged at the 1994 meeting in Valence (France) and to which the Working Group decided to commit itself was the writing of the IFP Guidelines for Stone Fruit. In the last two years a first draft was drawn up and presented at the Meeting of the "IFP Guidelines" Subgroup of which Jerry Cross is Scientific Secretary. The Subgroup prepared the document to be submitted to the IOBC Endorsement Committee who have already approved it with only a few slight changes. In a specific session during this meeting, Malavolta illustrated the text of the IFP guidelines which is being published in an IOBC bulletin.

The meeting was divided into 8 sessions chaired by A. Garrido (Spain), A. Arzone (Italy), J. P. Gendrier (France), G. Marboutie (France), and R. Olszak (Poland). There were 18 papers read. In addition, talks on phytosanitary problems in Hungary, Poland and the UK were presented. Representatives of these countries were attending the Working Group meetings for the first time and made interesting contributions.

Also worthy of note is a paper by Russian authors. They were unable to take part in the meeting but their paper was read and discussed and is included in the Proceedings.

Attendance at the meeting was low because of the high travel costs. When the location of the next meeting is chosen there will be an attempt to make it easier to reach for the numerous colleagues from eastern European countries who have expressed interest in Integrated Stone Fruit protection.

At the conclusion of the meeting it was clear that there were certain research areas of common interest. Among these, particular attention was paid to the study of the scale Pseudaulacaspis pentagona and a plan to which several participants subscribed was launched to prepare a co-ordinated research project which could be presented to the EU for financing.

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(Convenor)

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LYGUS RUGULIPENNIS POPPIUS, A MINOR PEST IN THE PEACH ORCHARDS OF NORTHWESTERN ITALY[(*)]

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ABSTRACT - In recent years, fruit injury attributable to the feeding activity of Miridae has caused economic losses in peach orchards in Saluzzo, province of Cuneo, northwestern Italy. Having determined that the mirid species responsible was *Lygus rugulipennis*, research was carried out during 1992-1994 to study its biology and investigate the potential of non-chemical methods for its control. In the study area, *L. rugulipennis* completed three generations a year. It overwintered as an adult at the base of weeds and in earth cracks, and in spring it flew to winter cereals where it completed at least one generation; then it moved onto numerous herbaceous weeds or, if these weed species are absent, onto fruit trees. To prevent *L. rugulipennis* moving onto orchards trees, alternative methods of weed control within the orchard were studied. Mowing the weed strips between alternate rows proved to be the most convenient method of preventing *L. rugulipennis* damage to the peach fruits without using insecticide treatments.

INTRODUCTION

Severe injuries to fruits, attributable to the feeding activity of mirids, were recorded in peach orchards of Piemonte (northwestern Italy) in 1990. Such injuries, very similar to those described for some nearctic mirids (Rings, 1958), have been occasionally reported in peach, kiwi and apple orchards elsewhere in Italy (Carli *et al.*, 1987; Cravedi & Carli, 1987; Culatti *et al.*, 1992).

Research conducted in 1991 showed that the commonest mirid causing damage to peach in northwestern Italy was the European tarnished plant bug, *Lygus rugulipennis* Poppius. Numbers of adult *L. rugulipennis* found on weeds between the orchard rows during the summer and autumn were more than 10-fold higher than those found on the adjacent peach trees (877 and 70 individuals respectively). By placing individual mirid species into cages on fruit-bearing branches, it was demonstrated that fruit damage was attributable to the feeding punctures made by *L. rugulipennis* (Tavella *et al.*, 1994).

The investigations described here were made in order to study biology of *L. rugulipennis* in Piemonte and develop a non-chemical method for its control, thereby complementing the integrated pest management (IPM) strategies already used in many of the peach orchards in

(*) Research supported by a grant of Italian M.U.R.S.T. 60%

this region.

MATERIALS AND METHODS

Field surveys were carried out in the area of Saluzzo, northwestern Italy, during 1992-1994. In 1992 and 1994, samples were taken from four peach orchards and neighbouring crops every two weeks from April to October and every four weeks from November to March. *Lygus rugulipennis* nymphs and adults were collected from peach trees and cultivated and wild herbaceous plants using a sweep net. Mirids caught in the field were brought into the laboratory where they were counted and sexed (nymphs were reared through to adults in order to determine their sex).

In 1994, the weed strips between alternate rows of peach trees were mown to see whether the selective management of orchard weeds could reduce the movement of *L. rugulipennis* onto peach. A row was only mown when the weeds in the adjacent rows were 20-30 cm in height. Samples were taken from 9 orchards, in which mirid feeding activity had caused severe damage to fruits in previous years. IPM, involving the use of pheromones to control *Cydia pomonella* (Busck), was practised in 5 of these orchards. The remaining four orchards were under supervised control (SC), where only permitted pesticides were sprayed if pest thresholds were crossed. Localities, cultivars, control methods, neighbouring crops and borders and the incidence of mirid damage during 1990-1993 are shown in Table 1. From June to the harvest, which generally occured in August, mirid populations on the herbaceous weeds were sampled every four weeks using a sweep net. Three sets of 10 sweeps were made along each of the four edges of each orchard and along its central row. At harvest-time, samples of peaches (which ranged from 650 to 540,000 fruits) from each orchard were monitored for damage.

Table 1. Characteristics of the peach orchards investigated in 1994

no.	locality	cultivar	control method	borders	damage %
1	Verzuolo	Venus	IPM	meadow, peach, road	10-15
2	Verzuolo	Glohaven	SC	farm, kiwi, peach	5-15
3	Saluzzo	Redhaven, Glohaven	IPM	farm, hedge, road, wasteland	13-15
4	Verzuolo	Stark Red Gold, Roberta	IPM	kiwi, peach, wheat	15
5	Saluzzo	Nectaross, Stark Red Gold	SC	kiwi, peach	8-30
6	Saluzzo	Spring Red	SC	peach, strawberry, wasteland	15-20
7	Manta	Nectaross, Roberta	IPM	kiwi, meadow, peach	5-10
8	Saluzzo	Flavorcrest, Roberta	SC	farm, meadow, peach	10
9	Savigliano	Duchessa d'Este	IPM	apple, hedge, pear	5-15

RESULTS

Lygus rugulipennis completed three generations per year and overwintered as an adult at the base of weeds and in earth cracks. In spring, the overwintered adults, which were predominantly female, flew to herbs and winter cereals where the laid eggs. Nymphs of the 1st generation appeared at the end of April and completed their development on the plants on which they hatched. Adults emerged from the beginning of June and moved from the nearly-ripe cereals to herbaceous weeds, where they then laid eggs. Nymphs of the 2nd generation appeared at the end of June and reached their highest density in mid-July. During this period, adults of both 1st and 2nd generations were present, both showing a 1:1 sex ratio. Nymphs of the 3rd generation appeared at the beginning of August and continued to hatch until early September. However, these later nymphs had a longer developmental period. As a result, nymphs were found in the field up until the beginning of November. The life-cycle of *L. rugulipennis* in the area of Saluzzo during 1992-1994 is given in Figure 1.

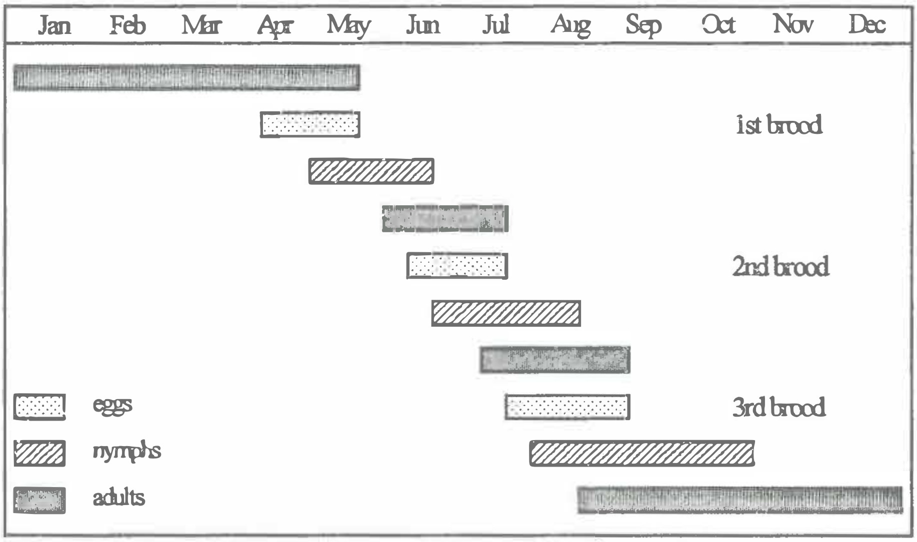

Figure 1. Biological cycle of *Lygus rugulipennis* Poppius in northwestern Italy

In spring, adult *L. rugulipennis* are concentrated mainly on winter cereals. In the area of Saluzzo, where peach orchards are especially abundant, adult *L. rugulipennis* of the 1st generation move from the nearly-ripe cereals to the weeds between the rows of fruit trees from mid-June to early-July. These individuals can also feed and lay eggs on any peach trees they encounter. The feeding punctures made by mirids result in a number of characteristic symptoms on the damaged peaches, including cat-facing, scarring, water soaking and gummosis.

In the peach orchards investigated in 1992 it was observed that mirids preferred the herbaceous weeds and only moved onto peach trees when these usual host plants were lacking. From a total sample of 1,615 mirids (936 adults and 679 nymphs) collected from two orchards where this ground cover was retaind throughout the season, only 5 adults were collected from the peach trees themselves.

The effects of mowing alternate rows, as a method of managing orchard weeds during 1994, are given in Table 2. The majority of *L. rugulipennis* were collected during early-July. This abundance corresponded with the movement of 1st generation adults from cereals, meadows or orchard weeds which had just been mown. During each survey, fruit-damage was observed on the lower branches which were in close contact with the weeds. At harvest, the highest levels of damage, found in orchards no. 4 and 5 (Table 2), were the result of the high proportion of damaged peaches found at the orchard margins adjacent to a wheat field and a kiwi orchard where weeds were continuously mown.

Table 2. Mirids sampled during surveys and damage to peaches checked at harvest in 1994

NO.	SAMPLED MIRIDS			DAMAGED PEACHES			
	07.06	05.07	02.08	CULTIVAR	HARVEST DATE	SAMPLE SIZE	%
1	9	16	51	Venus	17.08	28,160	0.0
2	16	6	3	Glohaven	04.08	650	0.6
3	23	12	(*)	Redhaven	19.07	2,000	0.4
				Glohaven	27.07	1,000	0.2
4	1	32	5	Stark Red Gold	04.08	26,410	0.0
				Roberta	31.08	604	3.8
5	24	52	7	Nectaross	09.08	531,000	2.3
				Stark Red Gold	19.08	9,326	3.3
6	10	(*)	(*)	Spring Red	27.06	1,100	0.6
7	13	24	0	Nectaross	12.08	1,000	0.0
				Roberta	24.08	63,600	0.4
8	17	41	7	Flavorcrest	03.08	300	1.0
				Roberta	02.09	1,250	0.2
9	22	52	49	Duchessa d'Este	24.08	1,680	0.2

(*) already harvested

CONCLUSIONS

Although *L. rugulipennis* prefers a warm and dry climate, it is spread all over the Palaearctic region (Erdélyi & Benedeck, 1974). However, the number of generations changes according to the latitude. This mirid can complete three generations per year in northwestern Italy, whereas it is bivoltine in England (Southwood, 1956) and univoltine in Finland where its abundance varies greatly from year to year and is generally higher after warm summers and dry autumns and springs (Varis, 1995).

Lygus rugulipennis is a very polyphagous species, probably attracted by the nitrogen content of its hosts. In fact, it feeds preferentially on flower buds and apical meristems which are organs with a high nutritive value (Holopainen & Varis, 1991). Damage to crop plants resulting from this feeding activity have been frequently recorded on alfalfa, clover, potato, cereals and sugarbeet in several European countries (Holopainen & Varis, 1991). In addition, this mirid has occasionally produced injuries to fruit trees in Italy. While Cravedi & Carli (1987) found *L. rugulipennis* and a number of other phytophagous Hemiptera in peach orchards,the present study has identified this species as solely responsible for fruit-damage in the investigated area.

After completing the 1st generation on cereals, weeds or other crops, e.g. alfalfa, onion, carrot and strawberry (Culatti *et al.*, 1992), newly emerged adults search for ovipositon sites on new host plants, favouring above all herbs which are in flower or approaching the flowering stage. During this period, *L. rugulipennis* can move into orchards, but it rarely moves onto peach trees provided there is good ground cover. Therefore, effective management of orchard weeds during this critical period is important in preventing *L. rugulipennis* from damaging fruits.

In North Carolina, where the closely related mirid *L. lineolaris* (Palisot de Beauvois) is a major pest on peach, it was observed that once *Lygus* was present on orchard weeds, mowing the vegetation increased the levels of mirid damage to fruits as insects moved from the ground and into the trees (Killian & Meyer, 1984). In the investigated area, damage to peach was caused mainly by the feeding activity of *L. rugulipennis* adults which rarely oviposited on trees, although they were able to do so. This was also the case for *L. lineolaris* in apple orchards in Canada (Boivin & Stewart, 1983). Moreover, levels of fruit-damage were independent of mirid density, peach cultivar and control method.

The research conducted during 1994 demonstrated that mowing the weeds between alternate rows of orchard trees reduced the movement of *L. rugulipennis* onto peach branches, thereby providing a good method of controlling mirid damage to peach fruits and an environmentally-sound alternative to insecticide treatments.

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IOBC/WPRS Working Group Meeting "Integrated plant protection in stone fruit"
Zaragoza (Spain) 24-26 September 1996

EFFECT OF TEMPERATURE ON THE EGG DEVELOPMENT OF *CERATITIS CAPITATA* WIEDEMANN (DIPTERA: TEPHRITIDAE) IN THE FIELD AND UNDER CONTROLLED CONDITIONS

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ABSTRACT - Egg development and survival of the mediterranean fruit fly, *Ceratitis capitata* Wiedemam, was studied under 16 different constant temperatures in the laboratory and under naturally-fluctuating temperatures in the field. *Ceratitis capitata* has a large temperature range over which embryonic development can be completed with a high survival rate. Provided average field temperatures remained between 13.3 to 19.5 °C, their effect on egg survival was considered equivalent to the effect of constant temperature within this range. Below 13.3 °C the mortality rate increases steeply with decreasing temperature. The lower threshold for survival was estimated experimentally at 9 ± 0.2 °C and the upper at 38.6 ± 0.5 °C. The rate of development of *C. capitata* eggs was strongly dependent on temperature. Different functions were fitted between temperature and development rate and applied to the data from laboratory and field experiments. The temperature at which the development rate under both field and laboratory conditions was equal was estimated at 17.9 °C. Experimental constants were calculated from the field data (K = 40.56 ± 2.66 day-degrees) and the data obtained at constant temperatures (K = 35.41 ± 6.85 day-degrees).

INTRODUCTION

The single most important abiotic factor influencing the development of different stages of an insect's life-cycle is temperature. While numerous studies have addressed the relationship between temperature and the development rate and survival of different life stages of *C. capitata*, the majority of them have been conducted at constant temperatures (Bodenheimer, 1951; Messenger & Flitters, 1958; Shrouky & Hafez, 1979; Muñiz & Gil, 1984; Del Rio *et al.*, 1986; Crovetti *et al.*, 1986; Laborda *et al.*, 1990; Conti, 1990).

Information regarding the development of insect life stages under different temperature regimes is an essential component of many modern pest management strategies. Such information can be used to estimate important parameters of pest phenlogy, such as the number of generations in a particular geographical area, the expected timing of each generation, or even the timing of a particular stage in the life-cycle (Fletcher & Kapatos, 1982; Ros, 1982; Tassan *et al.*, 1982; Meats, 1984).

In this study we estimated the effect of fluctuating temperature in the field and a range of constant temperatures in the laboratory on the development rate and survival of *C. capitata* eggs. The models obtained under laboratory conditions were compared to those obtained under field conditions in order to determine which was most appropiate for predicting mortality, rate of development and temperature parameters (thermal constant and survival thresholds) for the eggs of *C. capitata*.

MATERIALS AND METHODS

Ceratitis capitata eggs were obtained from the culture maintained in the entomological laboratory at IVIA (Instituto Valenciano de Investigaciones Agrarias), as described by Arroyo *et al.* (1967) and Albajes & Santiago-Álvarez (1980). The culture had been continuously reared for two years. In order to maintain the quality of the culture as close as possible to that of wild flies, wild males (obtained from fruit collected in the field) were periodically mated with laboratory-reared females.

For use in assays, a known number of eggs were placed in Petri-dishes containing a 3 mm thick layer of water agar. The eggs for each replicate were collected within 3 hours, with the egg placement procedure lasting an additional 2 hours. Thus, at the start of each experiment the eggs were 3-5 hours old.

CONSTANT TEMPERATURES

Sixteen different constant temperatures were used (Table 1). These temperatures were used sequentially until the maximum and minimum thresholds for survival were calculated. Experiments were performed in small temperature chambers with temperature control of ± 0.5 °C, a photoperiod of L:D 12:12 hours and relative humidity in excess of 90%.

A total of 3,000 *C. capitata* eggs were tested at each temperature (three replicates of 10 Petri-dishes, each containing 100 eggs). The number of hatched eggs was recorded every 24 hours. The number of days until hatch (Y) and mortality rate (%) were also recorded. Eggs were considered hatched once the larva had abandoned the chorion. Larvae which were able to rupture the chorion but unable to emerge from it and were recorded as dead. Experiments were ended once hatching had ceased for a period of 7 days.

FIELD EXPERIMENTS

To determine the rate of development of *C. capitata* eggs under field conditions, the Petri-dishes containing the eggs were placed in plastic boxes (to avoid evaporation, ant predation and contamination by pathogens) which were then hung outside in the shade provided by the canopy of an ornamental tree (*Schinus molle* L.). Six Petri-dishes, each containing more than 100 eggs, were used for each experiment. Another six replicates, prepared in the same way, were maintained in the laboratory under similar conditions (25 ± 2 °C, 65 ± 10 % R.H. and photoperiod L:D 12:12 hours) as controls.

To assess egg development in the field during winter we carried out 13 experiments with different starting dates ranging from late-September 1995 to early-April 1996 (Table 2). In an attempt to reduce the abrupt temperature change that eggs would experience when moved from the laboratory colony into the field, the experiments were started at 12:00.

Ambient temperature was recorded using the thermohygrograph at the institute meteorological station, which was located less than 20 m from the experimental sites. To calculate the thermal parameters, a sinoidal curve was fitted between the daily maximum and minimum temperatures (Allen, 1975; Tassan *et al.*, 1982; González & Hernández, 1990).

The rate of development (100/Y), the upper and the lower thresholds for egg survival and the thermal constant (degree-days, DD) were calculated from experimental data by fitting mathematical functions.

RESULTS

SURVIVAL AND MORTALITY RATES

In the controls, an average 96.4 % of eggs hatched successfully.

Table 1 shows the data recorded under constant temperatures. When the temperature was between 13.3 and 34.7 °C, egg mortality was less than 15 %. Less than 11 % mortality was found when the temperature was between 18.0 and 34.7 °C. The lowest mortality occurred at 28 °C (5.5%).

Survival rate decreased rapidly at temperatures below 13.3 °C and above 34.7 °C. At 10.3 and 36.7 °C egg survival was less than 30 %. Mortality increased to 100 % at 9.0 and 38.6 °C. Thus, the lower and upper thresholds for survival of *C. capitata* eggs were established at 9 ± 0.5 °C and 38.6 ± 0.5 °C respectively (Table 1). At these temperatures the embryonic development was interrupted, resulting in 100 % mortality (Fig. 1).

Table 2 shows the data from experiments conducted under field conditions. The lowest mean temperature was recorded in February.

Table 1. Effect of constant temperatures on survival rate and development rate of *C. capitata* eggs: experimental temperature (°C), number of egg used, survival rate (%), days until hatch (Y), development rate (100 /Y), and day-degrees accumulated above 9 °C.

TEMPERATURE °C	NUMBER OF EGGS	SURVIVAL RATE (%)	DAYS UNTIL HATCH (Y)	DEVELOPMENT RATE (100/Y)	MEAN DEGREES-DAYS
9,0 ± 0,5	6000	0	-	-	-
10,3 ± 0,3	3000	29,93 ± 7,94	17,89 ± 0,9	5,59	23,25± 1.22
13,3 ± 0,3	3000	85,03 ± 8,00	8,54 ± 0,69	11,71	36,72± 2.96
15,8 ± 0,5	3000	88,00 ± 2,69	5,00 ± 0,09	20,00	34,00± 0.61
18,0 ± 0,5	3000	89,50 ± 2,07	4,25 ± 0,44	22,22	38,25± 3.96
20,0 ± 0,4	3000	91,90 ± 1,11	3,72 ± 0,45	26,88	40,92± 4.95
22,0 ± 0,5	3000	92,16 ± 1,74	3,49 ± 0,50	28,65	45,37± 6.50
24,0 ± 0,5	3000	93,60 ± 5,40	3,06 ± 0,23	32,68	45,90± 3.45
26,0 ± 0,8	3000	93,80 ± 3,39	2,41 ± 0,49	41,49	40,97± 8.33
28,0 ± 0,3	3000	94,46 ± 1,00	2,00 ± 0,70	66,67	38,00± 13.30
30,0 ± 0,5	2800	92,17 ± 3,46	1,52 ± 0,49	65,79	32,13± 10.29
32,0 ± 0,6	3000	90,23 ± 3,24	1,33 ± 0,47	67,11	30,59± 10.81
34,7 ± 0,4	3000	92,26 ± 1,57	1,02 ± 0,14	98,04	26,01± 3.57
36,7 ± 0,4	3000	21,56 ± 3,35	1,01 ± 0,13	99,01	28,25± 3.60
37,6 ± 0,4	2800	3,64 ± 1,94	2,46 ± 0,49	40,65	70,36± 14.01*
38,6 ± 0,5	6000	0,00	-	-	-

(The value marked * was significatively different from the rest, and was excluded in calculating the thermal constant).

Figure 2 shows the relationship between mortality rate and mean temperature. When the mean temperature dropped below 9.8 °C, the mortality rate increased rapidly, although this data was inconsist due to the unusually warm weather during the winter of 1995-96. Above 9.8

°C, the mortality rate varied between 2.0 and 11.2 %.

Table 2. Effect of field temperature on survival rate and development rate of *C. capitata* eggs: date at start of each experiment, mean temperature (°C), survival rate (%), days until hatch (Y), development rate (100/Y), and degree-days accumulated above the threshold.

DATE	MEAN TEMP (°C)	NUMBER OF EGGS	SURVIVAL RATE (%)	DAYS UNTIL HATCH (Y)	DEVELOPMENT RATE (100/Y)	MEAN DEGREE-DAYS
26-sep	19,35	600	92,17± 2.38	4,07± 0.04	24,57	39,39± 0.58
2-oct	19,30	600	88,83± 3.17	4,07± 0.01	24,57	42,25± 0.00
13-oct	17,63	600	98,00± 1.21	4,00± 0.00	25,00	34,13± 0.00
27-oct	18,70	600	97,00± 0.86	3,90± 0.05	25,64	39,57± 0.58
7-nov	16,21	600	92,83± 2.93	5,67± 0.13	17,64	42,59± 0.96
15-dec	13,93	600	94,17± 0.72	9,75± 0.06	10,26	50,52± 0.53
21-dec	17,38	600	95,50± 0.80	4,00± 0.00	25,00	32,63± 0.00
11-jan	12,45	600	95,83± 2.38	10,00± 0.00	10,00	38,84± 0.00
9-feb	9,83	600	94,17± 2.30	14,98± 0.02	6,68	40,82± 0.00
14-feb	9,27	600	61,00± 3.53	19,46± 0.24	5,14	44,76± 0.48
20-feb	9.42	987	46,92± 10.45	17,81± 0.36	5,61	38,3± 2.75
7-mar	11,48	846	91,20± 13.99	12,00± 2.44	8,33	44,1± 3.68
2-apr	12,94	1251	95,39± 2.10	9,08± 0.13	11,01	39,39± 1.08

RATE OF DEVELOPMENT

Temperature/development rate curves were fitted to the data from both laboratory and field experiments.

For the laboratory experiments conducted at constant temperatures, the straight line ($100/Y = -41.84 + 3.61*T$), the logistic curve ($100/Y = 215.26/(1 + \exp(4.41 - T*0.19))$) and the polynomial function ($100/Y = 0.29 + 1.47*T - 0.12*T^2 + 0.006*T^3 - 0.00063*T^4$) were fitted to the data. The regression coefficients for each of these equations were 92.18%, 98.14% and 98.03% respectively.

The same functions were fitted to the data obtained from the field experiments. The regression coefficients were 93.38% for the straight line ($100/Y = - 15.84 + 2.16*T$), 94.70% for the logistic curve ($100/Y = 34.39/(1 + \exp(4.57 - 0.30*T))$) and 98.46% for the polynomial function ($100/Y = -808.7 + 247.2*T - 27.6*T^2 + 1.35*T^3 - 0.024*T^4$).

The best regression coefficient for both the field and the laboratory data was obtained using the polynomial function. However, this type of function is difficult to interpret biologically and, although adjusted conveniently to the mean data, the observed values towards the upper and lower end of the temperature scale were different to those predicted by the polynomial (Fletcher & Kapatos, 1982). To improve accuracy, a six degree polynomial function was fitted, although this did not simplify the biological interpretation.

The sigmoid curve has been used extensively (DelRio *et al.*, 1986; Conti, 1990) and gave good regression coefficients with the data from this study. However, when the lower threshold was calculated (4.41 °C at constant temperatures and 4.57 °C at field temperatures) the result obtained was very different to our experimental data (Tsitsipis, 1979; Fletcher & Kapatos, 1982).

When a straight line was fitted to the data (Bodenheimer, 1951; Tsitsipis, 1979; DelRio *et al.*, 1986; Conti, 1990) the regression coefficients were still good, the biological interpretation was simple and the lower thermal threshold calculated from these functions (11.59 ° C at the constant temperatures and 7.33 ° C at the field temperature, Fig. 3) was very close to that suggested by our laboratory experiments (9 °C).

DURATION

In order to compare our results with those obtained previously by other authors, the duration of egg development was related to temperature by fitting hyperbolic functions (Fig. 4). Fitting a rectangular hyperbola resulted in the function Y = -0.62 - 7.07/(1-0.13*T) for the constant temperatures (regression coefficient 99.00 %) and Y = -4.33 -32.29/(1-0.26*T) for the field temperatures (regression coefficient 97.26%). Using a Blunk-Bodenheimer hyperbola resulted in the function Y = 43.18/(T-7.89), r^2 = 99.00 % for the constant temperatures and Y = 58.75/(T - 6.20), r^2 = 96.33% for the field temeperatures.

The lower threshold and thermal constant predicted for the laboratory experiments from the Blunk-Bodenheimer hyperbolas were 7.89 °C and K = 43.17 DD respectively. These values differed only slightly from those obtained in laboratory, where egg development ceased at 9 °C. This function predicted development time very accurately within the range of temperatures where egg survival was high. Towards the upper range of temperatures the duration of egg development increased at 37.6 °C before ceasing at the experimental threshold of 38.6 °C. The threshold and thermal constant obtained from the field data using the Blunk-Bodenheimer hyperbola were 6.2 °C and 58.75 DD respectively.

THERMAL CONSTANTS

The thermal constant was calculated for each experiment by thermal summation K = Y*(X-T), where T is the lower threshold and Y is the duration of the development (days until hatch) at temperature X.

Tables 1 and 2 show the respective data obtained under constant and fluctuating (field) temperatures. The experimental threshold of 9 °C was used to compare them.

The mean experimental K obtained with constant temperatures was 35.41 ± 6.85 DD, which is similar to that obtained by other researchers working at constant temperatures, e.g. Muñiz & Gil (1984) obtained 30.75 DD, DelRio *et al.*(1986) obtained 31.2 DD. The data in the present study was derived from from a wider temperature range and with higher numbers of eggs than were used in these previous studies.

The thermal constant obtained from field data was K = 40.56 ± 2.66 DD. This was higher than the K-value calculated from the constant temperature data (K = 35.41 DD) and that obtained by other authors, e.g. Muñiz & Gil (1984) 30.75 DD, DelRio *et al.* (1986) 31.2 DD. However, it was lower than that calculated using the line regression (K = 45.03 DD) and that obtained using the Bodenheimer hyperbola (K = 61.40 DD).

CONCLUSIONS

The data presented in Table 1 and 2 show that below a constant temperature of 10.3°C and field conditions of 9.4 °C the mortality rate increased rapidly, reaching 100 % at a constant temperature of 9 ± 0.5 °C. Above an average field temperature of 10 °C, or 13°C constant temperature, the mortality rate was less than 15 %. In the laboratory, where high temperatures were tested, it was demonstrated that the mortality rose again at 36.7 °C, with values of 80 % and up to 100 % at 38.6 ± 0.5 °C, where the experimental upper threshold was established.

Fig. 1: Embryonic development of *C. capitata:* Relation between mortality rate and constant temperatures.

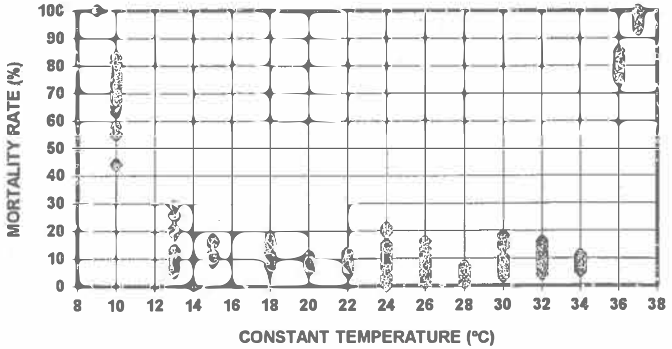


Fig. 2: Embryonic development of *C. capitata:* Relation between mortality rate and average field temperatures.

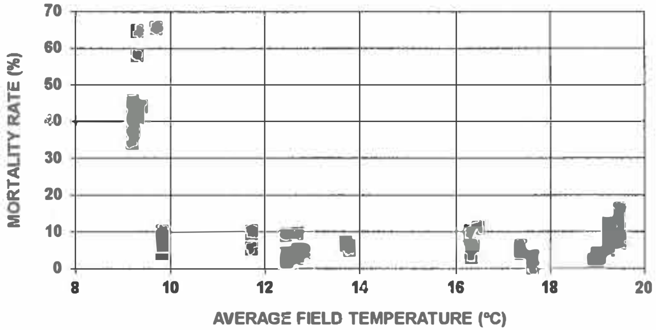


Fig. 3: Embryonic development of *C. capitata:* Relation between development rate with field and constant temperatures.

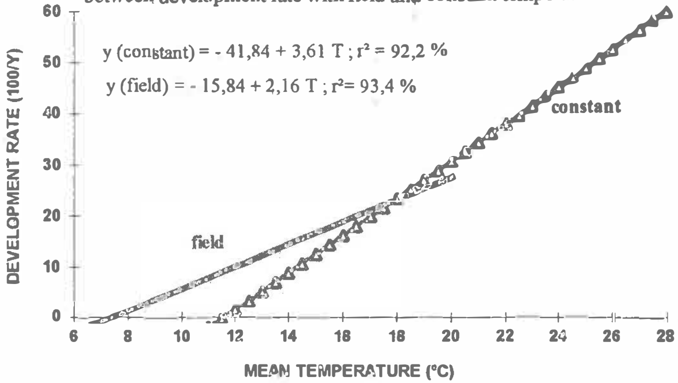
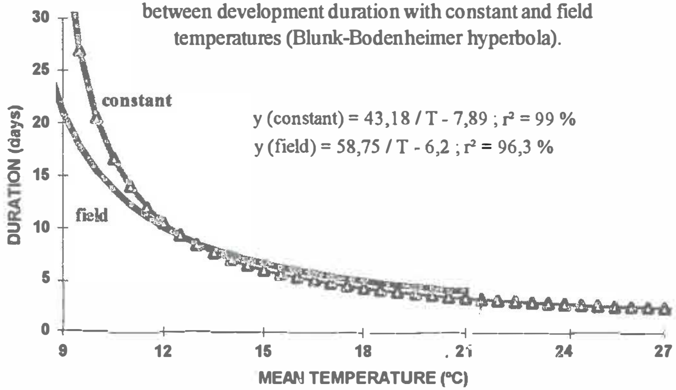


Fig. 4: Embryonic development of *C. capitata.* Relation between development duration with constant and field temperatures (Blunk-Bodenheimer hyperbola).



Thus, *C. capitata* has a large temperature range over which embryonic development can be completed with a high survival rate. Provided the average temperature in the field remained between 13.3 and 19.5 °C (upper temperature was not registered in the field), the effect on egg survival can be considered equivalent to the effect of constant temperatures (Figs. 1 and 2). Between 9.8 and 13.3 °C the survival rate was higher at average field temperatures than at constant temperatures.

The rate of development of *C. capitata* eggs is strongly dependent on temperature. This relationship, for both the fluctuating field temperatures and the constant temperatures, can be expressed as a straight line. The temperature at which the development rate is equal under both field and laboratory conditions is estimated at 17.9 °C (Fig. 3).

The duration of development was similar for both field and laboratory experiments. The Blunk-Bodenheimer hyperbola provided a relatively accurate description of the relationship between duration and temperature in both cases (Fig. 4).

The experimental constants calculated from field temperatures (K = 40.56 ± 2.66 day-degrees) and constant temperatures (K = 35.41 ± 6.85 day-degrees) differ significantly (Student's t test, confidence interval = 95 %), although they are close to those calculated in previous studies (Bodenheimer, 1951; Muñiz & Gil, 1984; Del Rio *et al.*, 1986).

The lower and upper temperature thresholds for egg survival were established experimentally at 9 ± 0.5 °C and 38.6 ± 0.5 °C respectively. In field experiments the average temperatures did not fall as low or rise as high as these respective values, as a result the experimental threshold could not be estimated. However, the data did indicate that average temperatures slightly higher than 9 °C (9.27 °C and 9.42°C) were close to the survival threshold.

The lower threshold (9 ± 0.5 °C) was less than those predicted by McBride (1935), Bodenheimer (1951) and Del Rio *et al.* (1986) (11.1 °C, 10.5 °C and 11.30 °C respectively), but closer to the lower threshold of 9.7 °C estimated by Shrouky and Hafez (1979).

The upper threshold of 38.6 ± 0.5 °C was similar to the mathematically estimated values obtained by Muñiz & Gil (1984) and Del Rio *et al.* (1986) (39.3 °C and 39 °C respectively).

ACKNOWLEDGEMENTS

We thank M.J.Verdú (IVIA) for providing access to constant temperature chambers and other facilities during the course of this project, also we thank E. Carbonell (IVIA) for assisting with experiments and H. Schweizer (U.C. Riverside) for his critical review of the manuscript.

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OILB/SROP Reunion du Groupe de Travail "Protection intégrée en vergers de fruit à noyau"
Zaragoza (Espagne) 24-26 September 1996

ETUDE DU CYCLE BIOLOGIQUE DE LA COCHENILLE BLANCHE DU PÊCHER *PSEUDAULACASPIS PENTAGONA* (TARGIONI-TOZZETTI) (*HOMOPTERA, DIASPIDIDAE*) ET SES ENNEMIS NATURELS EN EMILIE-ROMAGNE (ITALIE)

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RÉSUMÉ - La Cochenille blanche du pêcher *Pseudaulacaspis pentagona* est en recrudescence en verger de pêchers en Emilie-Romagne. En vue de mettre en place une stratégie de lutte intégrée, l'INRA a établi le cycle biologique de ce ravageur et a pu ainsi d'une part déterminer les périodes favorables aux lâchers d'auxiliaires et d'autres part préciser les périodes où la Cochenille est le plus sensible aux pesticides dans cette région d'Italie. Les ennemis naturels de *P. pentagona* ont été répertoriés; parasitoïdes et prédateurs sont présents mais nous constatons une forte proportion d'hyperparasites, très marquée par la présence de *Ablerus perspeciosus*.

INTRODUCTION

L'Italie est le premier producteur de pêches et de nectarines en Europe avec 1500000 tonnes. L'Emilie-Romagne est une des régions les plus productrices, elle comprend 34300 ha de pêchers dont 6550 ha en lutte intégrée.

En 1995, la société BIOLAB, spécialisée dans la production et la commercialisation d'agents biologiques, contacte l'INRA d'Antibes dans le but de mettre en place un pilote de production d'auxiliaires pour lutter contre la Cochenille blanche du pêcher, *Pseudaulacaspis pentagona* Targioni-Tozzetti (*Homoptera, Diaspididae*) en recrudescence depuis quelques années en Italie du Nord et dans le Sud de la France. Avant la mise en place d'un élevage d'auxiliaires, le cycle biologique du ravageur, ici la Cochenille, doit être étudié afin d'utiliser à bon escient ces auxiliaires: apprécier les périodes de lâchers correspondant à la présence du stade favorable au parasitisme, dresser un inventaire des ennemis naturels rencontrés en vergers de pêchers et connaître leur impact sur les populations de cochenilles.

TECHNIQUES ET MÉTHODES

Trois parcelles sont retenues pour suivre l'évolution de la Cochenille et pour inventorier les ennemis naturels. La première parcelle se situe dans la localité de Classe, en limite de la zone des vergers de pêchers d'Emilie-Romagne, adjacente à la zone de culture du pommier. On y retrouvera d'ailleurs la présence de *Diaspidiotus perniciosus* (*Homoptera, Diaspididae*), le Pou de San José. La deuxième parcelle retenue se situe dans la localité de Ravenne; proche du bord de mer, elle subit de façon plus importante, une influence maritime. La troisième parcelle est située dans la partie sud de la région, plus exactement dans la localité de Cesena.

Des rameaux de pêchers et de mûriers sont expédiés au Laboratoire de Biologie des Invertébrés à Valbonne tous les quinze jours.

Le dénombrement des cochenilles se fait sous loupe binoculaire et un minimum de cinq cents cochenilles par rameau est compté afin de dénombrer les différents stades de développement et d'établir, de façon précise, le cycle biologique de la Cochenille.

A chaque comptage, le bouclier des femelles adultes est soulevé pour vérifier si l'insecte est mort ou vivant, s'il est au stade de ponte et s'il est parasité.

Après le dénombrement, les rameaux sont immédiatement placés en éclosoir à 25°C, tous les parasitoïdes et prédateurs émergeants sont récoltés et mis en tube dans l'alcool à 70° pour détermination.

RÉSULTATS ET DISCUSSION

LE CYCLE BIOLOGIQUE

La femelle de *P. pentagona* présente deux stades larvaires et un stade adulte que nous avons divisé en trois âges selon des critères morphologiques précis: l'âge jeune femelle aux lobes abdominaux bien visibles, l'âge femelle gravide à l'abdomen gonflé et l'âge femelle pondeuse avec la présence des premiers oeufs. Le mâle présente deux stades larvaires, deux stades préimaginaux (la pronymphe et la nymphe) et un stade adulte qui, contrairement à la femelle, est ailé. En 1955, Monti étudie le cycle biologique de *P. pentagona* sur mûrier et constate que la Cochenille présente trois générations par an.

a) Les localités de Cesena et de Classe

Dans les localités de Classe et de Cesena, les femelles hivernantes commencent à pondre début avril et les larves de premier stade émergent une semaine après la présence des premiers oeufs pendant environ un mois. Le deuxième stade larvaire femelle est présent du mois de mai jusqu'à la première semaine de juin. Le stade adulte est le plus long: il apparaît vers la mi-mai et les dernières femelles pondeuses meurent vers la fin du mois de juillet. Les stades favorables au parasitisme par *Encarsia berlesei* (*Hymenoptera, Aphelinidae*) sont le deuxième stade larvaire et surtout l'âge jeune femelle présent, en première génération, de la mi-mai à la fin juin.

La deuxième génération débute avec la présence des premiers oeufs des femelles de la première génération. La ponte semble durer tout le mois de juillet et l'apparition des larves mobiles se situe vers la fin de la première semaine de juillet. Le deuxième stade larvaire femelle commence fin juillet pour finir dans la dernière semaine d'août. A la fin de la première semaine d'août, nous observons les premières jeunes femelles qui vont évoluer en femelles gravides. A ce niveau, nous avons observé que la cohorte de femelles gravides ne se comporte pas de façon homogène: une très faible proportion de femelles (les plus précoces) va évoluer en femelle pondeuse et donner une troisième génération qui débute vers la mi-septembre; les individus vont se développer et hiverner en femelle gravide, au mois de novembre. La majorité des femelles gravides ne va pas évoluer en femelle pondeuse et va donc hiverner sous cet état, ne donnant pas de troisième génération, les conditions abiotiques du milieu ne permettant pas d'atteindre l'âge femelle pondeuse.

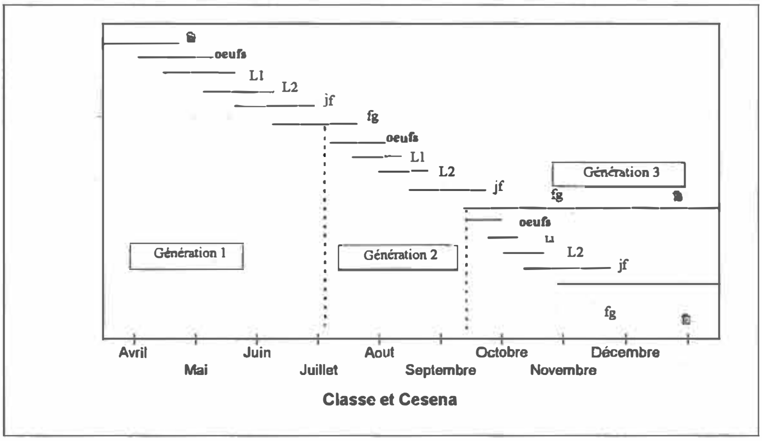

Figure 1 - Cycle biologique de *P. pentagona* femelle dans les localités de Classe et de Cesena (fh: femelle hivernante, oeufs: oeufs pondus, L1: larve de premier stade, L2: Larve de deuxième stade, Jf: jeune femelle, fg: femelle gravide).

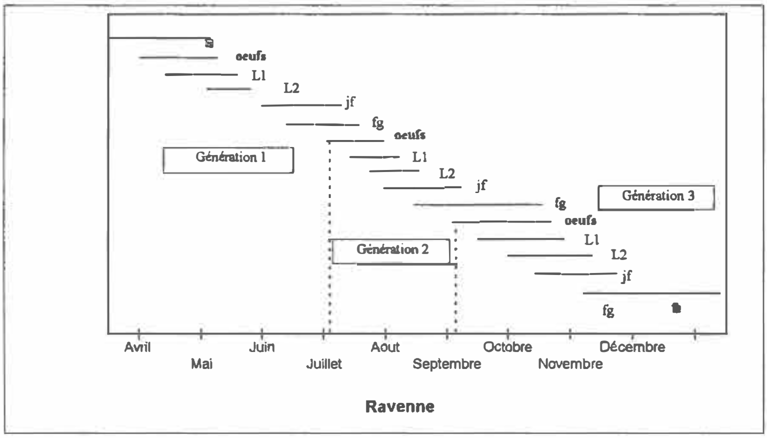

Figure 2: Cycle biologique de *P. pentagona* femelle dans la localité de Ravenne (fh: femelle hivernante, oeufs: oeufs pondus, L1: larve de premier stade, L2: Larve de deuxième stade, Jf: jeune femelle, fg: femelle gravide).

b) La localité de Ravenne

Le développement des femelles de *P. pentagona* est sensiblement le même dans la localité de Ravenne que dans les deux autres localités. Toutefois, il semble que la totalité des femelles de la deuxième génération donne une descendance qui se développe jusqu'à l'âge femelle gravide et qui hiverne jusqu'à la saison suivante sous cette forme.

c) Périodes favorables aux traitements

- Traitements chimiques.

L'objectif de cette étude est d'établir le cycle biologique du ravageur en vue d'une lutte biologique. Ce travail est aussi un outil indispensable dans le cadre d'une lutte chimique raisonnée. Il permet de cibler les périodes durant lesquelles la Cochenille est plus sensible aux pesticides. Toutefois, il n'est pas question, ici, de préconiser une méthode de lutte chimique plutôt qu'une autre.

Pour les localités de Classe et de Cesena et dans le cadre d'une lutte chimique raisonnée, la période la plus favorable se situe, pour la première génération, de la mi-avril à la mi-mai, période qui correspond à la sortie des larves mobiles du bouclier maternel. Pour la deuxième génération, la période où l'insecticide utilisé sera le plus efficace se situe dans la deuxième quinzaine de juillet, et pour la troisième génération, il faudra envisager de traiter vers la fin septembre.

Pour la localité de Cesena, les périodes diffèrent de quelques jours, à savoir que la période la plus favorable en première génération se situe de la mi-avril à la mi-mai. En deuxième génération, il est préférable de traiter à la mi-juillet et pour la troisième, le traitement pourra se faire de la mi-septembre à la mi-octobre.

- Traitements biologiques

Dans l'hypothèse d'une mise en place de production d'auxiliaires, les périodes de lâchers peuvent être programmées. La période de lâchers la plus favorable de *E. berlesei* correspond au stade femelle et plus exactement à l'âge jeune femelle. Toutefois, cet aphélinide pond aussi dans des larves femelles de deuxième stade et dans des femelles gravides, ce qui permet de faire des lâchers de cet auxiliaire sur une grande période. On le rencontre de façon très occasionnelle dans des larves de deuxième stade mâle et si le cas se présente, les individus émergent de la pronymphe de la Cochenille et donnent des parasitoïdes de taille réduite.

Les périodes les plus favorables aux traitements biologiques à l'aide de *E. berlesei* pour les localités de Classe et de Cesena et de Ravenne sont:

- en première génération: tout le mois de juin et quelques lâchers peuvent être envisagés dès la fin du mois de mai.
- En deuxième génération: de la mi-août à la mi-septembre.
- Pour la troisième génération, le traitement biologique n'est pas recommandé car les températures trop fraîches diminuent fortement les potentialités du parasitoïde.

Pour la localité de Ravenne les lâchers peuvent être envisagés quelques jours avant, compte tenu du léger décalage que l'on peut observer (figures. 1 et 2).

INVENTAIRE DES ENNEMIS NATURELS

La récolte des insectes issus des éclosoirs est faite de façon quotidienne. Chaque individu est immédiatement isolé et identifié.

Parasitoïdes primaires:

- *Encarsia berlesei* (Howard) (*Hymenoptera, Aphelinidae*).

Cet hyménoptère, endoparasite, est très présent dans les vergers des trois localités. Il est très difficile d'établir un taux de parasitisme, mais on peut tout de même dire que ce parasitoïde est prépondérant par rapport aux autres espèces.

E. berlesei a connu un grand succès en lutte biologique contre *P. pentagona* sur mûrier au début du siècle, notamment en Italie (Clausen, 1978). Il est aujourd'hui présent un peu partout dans le monde excepté sur le continent africain (Balachowsky, 1954; Benassy, 1954; Rubtov, 1957; Collins et Whitcomb, 1975; Habbibian, 1980; Stimmel, 1982; Kozár *et al.*, 1988; Hanks & Denno, 1993).

- *Aphytis proclia* (Walker) (*Hymenoptera, Aphelinidae*).

A. proclia, hyménoptère ectoparasite, est présent dans les trois localités. Son action contre la Cochenille est complémentaire à celle de *E. berlesei.* Ce parasitoïde est présent en Europe, aux Etats-Unis et en Asie du Sud-Est (Suire, 1948; Bennett, 1956; Benassy, 1958; Collins et Whitcomb, 1975; Garonna *et al,* 1988; Hanks et Denno, 1993).

<u>Prédateurs:</u>

- *Rhizobius satelles* (Blaisd.) (syn: *lophantae*) (*Coleoptera, Coccinellidae*).

Cette coccinelle est présente en grand nombre dans les trois localités et semble avoir un grand pouvoir de prédation sur *P. pentagona* car, au cours des comptages, nous avons souvent retrouvé des larves de *R. satelles* sous les boucliers en train de s'alimenter.

Cette coccinelle a fait l'objet de plusieurs introductions différentes parties du monde afin de compléter l'efficacité d'*E. berlesei* (Clausen, 1978).

- *Chilocorus bipustulatus* (L.) (*Coleoptera, Coccinellidae*).

C. bipustulatus est présente dans les trois localités. Toutefois peu d'individus sont sortis des éclosoirs et peu de larves ont été observées lors des comptages. Cela serait dû au fait que cette coccinelle est extrêmement polyphage. On peut la retrouver sur d'autres familles de cochenilles, à l'inverse de *R. satelles* qui a une préférence marquée pour les *Diaspididae*. Elle est présente sur *P. pentagona* en Asie et en Europe (Suire, 1948; Monti, 1955; Habibian, 1980; Kozár & Kosztarab, 1988).

- *Cybocephalus rufifrons* Reitter *(Coleoptera, Cybocephalidae)*.

Ce coléoptère a une action prédatrice qui complète celle des coccinelles dans les trois localités. En 1955, Monti signalait déjà sa présence en Emilie-Romagne. Selon Kozár et Kosztarab (1988), on le retrouve en Europe de l'Est.

- *Arthrocnodax diaspidis* Kieffer (*Diptera, Cecidomyiidae*).

Ce diptère prédateur n'a été retrouvé que dans les éclosoirs de Ravenne. Il est signalé en Italie en 1920 par Leonardi et par Hanks et Denno (1993) en Afrique. Son action prédatrice est peu étudiée.

<u>Parasitoïdes secondaires</u>

De nombreux hyperparasites ont émergé des éclosoirs.

- *Ablerus perspeciosus* (Girault) *(Hymenoptera, Aphelinidae*).

Cet hyménoptère est hyperparasite d'*E. berlesei* et d'*A. proclia*. Il est présent en nombre important dans les trois localités. Il est signalé en Europe, en Asie et aux Etats-Unis (Balachowsky, 1954; Garonna *et al.*, 1988; Hanks et Denno, 1993). De nombreux auteurs l'ont signalé comme parasitoïde primaire.

- *Zoamma lambinus*(*Walker*) (*Hymenoptera, Encyrtidae*).

Quelques spécimens de *Z. lambinus* ont été récoltés dans les éclosoirs des trois parcelles étudiées. Sa présence n'avait jamais été signalée en Europe Occidentale et *a fortiori* en Italie. Comme pour *A. perspeciosus,* certains auteurs l'ont décrit comme parasitoïde primaire (Park et Kim, 1991). Il semble être un hyperparasite d'*E. berlesei.*

- *Thysanus ater* Haliday (*Hymenoptera, Signiphoridae*).

Hyperparasite, bien que cité comme parasitoïde primaire par certains auteurs notamment Ortega (1956) sur *Parlatoria oleae* (Colvée) (*Homoptera, Diaspididae*). C'est sur le site de Cesena que quelques individus ont été récoltés.

CONCLUSIONS

L'étude du cycle biologique de *P. pentagona* nous renseigne sur les périodes d'intervention et évite, dans le cadre d'une lutte chimique raisonnée, de traiter hors des périodes sensibles de la Cochenille. Si un pilote de production se mettait en place, permettant ainsi un traitement biologique, deux périodes seraient favorables aux lâchers.

Toutefois, on constate que dans la région, *P. pentagona* présente trois générations par an, tandis que dans des régions situées plus à l'intérieur des terres, la Cochenille ne développe plus que deux générations complètes à l'exeption de quelques femelles qui donnent une troisième génération.

Il est donc indispensable, avant de mettre en place un programme de lutte chimique raisonnée, d'étudier le cycle biologique de la Cochenille afin d'éviter des traitements inutiles. La mise en place d'un modèle prédictif pourrait éviter un travail aussi laborieux, mais pour l'heure, l'étude du cycle biologique reste le seul outil efficace.

L'efficacité d'*Encarsia* est limitée par deux facteurs: les traitements chimiques et l'action des hyperparasites.

C'est pourquoi dans le cadre d'une lutte biologique contre la Cochenille, les populations d'*Aphelinidae* et de *Coccinellidae* devraient être renforcées tous les ans.

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IOBC/WPRS Working Group Meeting "Integrated plant protection in stone fruit"
Zaragoza (Spain) 24-26 September 1996

THE PROBLEM OF *MICROTUS (PITYMYS)* VOLES IN ITALIAN ORCHARDS

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ABSTRACT - In recent years, voles of the genus *Microtus* have caused serious damage in orchards (apple, citrus, plum, peach, apricot) all over Italy, with the exception of Sardinia. The voles gnaw the roots and the base of the trunk of young trees, killing them in a few days. The outbreaks were related to certain recent changes in cultural practice, particularly the introduction of permanent mulching and overhead or localised irrigation. An effective integrated control program is suggested, which includes strategies such as habitat manipulation, the use of suitable toxic baits and the maintainance of control.

INTRODUCTION

In the last 15 years, as fruit orchards have been planted in new areas and as a new irrigation and soil cultivation practices have been introduced, young trees have been subject to severe damage by voles (Rodentia, Microtinae) all over Italy, except on the island of Sardinia where these rodents are absent (Santini, 1977, 1986, 1988).

A single species, *Microtus (Pitymys) savii* De Sel. L., is responsible for attacks in nearly the whole of Italy, apart from the Adige Valley (Trento and Bolzano provinces) where *M. arvalis* Pallas is considered to be the pest species involved. *Microtus arvalis* is normally found in Central Europe (Werth, 1973).

DAMAGE TO ORCHARDS

Microtus savii is mainly a herbivorous species, with a marked fossorial behaviour.

The most evident symptom of its presence in orchards are the numerous round holes in the ground which are the openings to burrows. This factor is an important element to consider when it comes to controlling the pest.

Attacks occur mainly to apple trees and, in southern Italy, all citrus species. Recently, increasing levels of damage have affected plum, peach and apricot trees (see Fig. 1).

Damage occurs during winter, when grasses are scarce or completely lacking. The damage consists of large debarked areas of root and debarking at the base of the trunk, where annular band of bark are often completely removed just above ground level.

Because of the polyphasic activity of this species (Salvioni & Meylan, 1985), damage occurs by day as well as by night and within the space of 24 hours a single adult can cause sufficient damage to kill a tree.

Fig. 1 - Distribution of Italian orchards damaged by *Microtus* voles

It is proposed that the rapid outbreaks of vole infestation are due to several concomitants factors, listed below

1. CLIMATIC FACTORS. Higher than average rain-falls and cooler summer periods during the last 10-15 years have resulted in a greater availability of green feeds in June, July and August; the most critical period for this species.
2. PEDOLOGICAL FACTORS. The loose or mixed type soils which are usually chosen for fruit orchards are very favourable for the burrowing activity of voles.
3. AGRONOMIC FACTORS. Permanent grass cover, or soil ploughing only in inter-rows, and localised permanent irrigation create an habitat particularly favourable to the burrowing activity and permanent settlement of voles.
4. BIOETHOLOGICAL STRATEGIES. *Microtus savii* is a species which, despite a limited prolificacy, is capable of densely populating an orchard within a short space of time, by virtue of the following bioethological strategies (see Table 1) (cfr. Caroli & Santini, 1996):
   a) rapidly growing young which reach sexual maturity quickly;
   b) short pregnancies and inter-birth periods;
   c) capability of the oldest females to reproduce throughout the year;
   d) high levels of parental care, e.g. when threatened the mother transports the pups, which are firmly attached to the nipples, away from the perceived danger.

Table 1 - Developmental periods relating to the reproduction of *Microtus savii.*

Weaning	approximately 20 days
Days to sexual maturity	45 - 50 days (females) 75 - 80 days (males)
Length of pregnancy	22 days
No. offspring per birth	2
Duration of the inter-birth period	26 - 27 days
Possible number of births per year	~ 11
Reproductive activity	very low in summer increasing in autumn / winter highest in spring
Longevity (in nature)	1.5 - 2 years

CONTROL MEASURES

Until this study, no official recommendations existed in Italy for the control of voles in orchards. All control measures to date have been undertaken locally as the result of the farmer's own initiative, or at the suggestion of pesticide salesmen, usually without advice from a specialist technician. As a result, insecticides like aldrin, dieldrin, lindane, camphechlor, parathion and azinphos-methyl have been used indiscriminately to poison grass-cover. Dry baits, sold for rat and mouse control in domestic or urban areas, have also been distributed and used improperly. The inappropiate use of these products has had depressing effects on the local environment.

In an effort to remedy this situation, using the knowledge gained from recent experiences in some large orchards in central-southern Italy, we suggest an integrated control strategy for the control of voles in orchards. This is a strategy which can be effective, practical, economic and harmless for non-target species. The strategy is based on the following three components:

1) HABITAT MANIPULATION. Which means the removal, or reduction, of all opportunities for refuge and settlement by voles, both within and just outside orchards, by constant and careful soil cultivation and the removal of weeds from the cultivated surfaces.
2) USE OF SUITABLE TOXIC BAITS. Toxic baits are still necessary to resolve quickly any significant vole infestation and to stop (within 3-5 days) the damage in progress. To achieve effective results without danger to non target species, it is important to avoid the use of commercial formulations and instead prepare baits *de novo*; carefully choosing an appropriate active ingredient, the edible basis of the bait and the distribution technique.

   Active ingredients which must not be used include the "acute" rodenticides, which are highly toxic to non-target species. Among the first generation of "chronic" rodenticides (anticoagulants), Clorophacinone (0.005%) is the only compound registered for use in Italy against voles in the field since it is relatively safe if used correctly.

   For the edible basis of the bait we should take into account the fact that voles, during the late autumn and winter, favour cereal matter. Thus, whole bread wheat, also known as "tender" wheat grain, offers a stable, cheap and attractive edible base. This material also appears to be the safest as it is less easily taken by birds or larger mammals than any other formulation.

With respect to the distribution technique, the toxic baits must be placed in such a way that non-target species are unable to feed on them. The most satisfactory solution to date has been to distribute the bait directly inside the active holes which appear on the surface of an infested area. This can be achieved easily, without scattering any bait on the surface, by using a simple spoon made from a segment of bamboo cane.

The only way to confirm the effectiveness of the treatment is to close all the treated holes, using the shoe heel, four or five days after the first bait distribution. Within a further 3-4 days it is possible to spot any holes re-opened by surviving individuals and repeat the treatment where necessary. This whole process is repeated until there is a reasonable reduction in the population. It is important to note that the family groups of poisoned voles die underground in the nest chambers of burrows and not on the surface.

3) MANTAINING CONTROL. After clearing a heavily infested area, the vole population can be kept at reasonable levels if periodical surveys are conducted between late-September and late-March to check for any new infestations. If found, such infestations should be then treated specifically with the toxic bait.

CONCLUSIONS

When possible, it is always better to prevent vole infestations in orchards. This can be achieved successfully using an integrated control strategy which relies on a variety of ongoing techniques to prevent infestation and uses toxic baits only to eradicate the existing infestation and/or contain re-infestation from the surrounding area.

The safe use of toxic baits in open areas, within orchards, is not an ecological problem provided suitable materials and distribution techniques are carefully employed.

In addition, the timely and localised use of supplementary toxic bait and/or special traps could prove useful in removing small *foci* of re-infestation.

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IOBC/WPRS Working Group Meeting "Integrated plant protection in stone fruit"
Zaragoza (Spain) 24-26 September 1996

FIELD VALIDATION OF A DEVELOPMENTAL MODEL FOR *CYDIA FUNEBRANA* (TREITSCHKE)(LEPIDOPTERA: TORTRICIDAE) IN NORTHERN ITALY

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ABSTRACT - Initial results from the validation of a temperature-driven model for *Cydia funebrana* (plum fruit moth) in northern Italy are reported. The work was carried out in 1995 and 1996 in Emilia-Romagna. Having defined biological parameters in the laboratory, catches of male moths in pheromone traps and oviposition activity were monitored in orchards of mid- and late-ripening plum varieties. The model was then run using temperature data from each farm. When the oviposition activity forecast by the model was compared to that actually observed in three orchards, good correlations between actual and forecast oviposition were obtained, particularly where cumulative oviposition was between 30 % and 80 %. Actual oviposition generally occurred over a longer time period than predicted. It is proposed that in the near future, after further validation, the model will predict oviposition activity as a cumulative percentage and as a result technicians will be able to assess the risk of *C. funebrana* damage by sampling actual oviposition on just a single occasion.

INTRODUCTION

Monitoring *C. funebrana* (plum fruit moth) in northern Italy is problematic, largely because of the unreliability of pheromone traps when pest populations are low; a situation which occurs commonly in Emilia Romagna.

Previous research on the biology of *C. funebrana* in different areas of northern Italy has shown the presence of three oviposition periods per year (Molinari, 1995). In central and eastern Europe, where *C. funebrana* has been a serious pest for many years and the subject of extensive research, it has been shown to have just one or two generations per year.

In the Czech Republic, Hrdy *et al.* (1996) reported a strong correlation between cumulative temperature and catches of *C. funebrana* in pheromone traps. When more than 100 *C. funebrana* are caught per trap, it is possible to determine clearly the pattern of different flight periods. However, in Italy the numbers caught are usually lower and as a consequence a clear peak in flight activity is not apparent. Despite these low numbers fruit damage can still occur.

Weekly surveys of oviposition activity would provide the information needed to time the application of control measures exactly. However, monitoring on this scale is too time-consuming to be used as part of a routine management programme. Uusing temperature-driven models to forecast population dynamics would be one way of reducing the number of samples required, without increasing either the amount of chemicals applied or the risk of damage.

A laboratory for developing provisional models for agricultural pests was established in 1990 as part of the Integrated Fruit Production Programme of the Emilia Romagna Region. The pests currently being modelled include *Argyrotaenia pulchellana* Hw. and *Pandemis cerasana* Hb., *C. pomonella* L. and *Lobesia botrana* Den. & Schiff., *C. molesta* (Busck) and *C. funebrana* (Treitschke) (Butturini *et al.*, 1992; De Berardinis *et al.*, 1992a, b; Tiso *et al.*, 1992, 1993). These models are at various stages of completion. The present study is concerned with validating the model for *C. funebrana* in the field.

DESCRIPTION OF THE MODEL

Previous studies have used linear and non-linear models to predict the response of *C. funebrana* to temperature (Charmillot *et al.*, 1979; Baker, 1991; Kokourek *et al.*, 1995). In the present study, a distributed time delay model (Manetsch, 1976) was used.

The simulation is based upon the response to temperature of the different developmental stages of the pest. The equation described by Logan *et al.* (1976), which simulates the pathways of biochemical reactions catalysed by enzymes, provided an accurate mathematical representation of this response to temperature. This model has been developed into a personal computer program which is applicable to all Lepidoptera species with a similar behaviour. Distinctive parameters have to be defined for each species, in particular:

- parameters concerning the Logan curves of eggs, larvae and pupae;
- ageing rate of females;
- fecundity of females (in relation to age);
- H coefficient (represents the variability of each stage).

These parameters, together with temperature data, are entered into the model and then the resulting output details the age structure of the species, i.e. the percentage of individuals having reached each developmental stage.

METHODS AND MATERIALS

The first step of the research was to establish the biological parameters, then the resulting preliminary versions of the model could be validated in the field.

The parameters were determined by rearing the different stages of *C. funebrana* at 5 different constant temperatures, ranging from 14-34°C, with 70 % R.H. and a photoperiod L:D 17:7 hours. All the insects used were collected from the field to avoid changes in biology which can occur as a result of prolonged laboratory rearing. The larvae were fed on their natural diet and the adults were given water and honey. Oviposition was obtained on plums in the mating cages (Deseö, 1967).

All stages were individually reared, with data recorded daily, to assess variability.

The developmental rates (1/no. of days of duration) of eggs, larvae and pupae were fitted to the Logan curve; adult ageing was analyzed using a linear function and age-related fecundity was fitted to a Bieri curve, as conducted for other tortricids (Butturini *et al.*, 1992).

VALIDATION

The on-going validation of the model for *C. funebrana* is based on:

1) <u>comparison of forecast flights and pheromone trap catches</u>

Data were collected in 1994, 1995 and 1996 from plum orchards of a late-ripening cultivar. Two to three traps ("Traptest", Isagro) were placed in each plot. Catches of male moths were checked once or twice per week during the whole season.

The model was run on the basis of temperature data from each farm.

2) comparison of forecast and actual oviposition pattern.

Cydia funebrana oviposition was monitored in plum orchards (again, of a late-ripening cultivar) in 1995 (4 orchards) and 1996 (5 orchards during the whole season and 4 during the second generation only). In each plot, a number of branches on 10-15 trees, bearing 800-1000 fruits in total, were marked. No insecticide was applied to these trees. During the flight period, oviposition on the fruits present on marked branches was monitored at 5-day intervals. Any eggs found were marked and thereby not counted again. Meteorological data were recorded from each orchard. The cumulative percentage of eggs found in orchard samples was compared to that predicted by the model, which was obtained using local temperature data.

RESULTS

1) comparison of forecast flights and pheromone trap catches

From the flight curves it was difficulty to distiguish peaks of flight activity when catches were low (even with the highest catch of 184 males/trap), as found in previous studies (Molinari, 1995) (Fig. 1).

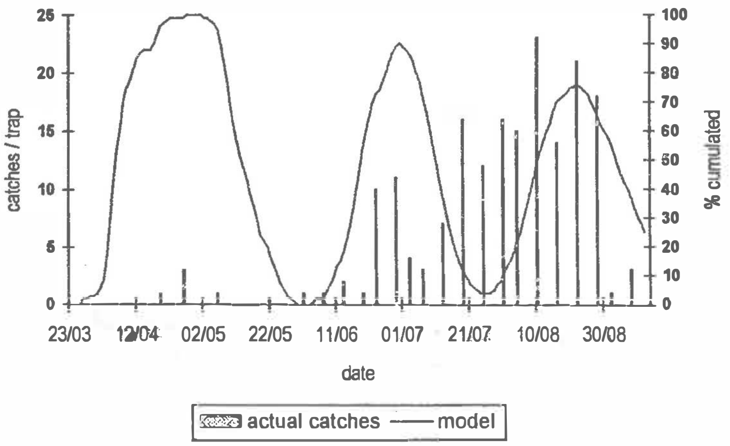

Fig. 1- Sorrivoli (Forlì), 1995. Comparison of forecast flights and pheromone trap catches

2) comparison of forecast and actual oviposition pattern.

The orchards used had a history of being heavily infested with *C. funebrana*. However, in 1995 the level of infestation by plum fruit moth was very low, maybe as the result of the unusual weather conditions experienced in that year. Of the four orchards which were monitored in 1995, only one (at Sorrivoli, near Forlì) had a sufficient number of eggs during the third generation for comparison with the model. This field data fitted the the forecast curve very well (Fig. 2), particularly above 30 % cumulative oviposition.

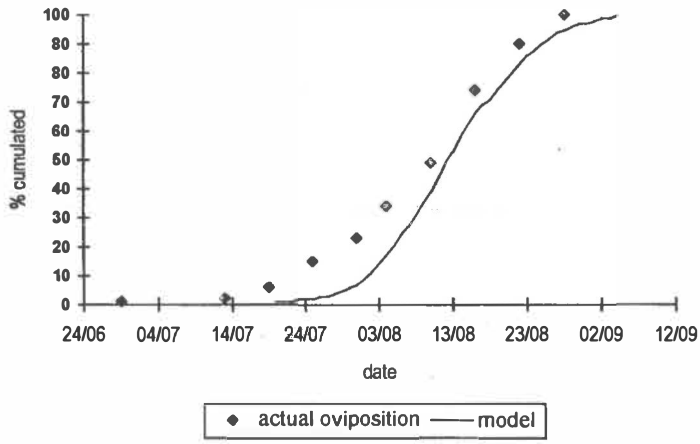

Fig. 2- Sorrivoli (Forlì), 1995. Comparison of forecast and actual oviposition pattern: third generation.

In 1996, only two plots out of the 5 examined were sufficiently infested to enable the data to be compared to the model. In the first orchard, at Sorrivoli, a sufficient number of eggs was found during the second and third generations (Fig. 3). In the second orchard, at Spilamberto, (near Reggio Emilia), only the second generation oviposition was high enough (Fig. 4). A good correlation between actual and forecast oviposition was obtained, particularly at Spilamberto between 30 % and 80 % cumulative oviposition. Actual oviposition generally occurred over a longer time period than predicted.

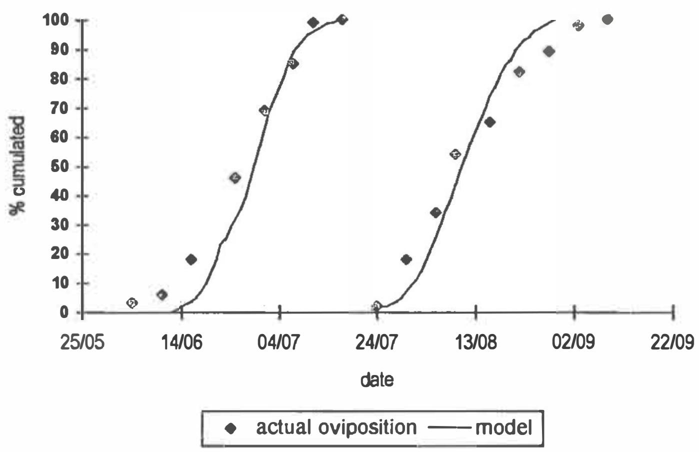

Fig. 3 - Sorrivoli (Forlì), 1996. Comparison of forecast and actual oviposition pattern: second and third generation

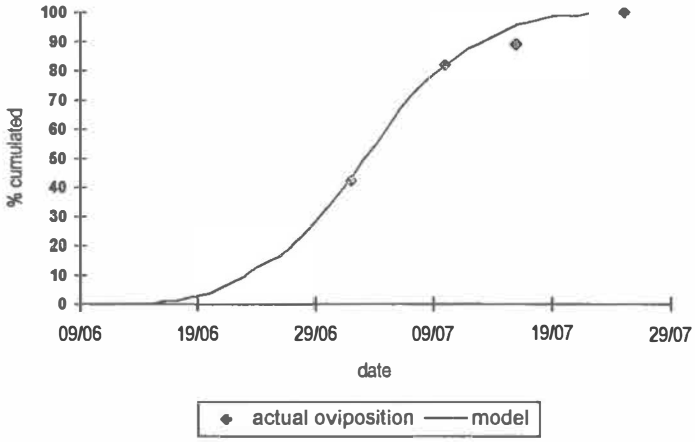

Fig. 4 - Spilamberto (Reggio Emilia), 1996. Comparison of forecast and actual oviposition pattern: second generation

CONCLUSIONS

Of the 13 orchards investigated only three produced data which were useful for validating the *C. funebrana* model. The deviation between forecast and actual field data was acceptable, particularly at levels of cumulative oviposition between 30 % and 80 %.

The population trend of *C. funebrana* within an orchard can be estimated, to some extent, by pheromone traps. For accurate timing of insecticide treatments, the oviposition activity in the field should be monitored, however, this is too time-consuming and impractical to undertake for each orchard on a weekly basis.

A practical use of the model under development would be to estimate oviposition status, in terms of cumulative percentage, so that technicians could assess the risk of damage by sampling actual oviposition on just a single occasion, e.g. at 50 % cumulative oviposition.

The computer network already established in Emilia Romagna would make it possible to run the program at a local level, thereby increasing the efficiency of the model through the input of local information and the accuracy of the model through the input of a wider collection of data.

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OILB/SROP Reunion du Groupe de Travail "Protection intégrée en vergers de fruit à noyau"
Zaragoza (Espagne) 24-26 September 1996

STRATEGIES DE LUTTE ET TECHNIQUES D'OBSERVATION SUR LE THRIPS CALIFORNIEN (*FRANKLINIELLA OCCIDENTALIS* PERG.) EN VERGER DE PECHER ET DE NECTARINIER DANS LE SUD DE LA FRANCE

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RESUME - *Frankliniella occidentalis* a été signalé pour la première fois dans le Sud de la France en 1989. Des observations ont été réalisées pendant 4 ans pour raisonner au mieux les traitements insecticides. Dans cette étude nous avons établi une relation entre le niveau de présence de thrips sur fruit, sur pousses et l'importance des dégâts. Nous avons également comparé différentes techniques d'évaluation des populations de thrips sur pousses et sur fruits.

ABSTRACT - *Frankliniella occidentalis* has been reported in France on nectarins and peaches since 1989. We have compared some méthods of thrips monitoring on fruits and shoots. In this article we have showed a relation ship between level of presence of thrips and damage.

INTRODUCTION

Frankliniella occidentalis est signalé pour la première fois par Bournier en 1986. D'abord présent en cultures sous abri il est l'objet d'une première série d'études (Grassely *et al.*, 1988). Cet auteur le signale sur pêchers et nectariniers dans le Gard en 1989. Cette même année il est signalé dans les Pyrénées-Orientales sur ces mêmes cultures fruitières (Nicolas, 1989). Mais il faut attendre 1991 pour avoir les premiers dégâts sérieux. La présence du thrips d'abord limitée à la proximité des serres se généralise rapidement à l'ensemble des vergers de pêches et nectarines. Sur ces 5 dernières années nous avons eu une campagne, 1995, avec une incidence très forte, deux récoltes avec des attaques faibles ou nulles 1992 et 1996, les années restantes présentant des dégâts modérés ou variables en fonction des zones de production.

Les dégâts observés dans le Sud de la France sont identiques à ceux décrits dans la région de Murcie (LaCasa *et al.*, 1990).

A l'approche de la maturité le fruit se couvre de plages blanchâtres, de couleur aluminique, qui le déprécient à la vente.

Ces taches d'abord limitées à la cavité pédonculaire peuvent ensuite se généraliser sur tout l'épiderme. Mais ce sont les zones de contact (entre les fruits ou entre un fruit, une feuille ou un rameau) qui sont les plus touchées. Les fruits situés dans les zones basses de l'arbre ou ceux qui sont à l'intérieur de la frondaison sont les plus atteints.

A l'époque où ce thrips est apparu nous étions en pleine phase de développement de la technique de confusion sexuelle pour lutter contre la tordeuse orientale (*Cydia molesta* Berk) en verger de pêcher. A ce titre le thrips californien nous a beaucoup gêné puisqu'il fallait réaliser des traitements spécifiques pour le combattre.

Dans le cadre d'études permettant la mise au point d'une méthode de lutte respectant les règles de la lutte intégrée nous aborderons trois points:

1. Les techniques d'observation: le but étant de développer auprès des producteurs une technique d'observation simple et fiable.
2. Les relations entre les populations de thrips et les dégâts. Il s'agissait ici de définir des stratégies de lutte, des époques de sensibilité et des seuils de nuisibilité.
3. Les relations climat et développement du thrips. C'est une tentative pour essayer d'expliquer les grandes différences de comportement du thrips d'une année sur l'autre et pour donner au technicien un moyen complémentaire d'évaluation du risque.

Par contre nous n'avons que peu travaillé l'action des auxiliaires sur la réduction des populations de thrips. Seules quelques observations fragmentaires ont porté sur les thrips prédateurs (*Scolothrips* sp) et sur les *Orius* sp.

MATERIEL ET METHODES

Toutes les observations ont été réalisées sur variétés sensibles (nectarines et pêches à peau peu duveteuse). Elles ont porté sur l'évaluation des populations de thrips et sur l'estimation des dégâts. Plusieurs techniques ont été comparées:

- extraction des thrips avec un appareil spécialisé, la Berlèse utilisant l'essence de térébenthine, pour les pousses et les fruits.
- frappage des pousses actives (extrémité feuillée avec absence de bourgeon terminal) sur un entonnoir ou un carton blanc.
- trempage des fruits dans de l'eau additionnée de teepol puis filtrage.
- comptage visuel sur fruits, réalisé immédiatement après le prélèvement.
- utilisation de plaquettes engluées jaunes ou bleues disposées à différentes hauteurs dans l'arbre.

Au laboratoire les thrips sont identifiés et dénombrés. Ce travail a été réalisé pendant quatre campagnes de 1991 à 94:

- observation pendant toute la phase végétative des infestations de thrips sur pousses (environ 10 vergers/an)
- observation pendant la phase de maturation des niveaux de thrips et des dégâts sur fruits (environ 30 vergers)
- observation à la récolte uniquement des dégâts et des niveaux de thrips sur fruit (45 parcelles)

RESULTATS

EVOLUTION DES POPULATIONS PENDANT LA PERIODE DE VEGETATION ET COMPARAISON DES DIFFERENTES TECHNIQUES D'OBSERVATION

Dans le Sud de la France nous n'avons jamais trouvé de thrips Frankliniella au moment de la floraison du pêcher. Dans le cas général après quatre années d'observation:

- les premiers individus sont trouvés sur fleurs d'adventices au début du mois d'avril sur *Cardaria draba*, *Trifolium repens*, *Trifolium pratense*, *Anthemis* sp. par contre les populations sont généralement faibles sur les fleurs de couleur jaune, *Taraxacum officinale*, *Sonchus* sp.

- sur pousses apparition au début mai, avec un développement faible jusqu'au 15 juin. Les populations deviennent importantes en juillet et culminent généralement fin juillet à début août, elles vont ensuite décroître fortement à partir du 15 août. Cette baisse semble être en relation étroite avec les courants de sève (Fig. 1) (la disparition des pousses actives entraîne une chute des populations). En été les populations de thrips peuvent être importantes sur *Anthemis* sp., *Malva silvestris*, *Convolvulus arvensis*, *Amaranthus* sp., *Trifolium* sp., *Chenopodium album*. Plusieurs cas de transfert des populations des fleurs d'adventice vers les pêchers ont pu être mis en évidence lors du dessèchement des mauvaises herbes dans le courant de l'été.
- Les dégâts ne sont importants que sur les variétés arrivant à maturité entre la fin juin et la première quinzaine d'août. Toutefois les jeunes vergers très poussants peuvent présenter des dégâts après la mi-août. Comme nous le verrons dans le chapitre suivant les populations de thrips sur fruit ne deviennent importants qu'à l'approche de la maturité.

En ce qui concerne les différentes techniques d'observation:

- sur pousses, (Fig. 1) les méthodes utilisées sont pratiquement équivalentes pour des raisons d'ordre pratique c'est le frappage sur support blanc qui sera conseillé aux producteurs.
- sur fruits, (Fig. 2) le Berlèse est inférieur aux deux autres méthodes, l'observation visuelle au champ est la seule qui permette d'évaluer correctement les populations d'adultes.

Les pièges englués, de couleur bleue, présentent un rendement 5 à 6 fois supérieur aux jaunes. Mais ce système a été abandonné pour des raisons de commodité. Il est jugé peu pratique, problèmes de vent et de poussières.

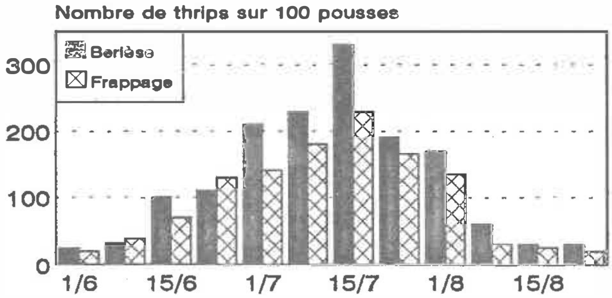

Fig. 1. Sur pousses comparison de 2 techniques d'observation (moyenne de 5 essais - données SPV et Nicolas SCREAPO)

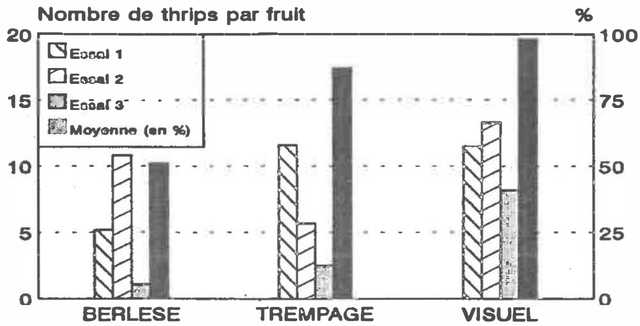

Fig. 2. Sur fruit comparison de 3 techniques d'observation

RELATIONS ENTRE POPULATIONS DE THRIPS ET DÉGÂTS

Pour mettre au point une stratégie de lutte il faut d'abord définir les périodes de sensibilité. Les premières observations ont montré que le début des dégâts pouvait intervenir sur des fruits à R-15 (séparés de la date de récolte commerciale de 15 jours). Ces observations (Fig. 3) ont été largement confirmées depuis. Toutefois il peut exister quelques exceptions, cas notamment des variétés se colorant tôt ou celle des jeunes vergers très poussants pour des variétés récoltées en août. Mais dans ce dernier cas si l'on peut observer les premiers dégâts plus tôt, généralement à la récolte, les pertes restent le plus souvent faibles ou modérées.

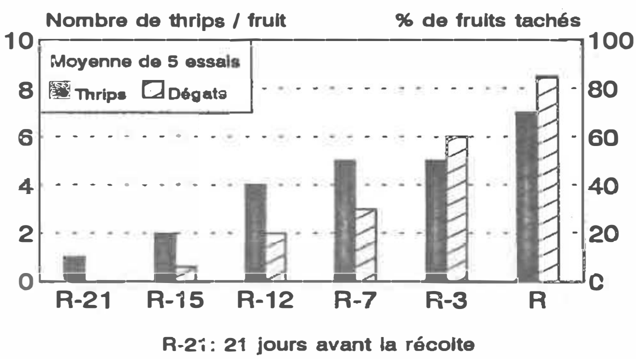

Fig. 3. Sur fruit évolution des dégats et des populations de thrips

En pratique, il est préférable de commencer à surveiller 15 à 20 jours avant la récolte.

Le schéma théorique (Fig. 4) donne l'évolution des dégâts et des populations de thrips. Tout d'abord nous n'avons pas trouvé de relation entre l'évolution du thrips sur pousses et sur fruits. Généralement sur pousses les niveaux sont croissants du 15 juin à la fin juillet, décroissant à partir du 15 août. Ceci dit pour des vergers qui sont entre 30 et 15 jours de la récolte le niveau de thrips sur pousses reste un moyen sûr pour évaluer la pression du ravageur.

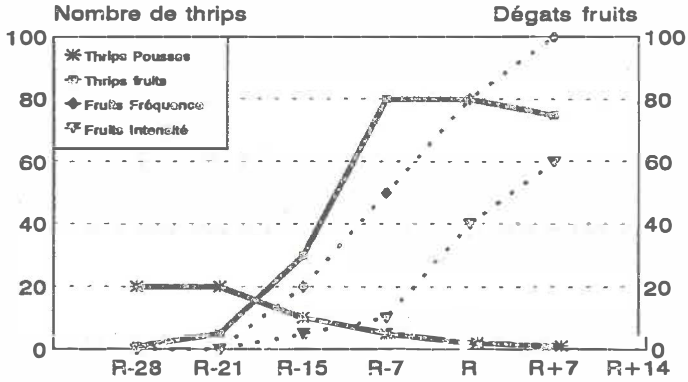

Fig. 4. Evolution theorique des dégats et des thrips sur fruits et pousses

Les fruits deviennent très réceptifs dans les 15 derniers jours, attention tout de même pour les fruits se colorant tôt. Pendant cette période les populations augmentent rapidement avec en parallèle les dégâts. A ce titre il faut noter un décalage de 7 à 10 jours entre la présence de dégâts faibles sur fruits et l'apparition de dégâts plus sérieux pouvant conduire à un déclassement.

Nous avons ensuite essayé de mettre en évidence des seuils de tolérance. Tout d'abord avec la relation (Fig. 5) entre les niveaux de thrips sur pousses à 21 jours de la récolte et les dégâts. Il apparaît que pour des niveaux inférieur à 0,5 thrips par pousse les dégâts sont généralement faibles (la barre horizontale dans le schéma marque la limite de 1,5% de dégât).

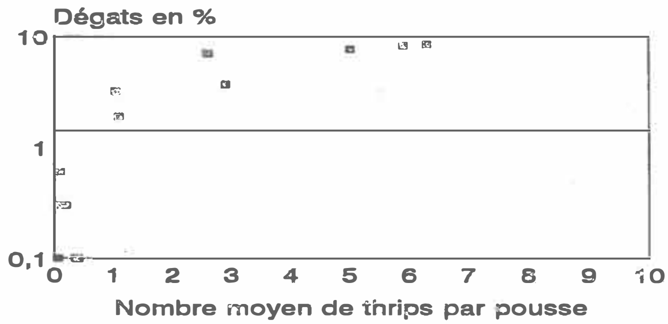

Fig. 5. Relation entre les niveaux de thrips sur pousses à 21 jours de la récolte et les dégats

Une autre relation (Fig. 6) a été étudiée, sur fruits, entre le niveau de thrips notés par comptage visuel et les dégâts. Ici ce sont des niveaux de l'ordre de 2 thrips par fruit qui marquent la limite à ne pas dépasser. Toutefois certaines variétés, notamment celles à récolte très échelonnée, semblent avoir un comportement différent (les derniers passages sont souvent très attaqués, les fruits laissés en surmaturité assurent un pied de cuve pour les fins de cueille).

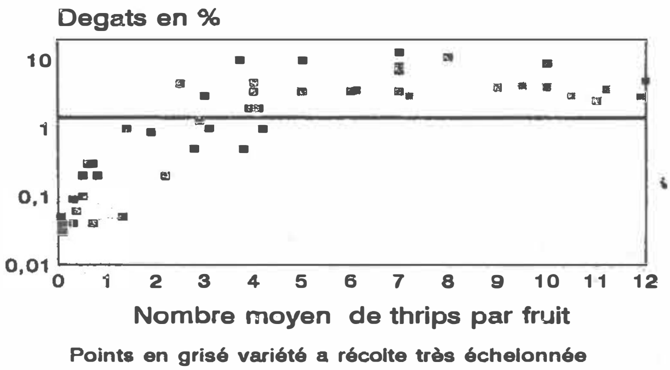

Fig. 6. Relation entre les niveaux de thrips et les dégats à la récolte

RELATIONS ENTRE LE CLIMAT ET LE DEVELOPPEMENT DU THRIPS

Les dégâts dus au thrips sont très différents d'une année sur l'autre. Le calcul du nombre de cycles théoriques, en fonction de la température, montre des variations assez faibles d'une année sur l'autre. En moyenne nous avons 6 cycles complets par an, le troisième intervenant au début du mois de juillet. Par contre les années à fort développement correspondent aux années les plus sèches. Il semble qu'il y ait une relation inverse entre la gravité des attaques et le nombre d'heures où la végétation reste mouillée. Parmi les corrélations étudiées c'est la seule qui soit vraiment significative. L'effet régulateur des pluies printanières a déjà été mis en évidence (Bournier, 1990).

CONCLUSION

Dans le cadre de la lutte intégrée un certain nombre de recommandations sont proposées:

- tout d'abord des mesures prophylactiques avec un contrôle de l'enherbement (le thrips étant floricole la strate herbacée peut assurer une multiplication importante du ravageur, des cas de transfert de la strate herbacée vers les arbres ont été observés). Il faut donc désherber sous le rang et entretenir l'inter-rang par des fauchages réguliers. La taille en vert et l'éclaircissage permettent de limiter les zones de contact et donc l'incidence du ravageur. Pour finir, sur les variétés à récolte échelonnée il faut enlever les fruits en surmaturité.
- pour le contrôle des populations de thrips nous proposons au producteur deux grands rendez-vous. Le premier se situe à 20-25 jours de la récolte, l'observation sera réalisée par frappage de 100 pousses sur un support blanc. Le risque est jugé faible si l'on a moins de 50 thrips (adultes et larves). Le deuxième à 10-15 jours de la récolte, il correspond au début de la phase de très grande sensibilité du fruit. L'observation portera

sur 50 fruits, le risque est jugé faible s'il y a absence de dégâts, y compris dans la cavité pédonculaire, ou si l'on compte moins de 100 thrips.

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VIRUSES AND PHYTOPLASMS TRANSMITTED BY INSECTS
(PRESIDENT: A. ARZONE)

IOBC/WPRS Working Group Meeting "Integrated plant protection in stone fruit"
Zaragoza (Spain) 24-26 September 1996

EARLY RESULTS OF WORK ON THE VECTORS OF EUROPEAN STONE FRUIT YELLOWS PHYTOPLASMA

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ABSTRACT - Recent research has been initiated to identify the main species of leafhopper (Homoptera Auchenorrhyncha) present in stone fruit orchards in Emilia-Romagna and to search for possible vectors of European stone fruit yellows (ESFY) phytoplasma. The presence of ESFY-phytoplasma, as well as that of other phytoplasmas, was detected in some of the cicadellid leafhoppers (in the genera *Anaceratagallia* and *Euscelis*, and the subfamily Typhocybinae) collected from the orchards. The proportion of phytoplasma-positive leafhoppers was low. A list of the leafhopper taxa collected in plum orchards in Emilia-Romagna is provided.

INTRODUCTION

In recent years infestations of leafhoppers in stone-fruit orchards have increased in both southern (Viggiani *et al.*, 1992) and northern (Pollini & Bariselli, 1995) regions of Italy.

The leafhoppers species found most commonly is *Asymetrasca decedens* (Paoli), which can be responsible for serious direct damage to fruit-trees, particularly in nurseries during the first years of planting. However, *Auchenorrhyncha* species may also cause indirect damage as potential vectors of phytoplasmas such as the main causal agent of apricot chlorotic leaf roll, Japanese plum leptonecrosis and peach yellows (peach decline).

These diseases are induced by the same phytoplasma (Lorenz *et al.*, 1994; Poggi Pollini *et al.*, 1995) and are now collectively referred to as European stone fruit yellows (ESFY) (Seemuller & Foster, 1995). The same phytoplasma also causes diseases in nectarine, almond, European plum (*Prunus domestica*) and cherry.

The possibility of alternative host plants for vector insects is being studied with the aim of putting integrated control strategies into practice by managing such plants through the orchard grass regeneration programme.

To ensure the success of new orchards it is also essential to consider carefully the choice of nursery stock to be used for planting and to assess the risk of transmission of diseases caused by viruses and phytoplasmas.

INCIDENCE, SPREAD AND SYMPTOMOLOGY OF ESFY

In Europe, apricot chlorotic leaf roll and Japanese plum leptonecrosis severely affect the relative plants in most of the areas where they are grown.

In Italy these diseases are particularly common in Tuscany, Friuli, Emilia-Romagna and Veneto, with many cases of up to 25-30% of trees in commercial orchards becoming infected within the first four years after planting (Carraro *et al.*, 1992; Poggi Pollini & Giunchedi, 1993). The diseases have also been found in orchards in Lazio and Campania.

The main symptoms are essentially the same in apricot, Japanese plum and, when grown on susceptible rootstocks, European plum (Poggi Pollini *et al.*, 1995). Within an orchard, leaves on affected trees generally emerge one to two weeks earlier than those on healthy trees of the same cultivar. Sometimes leaves are produced as early as November or December.

Initial symptoms are frequently restricted to one or a few branches of a tree, they spread gradually and by the second or third year the whole crown is affected. Shoot growth on affected branches is much reduced, resulting in shortened internodes and smaller leaves which also have yellow-green areas. As the season advances, foliage on infected trees either rolls up in a typical conical or poligonal shape with the base towards the petiole, e.g. apricot, or it becomes reddish, brittle and markedly rolled up along the midrib in a tubular shape, e.g. plum. The leaves drop prematurely in late summer.

Infected trees can also produce latent buds and produce twigs with extremely short internodes and small rolled-up leaves in late summer. Growth may continue during the winter while the temperature remains above 2-4 °C.

Affected branches progressively decline and die within a few years. Eventually the entire crown dies. The time-period between the appearance of symptoms and the subsequent death of the tree is strictly linked to rootstock susceptibility and winter climate conditions, both of which influence the appearance and intensity of internal symptoms. These symptoms, when present, consist of phloem necrosis of the affected branches. This necrosis can involve small portions of branch tissues or expand down the trunk, but never spreads below the graft union in the case of plum rootstocks. The extent of phloem necrosis is not directly determined by the disease but is the consequence of frost damage which occurs when the temperature falls below -5 °C.

In infected peaches, symptoms begin to appear in late summer and consist of severe upward longitudinal rolling of the leaves, which are thicker and more brittle than normal; in some cultivars the primary veins appear reddish in colour (along with the areas at the border of the lamina delimited by veins) and are also abnormally enlarged. In most peach cultivars the leaves with symptoms drop prematurely and vegetative growth of the trees is much reduced; out of season growth is less frequent than in apricots or plums.

RESEARCH ON LEAFHOPPERS IN INFECTED ORCHARDS

Research was conducted in order to identify the main species of leafhoppers in stone-fruit orchards in Emilia-Romagna region and to search for possible vectors of the ESFY-phytoplasma. Observations were made in two infected orchards of apricot and plum in Emilia-Romagna during 1994-1996.

Leafhoppers present on orchard trees and the vegetation between the rows were collected weekly from June until October using a sweep net. The catches were identified in the laboratory. The preliminary results are shown in Table 1, although this monitoring programme is still underway.

Table 1. Identified taxa of leafhoppers collected in plum orchards in Emilia-Romagna (1994-95) (abundance: + = rare; ++ = common; +++ = abundant)

FAMILY, SUBFAMILY, SPECIES	ABUNDANCE	FAMILY, SUBFAMILY, SPECIES	ABUNDANCE
CIXIIDAE	+	CICADELLIDAE	
DELPHACIDAE	+++	Typhlocybinae	
DICTYOPHARIDAE		*Emelyanoviana mollicula* (Boheman)	++
Dictyophara sp.	+	*Asymmetrasca decedens* (Paoli)	+
ISSIDAE		*Edwardsiana* sp.	+
Caliscelis sp.	+	*Eupteryx notata* Curtis	++
FLATIDAE		*Zyginidia* sp.	+
Metcalfa pruinosa (Say)	+	*Zygina flammigera* (Fourcroy)	+
CERCOPIDAE		Deltocephalinae	
Philaenus spumarius (L.)	++	*Neoaliturus fenestratus* (Herrich-Schäffer)	+
CICADELLIDAE		*Macrosteles quadripunctulatus* (Kirsch.)	+
Agalliinae		*Recilia* sp.	+
Anaceratagallia laevis (Ribaut)	+++	*Doratura* sp.	+
A. ribauti (Ossiannilsson)	+++	*Fieberiella florii* (Stål)	+
Dorycephalinae		*Euscelis incisus* (Kirsch.)	++
Eupelix cuspidata (Fabricius)	++	*Psammotettix alienus* (Dahlbom)	+++
		P. confinis (Dahlbom)	+++

RESEARCH ON THE PRESENCE OF PHYTOPLASMAS IN LEAFHOPPERS

Davies *et al.* (1995) conducted parallel reseach on phytoplasmas in leafhoppers, grouping them by subfamily or genus using PCR and "nested" PCR, with the aim of detecting the presence of phytoplasmas and identifying vectors at the group or species level. Insects were subdivided into groups of two, five or ten individuals according to their size and then submitted to a modified extraction procedure previously described (Goodwin *et al.*, 1994).

Nested-PCR assays were carried out with two sets of universal primer pairs P1/P7, followed by U5/U3 (Lorenz *et al.*,1995). The positive samples were then submitted to further tests with restriction enzymes Alu I, Rsa I, Kpn I and Ssp I and subsequent RFLP analysis through a 1.5% agarose gel.

The results obtained established the presence of ESFY phytoplasmas in Cicadellidae (in Typhocybinae and the genera *Anaceratagallia* and *Euscelis*) aswell as the presence of other phytoplasmas, e.g. pear decline agent and phytoplasmas of the Western-X disease strain cluster. The proportion of phytoplasma-positive leafhoppers was low, ranging from 0.13-1.33%, provided that in the pooled samples only one insect was phytoplasma-infected.

These are early results from which no firm conclusions can yet be drawn as it is well known that the detection of pyhtoplasmas in an insect does not necessarily indicate that the insect is a vector (Vega *et al.*, 1993), nevertheless, such results may be the starting point for further transmission experiments with leafhoppers.

The exchange of information concerning the pest and disease status of crops in different European countries deserves full encouragement and to this purpose the meetings of the IPM Research Group on Stone Fruit offer a suitable forum for gathering information and planning coordinated research activities.

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Pheromones

(President: A. Arzone)

IOBC/WPRS Working Group Meeting "Integrated plant protection in stone fruit"
Zaragoza (Spain) 24-26 September 1996

COMPARISON OF FLIGHT PERIODS OF MALE *PSEUDAULACASPIS PENTAGONA* IN HUNGARY AND NORTHERN ITALY

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ABSTRACT - In recent years the white peach scale *Pseudaulacaspis pentagona* (Targioni-Tozzetti) (Homoptera, Diaspididae) has shown a substantial northward expansion of its geographic range within Europe in a short space of time. During the period 1991-1996, a monitoring programme, using pheromone traps, was carried out in Hungary and in northern Italy. The total number of *P. pentagona* males collected on traps was much higher in Italy than in Hungary. Since 1992 the number of males in Hungary decreased sharply. The catches of males of the first generation were much higher than those of the second generation in both countries. The beginning and the peak of the first flight period in Italy were similar in each year. In Hungary, this phenological stage was much more variable, with the timing of the first generation varying by as much as six weeks between different years. The timing of the start of the second flight period showed large variation in both countries (5-6 weeks). All flight periods started in Hungary about one month later than in northern Italy. Two flight periods were found during each year in both countries.

INTRODUCTION

Any change in the climate could be reflected very quickly in the distribution and density of a mobile group of animals, such as insects (Kozár and Nagy Dávid, 1986; Kozár, 1992). This proposal appears to be clearly confirmed when examining the changes in the distribution of the white peach scale, *Pseudaulacaspis pentagona* (Targioni-Tozzetti) (Homoptera, Diaspididae). This pest is certainly one of the best examples of the northward expansion of an insect within Central Europe during recent years.

P. pentagona is a thermophilous insect which for a long time was found only in the southern part of Europe, having a wide Mediterranean distribution (Anonymous, 1988).

However, after a so called "resting" period this species started to expand its range towards different parts of Europe. This movement accelerated after 1970 and during the last 20-25 years the white peach scale has expanded its range substantially in a northward direction. Curerntly this pest has become established in a number of different regions and is still expanding into new areas (Baggiolini *et al.*, 1993; Jansen, 1995; Kozár, 1990; Kozár *et al.*, 1994, 1995; Kreiter, 1996; Celada Grouard, Spain, personal communication). Movements, direction and associated chronology are shown in Figure 1, the years shown are the date of publication, collection or supposed identification. In most cases it is impossible to identify the exact introduction date. In England, the early introduction and establishment of *P. pentagona* needs further verification.

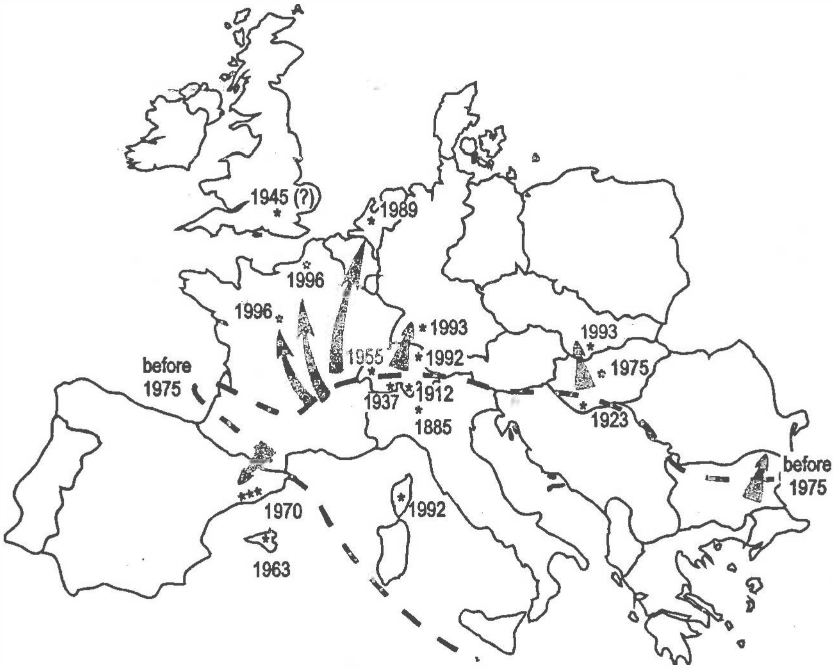

Fig. 1. Distribution and spread of *Pseudaulacaspis pentagona* in Europe (from Kozár, 1996).

P. pentagona is a good indicator species with which to study the effect of climate change on migration and invasion of insects. These effects can be summarized as:

- the change in distribution and the speed of expansion;
- the change of density in time and space and the frequency of outbreaks;
- the change in the number of generations and the differences in flight phenology between different years, different generations and different countries.

Pheromone traps were used by Cravedi & Mazzoni (1993) to study the phenology of male flight in Italy and France. At the monitoring sites used there were between two and three generations. In Hungary, Sheble & Kozár (1995) found two generations.

The beginning of the flight period for the first generation did not show considerable variation in Italy and southern France, it usually started during the first week of June. Conversely, the beginning of the second flight period varied from mid-July to mid-August (Cravedi & Mazzoni, 1993).

The pheromone traps also proved to be an efficient tool with which to study population dynamics (Cravedi & Mazzoni, 1993; Kozár & Sheble, 1996).

Some of these points will be discussed in more detail later in this paper.

MATERIALS AND METHODS

During the period 1991-1996 we studied the flight of male *P. pentagona* in Hungary and Italy using pheromone traps.

The traps used in Hungary were of the Hungarian tent trap design (10 x 10 cm, transparent plastic square) with a transparent glue (Tanglefoot). In Italy, a larger tent trap was used (21 x 21 cm, pale yellow plastic square) with a transparent glue (Visspray from Siapa or Temostick from Kollant). The pheromone dispenser was suspended *c.* 3-4 cm below the trap. Commercial pheromone dispensers from Trifolio-M GmbH (Germany) and Isagro (Italy) were used. The dispensers were left in the field for *c.* 4-5 weeks and then replaced.

The sticky-trap squares were replaced every time the traps were inspected and the number of male *P. pentagona* was counted in the laboratory. In Hungary, traps were inspected every week, in Italy every 3-4 days. The Italian data for each week were summed for comparison.

The traps in Hungary were placed on ornamentals (*Sophora japonica*) in a town park (in Budapest) and on plum trees in a home garden. Although these trees were not infested, nearby there were infested *Sophora* trees. In Italy, traps were placed in abandoned peach and nectarine orchards near Piacenza.

Three traps were used in parallel as replicates.

RESULTS

POPULATION DYNAMICS.

Due to the difference in size between the Italian and Hungarian trap (the former having a sticky area more than 75% larger than that of the latter), absolute catch per trap was converted to catch per unit area (i.e. males/cm^2) in order to allow comparison of trap data, as conducted by Hoyt *et al.* (1983) with San José scale pheromone traps of differing sizes.

The total number of males collected in Italy in each year was much higher than in Hungary. This was also the case when trap catches were expressed as average number of males/cm^2 (Fig. 2), except in 1992. In Italy, the maximum number of males captured was 39,960 in 1994. In Hungary, the maximum was 11,868 in 1991 (second generation only) and 11,178 in 1992. After 1992 the number of males captured in Hungary decreased sharply (Fig. 2). In Italy, there was a clear increase from 1991 to 1994, but in 1996 numbers decreased

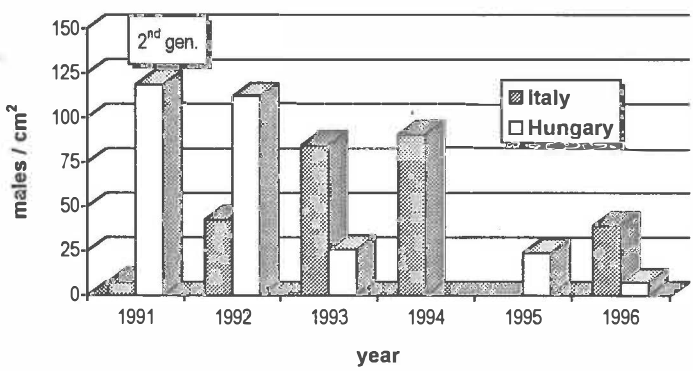

Fig. 2. Total no. of males collected in Hungary and Italy from 1991-96 (all values are the average no. of males/cm^2 for two generations, except in Hungary in 1991 which refers to the 2nd generation only).

substantially.

The ratio between the number of males collected during the first generation and the number collected during the second generation was similar in both countries (Fig. 3).

In most years, the number of males from the first generation was much higher than that from the second. However, the ratio was the opposite in Italy during 1991 and in Hungary during 1993, when the total number of males captured was lower than in the other years.

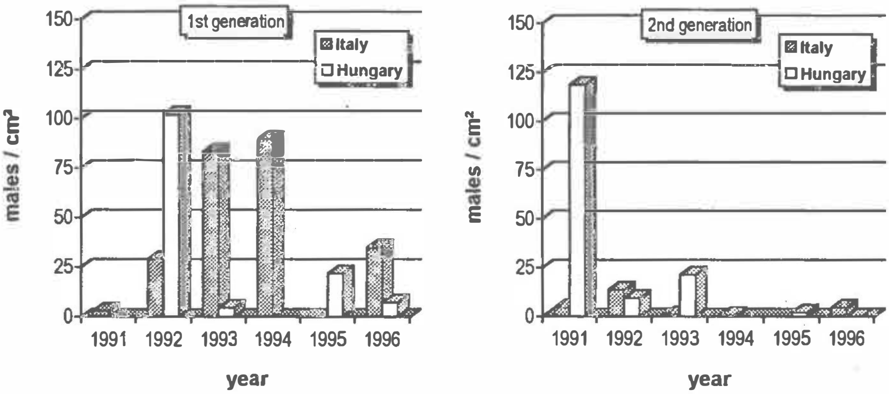

Fig. 3. Total number of males collected during the first and second generation in Hungary and in Italy, 1991-96.

SEASONAL DEVELOPMENT

The start of the first flight in Italy was very consistent. Each year it was recorded during the 24th week of the year, except in 1994 when it began during the 22nd week. In Hungary, the start of the first flight varied by 6 weeks between years; from the 25th to the 30th week. With the second generation there was a greater variation in both countries; 5 weeks in Italy (30th - 34th week) and 6 weeks in Hungary (33rd -38th week) (Fig. 4).

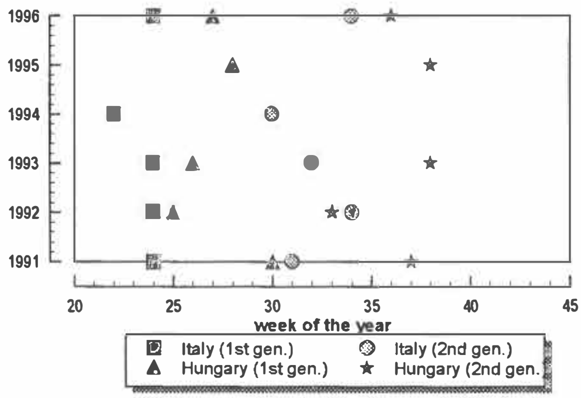

Fig. 4. The start of the first and second generations in Hungary and Italy, 1991-96.

The peak of the first flight period in Italy also showed a significant consistency between years; from 1991 to 1996 the peak occurred during the 25th or 26th week of the year. In Hungary, this phenological phase was more variable between years and was recorded with a range of 6 weeks (25th - 31st week of the year).

There was more variation in flight phenology with the second generation in both countries. During the different years, the peak of the second flight period occurred over a range of 5 weeks (32nd - 37th week) in Italy and a range of 6 weeks (36th - 42nd week) in Hungary (Fig. 5). All flight periods started in Hungary about one month later than in northern Italy.

In both countries there were two flight periods per year, lasting a maximum of about one month for the first generation and two months for the second generation (Fig. 6). However, Cravedi & Mazzoni (1993) observed three flight periods in central and southern Italy and in southern France.

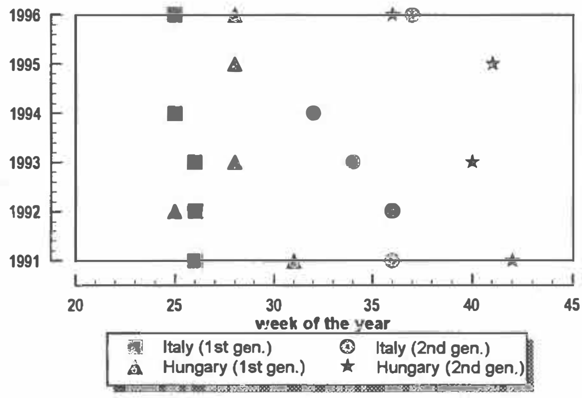

Fig. 5. Number of the week of the year of the peak of the flight in the first and second generation in Hungary and in Italy from 1991 till 1996.

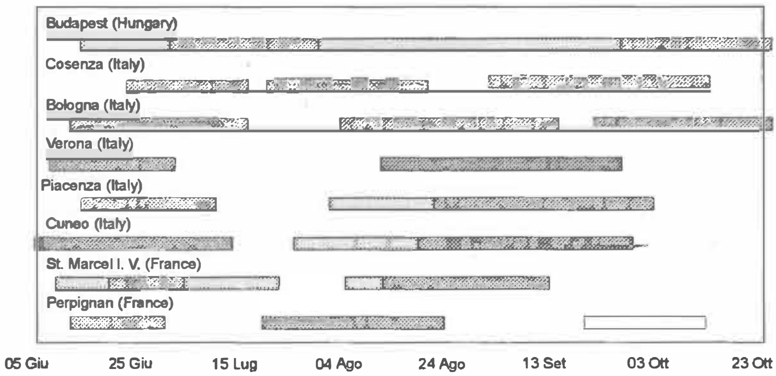

Fig. 6. Schematic representation of the male flights of *P. pentagona* in different parts of Europe (modified from Cravedi & Mazzoni, 1993).

DISCUSSION AND CONCLUSION

From these results some conclusions can be drawn concerning the successful and substantial northward spread of *P. pentagona* into new areas of Europe, as observed in recent years.

This phenomenon has been explained by milder winters (Kozár & Nagy Dávid, 1986). In Hungary, cold winters can cause high levels of mortality, close to 100% in some places (Sheble & Kozár, 1996). As a result, there are great fluctuations in the density between different years. The same reason can be used to explain the higher population density recorded in Italy; milder overwintering conditions can favour the increase of *P. pentagona* populations.

The significant reduction of trap catches during the second generation in both countries suggests that the larval stages of male *P. pentagona* are very sensitive to hot and dry summers, despite this species being recognized as a thermophilous one.

On the other hand, the abundance of males in the first generation demonstrates that even the smaller number of males during autumn is sufficient to fertilize the overwintering females, so that they can produce a large number of offspring in the following year.

This summer mortality of males could be one reason for the unusually high male to female ratio in *P. pentagona* populations (Nur, 1990); females that mate later in the season show a tendency to produce more males in their progeny than females, which are then fertilized as soon as they emerge.

The white peach scale, as a new insect species in Central Europe, is not well adapted to the conditions of that region and shows great variation in both population dynamics and phenology. In Italy, at least the phenology of the first generation is generally stable and more predictable, while in Hungary the male flight can show more than a months difference in different years.

This variation can result in a lack of synchronisation between the parasitoids of *P. pentagona* and their host, possibly explaining the failure of biological control attempts. In addition, summer pesticide applications can be difficult to time accurately because of the difficulty in predicting the most sensitive period.

In Italy, large variations were found only with the second flight. The variations in the timing of the second flight in both countries again suggest that this species is sensitive not only to winter, but also to summer temperatures. The one month difference in flight phenology between Hungary and Italy could be explained by the differences in the climate of these two countries.

This study has shown that there are several theoretical, practical and new questions concerning the biology of *P. pentagona* that need to be answered, even though this pest is a so called “well known” insect species. It will be important for future studies to investigate the role of the various factors which cause the differences identified in this study.

ACKNOWLEDGEMENTS

The Authors express their thanks to Daniele Matile Ferrero (Natural History Museum, Paris, France) and Barbara Celada Grouard (Generalitat de Catalunya Department de Agricultura, Tarragona, Spain) for the unpublished distribution records of *P. pentagona* and for the data contained in the paper by P. Kreiter (INRA, Valbonne, France) which is currently in press.

The work of Dr. F. Kozár was founded by OTKA grants No. 12980 and 22005.

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IOBC/WPRS Working Group Meeting "Integrated plant protection in stone fruit"
Zaragoza (Spain) 24-26 September 1996

MONITORING CHERRY FRUIT FLY (RHAGOLETIS CERASI L.) USING YELLOW TRAPS

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ABSTRACT - During observations on the flight activity of cherry fruit fly (*Rhagoletis cerasi* L.) in 1995 and 1996 it was found that catches were always higher on vertical rectangular yellow traps than on cylindrical ones. It was found that the flight activity of *R. cerasi* began some 7-8 days earlier in sweet-cherry orchards than those of sour-cherry. Catches on traps placed on the south and west side of the tree canopy were higher than those found on traps placed on the north and east sides.

INTRODUCTION

Despite the fact that research on cherry fruit fly has been well practised, because its damaging effects have been known for long time, several aspects of its biology have yet to be revealed. Among them we found the flight biology of this pest, and therefore the biotic and abiotic factors influencing it, have yet to be studied.

Observations were made in cherry and sour-cherry orchards in 1995 and 1996. The direct objective of these investigations was to study whether yellow traps can be used to monitor flight activity, i.e. to identify the extent to which the catches reflect the flight of the adult within the orchard..

MATERIALS AND METHODS

Observations were made in three experimental orchards (with trees 10-12 years old); one planted with a cherry hybrid, one planted with a sour-cherry hybrid and one planted with a sour-cherry genebank. Within each orchard there were trees of different cultivars, including early-, medium- and late-ripening varieties.

The soil and aspect of each experimental orchard were similar.

The yellow traps used had glue on one side only and were not baited. Yellow sticky traps have been used to monitor flight activity of cherry fruit fly for many years (Prokopy & Boller, 1971, Remund & Boller, 1975, Jenser & Tóth E., 1976, Remund *et al.,* 1983, Voigt, 1996).

In the present trial, the "*Csalomon*" trap (a Hungarian trap design) was used as it is the same colour as the Swiss Rebell trap

EXPERIMENTS OF 1995

In 1995 the possible effects of different trap-shapes on the catch of *R. cerasi* were studied. Catches on two trap types; a vertical rectangular trap and a cylindrical trap, were compared in all three orchards. Four replicates of each trap were placed 150-160 cm above the ground on the south side of the trees, where they were sheltered from the wind.

EXPERIMENTS OF 1996

Cherry fruit fly has weak flight activity and will remain on the sunny parts of the tree canopy. This trial focused on the question of how this observation is reflected in the catches of adults. The same three experimental orchards were used. Only the vertical rectangular traps were used. The traps were placed on the south and north and the east and west sides of the trees, this arrangement was replicated four times.

RESULTS

The flight activity of *R. cerasi* observed in the cherry hybrid orchard and the sour-cherry genebank orchard during 1995 is shown in Fig. 1 and Fig. 2 respectively. By comparing the catching capacity of the vertical rectangular traps with that of the cylindrical traps it is clear that the rectangular traps caught higher numbers of cherry fruit fly adults in both orchards.

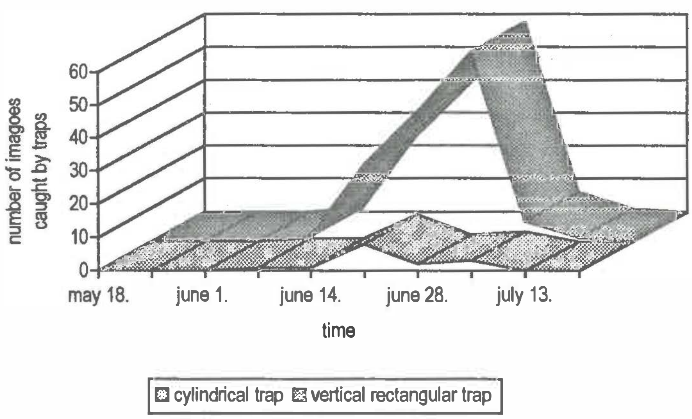

Fig. 1 - Number of *Rhagoletis cerasi* L. caught on yellow traps in cherry hybrid orchard in 1995

By comparing the start of flight activity in the two orchards it was found that the seasonal activity started earlier in the cherry hybrid fields (8 June 1995) than in the sour-cherry fields (14 June 1995). Although the start of the flight activity could not be directly related to the ripening or pre-ripening stages of any variety or variety group, it followed, to some extent, the ripening of the host tree and that is probably the reason why *R. cerasi* flew later in the sour-cherry fields. Flight activity lasted for 15-20 days in each case.

The flight activity observed in the cherry hybrid orchard and the sour-cherry genebank orchard in 1996 is shown in Fig. 3 and Fig. 4 respectively. Catches of *R. cerasi* on traps were always higher on the lighter and warmer parts of the canopy (i.e. those parts receiving more direct sunshine). In the sour-cherry and sweet cherry orchards this meant that catches were higher on the southern and eastern sides than on the northern and western sides of the tree.

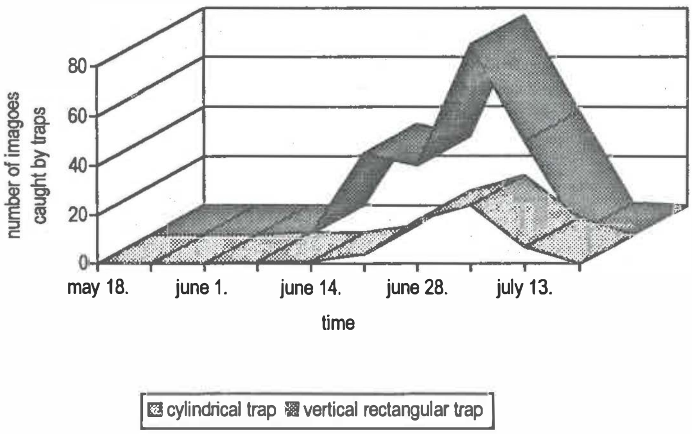

Fig. 2 - Number of *Rhagoletis cerasi* L. caught on yellow traps in sour-cherry genebank orchard in 1995

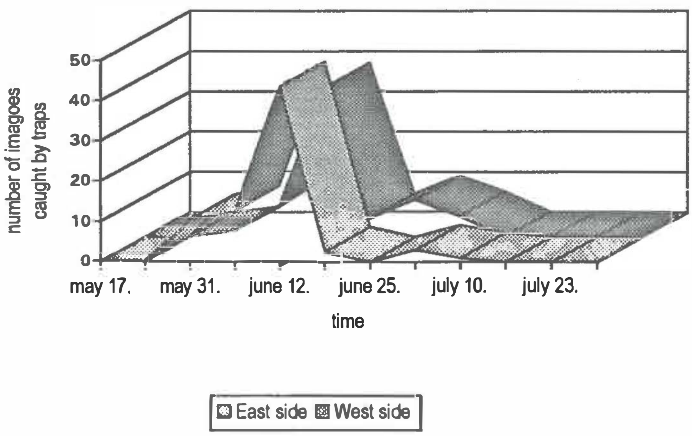

Fig. 3 - Number of *Rhagoletis cerasi* L. caught on yellow traps in cherry hybrid orchard in 1996

CONCLUSIONS

1. Vertical rectangular traps were the most effective and accurate trap for monitoring the flight activity of cherry fruit flies.

2. No direct relationship between flight activity and the ripening dates of cherry and sour-cherry varieties could be demonstrated.
3. Traps used for monitoring the flight activity of *R. cerasi* should be placed on the sides of the canopy which receive most light, where the catches are higher.

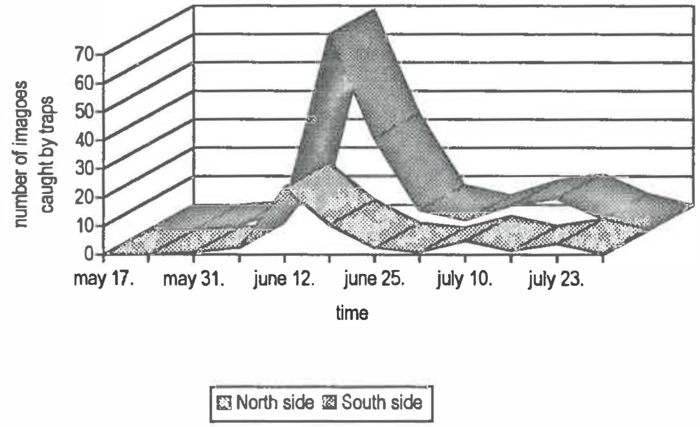

Fig. 4 - Number of *Rhagoletis cerasi* L. caught on yellow traps in sour-cherry hybrid genebank orchard in 1996

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Integrated Fruit Production programmes
(President: J. P. Gendrier)

IOBC/WPRS Working Group Meeting "Integrated plant protection in stone fruit"
Zaragoza (Spain) 24-26 September 1996

FRUIT ORCHARD MANAGEMENT AND STRATEGIES TO REDUCE CHEMICAL SPRAYS AND IMPROVE TREE RESISTANCE TO DISEASES AND PESTS

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INTRODUCTION

For decades fruit growers aimed to achieve maximum yields without taking into account the environmental aspects involved in fruit production. The number of chemical sprays, either against insect pests or diseases, have increased. This is particularly true in some areas of northern Italy (e.g. the Po' valley) where more than 30 sprays per year can be applied to apple orchards. The market has played an important role since customers require fruits without skin damage, preferring less healthy but more attractive products. Maximum yield has been achieved by increasing tree density, increasing fertilizer and water inputs way above the tree's requirements and often using chemical growth regulators like Chlormequatchloride (Triazol) (Deckers, 1992) to reduce vegetative growth. With such inputs, the control of tree growth with traditional tools is hardly necessary. Following the market requests, orchards have become more specialized and the number of varieties within a single fruit area have decreased. As a consequence, genotypic variability has been reduced and at the same time the more popular cultivars have been replanted on the same soil. The prolonged presence of the same variety in the same environment has led to a strict relationship between specific pests or pathogens and plant material (either rootstock or scion).

Economic returns from early fruit tree production have become one of the most important factors contributing to orchard profitability. In order to contain the expenses and shorten the tree's unproductive phase, globe training systems like spindle have been preferred over the palmette system because they do not limit the natural growth of the tree and they compliment better the fruit-tree's physiological behaviour. Furthermore, tree density has been increased up to 3000 trees per hectare, with the attempt to obtain high early yield and to manage the tree from the ground. But high density orchards are more difficult to manage in terms of training and pruning, particularly when the soil has a high level of fertility and dwarf rootstocks or spur varieties are unavailable. Mistakes in tree management lead to high leaf densities which increase the difficulty of pest control.

In more recent years, fruit-growing has been characterized by the over-production of many fruit crops for an increasingly environmentally-aware society. Growers are requested to produce fruit of high quality, grown under conditions which respect the environment in accordance with the new concept of "sustainable agriculture" which encourages the reduction of chemical sprays and fertilizer inputs. Compared to 20 years ago, the whole concept of fruit production has been modified so that high fruit yields can be achieved while still respecting the environment. In Italy, integrated fruit production has been introduced in the most important fruit areas and farmers are encouraged to follow the guide-lines suggested by IOBC.

TREE MANAGEMENT

Considering these new concepts of orchard management, the training system should permit a regular distribution of fruits within the canopy, so that air and solar light, as well as chemical spray, can reach the leaf and fruit surfaces. Low leaf density and the correct training system help avoid high levels of humidity and darkness within the canopy, making the micro-environment less favourable for the development of disease. At the same time, chemical sprays can be more effective against pests and pathogens. All the training systems which permit a reduction in the canopy width (such as palmette, central leader or spindle) have to be preferred over the large volume training systems (such as vase or globe) (Table 1) as they enable the high performance of leaves within the tree canopy. Even preferred training systems are useless if not managed using an appropriate pruning technique, one which has to be performed in the winter and in the summer. Pruning is more important in the summer than in the winter because the vegetative growth can become excessive during the growing season, with the resulting abundant foliage producing a dark and humid micro-environment within the tree canopy. Removing vigorous unproductive suckers during the first steps of their development leads to an improved solar energy exposure of the whole canopy, which in turn increases the efficiency of carbon assimilation within the leaf and the thickness of the leaf epidermis.

Table 1. Effect of different training systems on canopy volume, leaf and fruit density and leaf area index of six-year old peach trees of percoche "Loadel" (Sansavini *et al.*, 1984)

TRAINING SYSTEM	CANOPY VOLUME (m^3)	LEAF AREA (m^2 $hectare^{-1}$)	LEAF AREA INDEX (leaf m^2 soil m^{-2})	FRUIT DENSITY (fruit canopy m^{-3})
Palmette	16.8	16500	1.7	28.4
Vase	21.1	23400	2.3	22.8
Free training	21.4	24600	2.5	25.2

Tree density and leaf area index (LAI) can be optimised by considering the different training systems, the rootstock/variety combination, soil management techniques, soil fertility, light, temperature and rainfall. Soil fertility, which affects plant growth, modifies rootstock performance and plant vigour; the higher the fertility of the soil the larger the space required for each tree. With high soil fertility, winter pruning must be carried out carefully since the plant responds dramatically. The rootstock can strongly influence leaf density (Table 2), M9, for example, induces a higher leaf density than M26 or Mark (Barrit, 1989). With dry weather, high light intensity and long light exposure a higher LAI is acceptable, while in climatic conditions with frequent rainfalls and short summers, more attention should be paid to avoiding excessive leaf density.

Table 2. Effect of different apple rootstocks on canopy volume and leaf area density of cv. "Granny Smith" (1270 trees per hectare) (Barrit, 1989)

ROOTSTOCK	CANOPY VOLUME (m^3)	LEAF AREA (m^2 $tree^{-1}$)	LEAF AREA (m^2 $hectare^{-1}$)
Mark	2.6	3.8	5502
M26	2.2	3.9	4422
M9	2.8	6.1	7798

The leaf surface per hectare should be considered when calibrating the amount of chemical solution sprayed onto the canopy, in order to avoid the excess liquid seeping into the ground. New spray equipment, which is able to collect the excess liquid which falls to the soil from the canopy, should be recommended for use in integrated fruit production.

A consistent reduction of chemical sprays could be achieved by introducing the most appropriate varieties and rootstocks, in terms of resistance to pests and diseases, into each fruit area. For example, in recent years breeding programs have produced new varieties which are tolerant to apple scab (*Venturia inaequalis*), such as Florina and Freedom. The use of these varieties could help to reduce the number of fungicide sprays, which in some years can be more than 20.

NUTRIENTS AND WATER MANAGEMENT

Nitrogen and water supplies also play an important role with respect to vegetative growth and they must be used in the correct way for efficient fruit orchard management. Too much nitrogen fertilizer applied during the summer promotes vegetative growth. Since shoots are important metabolic sinks in strong competition with fruit growth, these excess amounts of nitrogen, applied when the rate of shoot growth is the highest, result in an increase in shoot length and number of leaves and a decrease in the dry-matter content of the fruit. In such conditions leaf density increases beyond the optimum, leaf carbon assimilation efficiency is depressed and the tree becomes a more favourable target for insect pests and disease due to the increased availability of new-growth (leaves and shoot) (Rease and Staiff, 1989). In addition, the lower dry-matter content of the fruits increases their susceptibility to rots and storage diseases. Tagliavini *et al.* (1995) have demonstrated that the percentage of non-marketable kiwi-fruit can be positively related to nitrogen content of the leaves (Fig. 1). In nectarine, excess nitrogen has been shown to reduce the thickness of the fruit skin, which then becomes a weaker barrier to attack by insect pests and disease (Daane *et al.*, 1995). To avoid such problems, nitrogen fertilization should be supplied before and/or after the period when the vegetative growth rate is highest and doses should never exceed the plant's requirement.

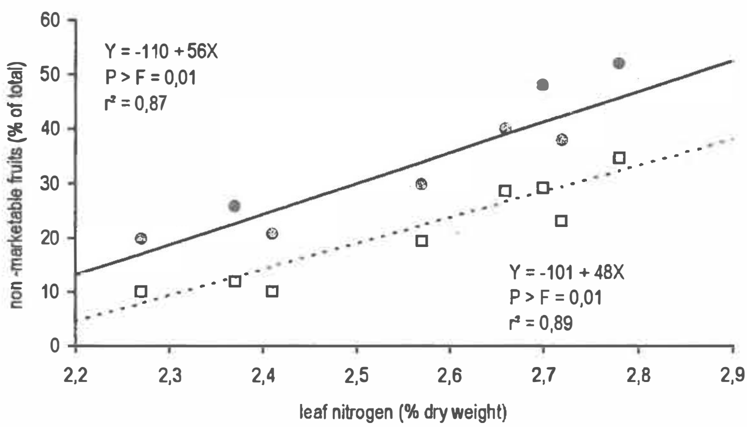

Fig. 1. Linear regressions of the percentage of non-marketable fruits versus total N content of leaves collected during mid-July. Dashed line and squares refer to 17 weeks' storage; solid line and circles refer to 24 weeks' storage. Fertiliser trial.

When the soil is well enriched with organic matter, a high mineralization rate to ammonium and nitrate occurs. For example, in an unfertilized pear orchard located in the Po' valley, levels of $N-NO_3^-$ in the soil solution as high as 40-60 ppm were detected over the whole vegetative season (Marangoni, unpublished data). The nitrates in the soil solution contribute significantly to the trees' requirements and an accurate evaluation of $N-NO_3^-$ availability could provide a helpful indicator as to the correct amount of fertilizer to be applied (Tagliavini *et al.*, 1996).

In apple and pear fruits high ratios N/Ca and K/Ca could promote physiological disorder as well as an increase of incidence of disease such as *Gleosporium* (Martinger, 1986); calcium sprays during the early season, and a balanced use of nitrogen and potassium fertilization have been showed to improve fruit resistance to both storage physiological disorders and disease.

A rational use of water could contribute to reduce the number of chemical sprays in orchards. The volume of irrigation water has to be evaluated very carefully, considering tree performance, root density, soil moisture. Often, soil humidity is evaluated only in shallow layers, ignoring the deeper ones, therefore water supply exceeds the real tree requirement. The peach rootstock hybrid GF 677, for example, does need a lower amount of water compared with seedling trees and this characteristic contributed, in the past, to water supplies exceeding plant requirement with the result of increasing the percentage of rotten fruit. Summer irrigation, when shoot growth rate is high, produces the same effect as previously described for nitrogen. In stone fruit with a short productive cycle such as peach, apricot or cherry, it is suggested to impose a mild water stress during the fastest vegetative growth (May, during the so called phase II), with the objective of reducing shoot growth and inhibiting competition with enlarging fruit cells. In apple the same effect is applicable, with a moderate water stress between 50 days after full bloom and the end of shoot growth (Giulivo and Xiloyannis, 1988). Soil moisture is difficult to control during this period since in many fruit areas spring is the season when the amount of rainfall is the highest in the year. Orchard floor management with grasses can play a positive role, as it contributes to the uptake of excess water. Grass species like *Poa pratensis*, *P. annua*, *Festuca ovina*, *F. rubra* can be introduced into the alley between tree rows, where they will absorb water during the wet season, but, due to the small root system, compete less vigourously for water during the dry season. Grass plays another important role; absorbing excess nitrogen and fixing it into organic matter which consequently, via mineralization, becomes available over a longer period of time, avoiding peaks of nitrate in soil solution which could unbalance plant requirements.

Localized irrigation systems, such as drip-irrigation or microjets, which supply water underneath the canopy, avoid wetting leaf and fruit surfaces and could limit the incidence of diseases at canopy level. However, with some pear varieties that are not susceptible to fruit rot (*Alternaria* spp.), e.g. Bartlett, overhead irrigation is preferred to drip irrigation because the frequent washing of new shoot growth can help to control pear psylla (*Psylla piri*).

CONCLUSION

The rationalised use of pesticide sprays in fruit orchards could be more easily realised if orchard managers understood the importance of the "biological equilibrium" concept and worked to achieve and maintain it. In such a biological equilibrium, harmful and beneficial insects and pathogens control each other so that pest and disease incidence is constantly below a certain threshold which limits the risk of economic damage.

Orchards have to be part of an balanced fruit ecosystem in which biodiversity has to be preserved by increasing the number of species and varieties, orchard floor management with grasses has to be introduced and trees or shrubs should be planted to increase the number of microorganisms helpful for biological pest control in the vicinity of the orchard. Biological pest and disease control should be extended and promoted as widely as possible, since the success of this challenge is strictly linked to the number of orchards involved within a certain area. Natural soil fertility must be evaluated in relation to plant requirements during its different phenological stages and the availability of storage nutrients (carbohydrate and proteins) in the woody parts of the tree. Such compounds are re-mobilized during the early vegetative season and are a consistent input to reproductive and vegetative growth..

Extension services and public research institutions should play an important role in promoting integrated pest management and providing economic support to the growers who follow alternative strategies to control pests and diseases. Collaboration among research and scientific institutions specialising in different areas of horticulture (plant physiology, plant pathology, agronomy, plant breeding) would be useful in achieving the goal of integrated fruit production.

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IOBC/WPRS Working Group Meeting "Integrated plant protection in stone fruit"
Zaragoza (Spain) 24-26 September 1996

VERIFICATION OF INTEGRATED FRUIT PRODUCTION STRATEGIES IN STONE FRUIT IN EMILIA ROMAGNA (NORTHERN ITALY)

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ABSTRACT - Some years ago, the Emilia-Romagna region started a project to spread Integrated Production strategies in stone fruit orchards and develop software to manage a database for storing data collected on pilot farms. In 1995, the collected data was analyzed to verify the application of project guidelines and also obtain information about the incidence of major pests and diseases in different regional areas.

INTRODUCTION

The Emilia-Romagna region is one of the most important fruit-growing areas in Italy. Within the region there are 87,800 ha of orchards, of which 34,000 ha are peach, 25,000 ha are pear and 14,000 ha are apple.

To spread Integrated Production strategies and techniques among fruit growers, regional administration created the "crop advisory service".

In 1995 this service involved *c.* 17 % of the regional area, which included 17,800 ha of orchards; about one half of this area (*c.* 8,900 ha) were stone fruit orchards (Malavolta *et al.*, 1996). The areas involved are shown in Table 1.

Table 1. - Stone fruit orchards in Emilia Romagna in 1995 (from Malavolta *et al.*, 1996).

crop	Total (ha)	IPM (ha)	IPM (%)
peach	34300	6550	19.1
plum	4000	700	17.5
apricot	3200	570	17.8
cherry	2600	160	6.1

Together with the creation of the crop advisory service, software to manage a database was created. The aim of this database was to store data collected by technicians.

Technicians only collected data from orchards on "pilot-farms". On these farms, data concerning pests and diseases and the control measures adopted were collected. Technicians also visited other farms involved in the project, but less frequently, and the data was collected by the growers. The number of different farms and orchards involved in the project in 1995 are shown in Table 2.

Technicians took care of farms on a provincial basis. The Emilia-Romagna region is subdivided into 9 provinces (Fig. 1). To the north it borders on the Po river and to the south it borders on the "Appennino" mountains. As a result, the hilly areas are distributed in the southern part of every province, except Ferrara, which is in the lowlands. Rimini province was set up only recently and therefore it is to be considered together with Forlì.

Table 2 - Sample size: area and no. of orchards in 1995

	peach (ha)	(#)	plum (ha)	(#)	apricot (ha)	(#)
pilot	492.4	247	46.7	53	28.9	32
new	721.5	362	109.4	88	80.9	74
weekly visited	1111.6	495	205.0	189	62.0	51
fortnightly visited	1993.9	809	123.7	99	145.4	124
self-managed	2448.2	927	119.5	129	189.1	147
biological	3.7	3	=	=	1.1	1

Fruit growing and integrated pest management are of greatest importance in the eastern provinces. In the western provinces (Piacenza, Parma and Reggio Emilia) fruit growing is relatively unimportant. While peach is under integrated pest management in all the eastern provinces, plum is most important in Modena. Apricot orchards in which the IPM techniques are applied are in Bologna, but mainly in Forlì.
Table 3 shows the area and the number of orchards from which complete data collection was made in 1995.

Fig. 1 - Emilia Romagna in northern Italy and its provinces.

In peach orchards, data concerning cultivar distribution were analyzed. The results showed that while a large number of peach cultivars are grown, the area of each cultivar was small. The nectarine "Stark red gold" was the most widely distributed cultivar (*c.* 12% of the total peach orchard area). Among the peaches, the most abundant cultivar was "Red haven" (*c.* 4% of the total peach orchard area).

Table 3 - 1995 - IPM plots with full data sets

	peach orchards ha	no.	plum orchards ha	no.	apricot orchards ha	no.
Modena	8,76	13	27.16	21	=	=
Bologna	46,32	28	4.13	6	4.51	5
Ferrara	54,71	44	=	=	=	=
Ravenna	130,03	59	5.29	7	=	=
Forlì	109,69	52	5.48	9	16.14	18

TREATMENTS

The database was analyzed to obtain information about the pest management strategies adopted in orchards of the most important stone fruit crops; peach, plum and apricot.

In the following graphs (Figs. 2-8), treatments are plotted against pests and diseases in each of the various provinces. Data are expressed as "number of entrances"; a parameter which expresses the number of times that it was necessary to go into the orchard to control a pest, whether spraying the whole plot or only a portion of it.

PEACH

In all peach orchards, the pests requiring the most treatments were *Cydia molesta* and then *Myzus persicae*.

In provinces where peach growing was patchy and dispersed, such as Forlì and Ravenna, treatments were recorded more accurately and were less numerous.

In Modena, information extracted from the database seemed to indicate greater aphid problems. The number of "entrances" against aphids were greater in Modena than elsewhere and as a result more attention should be given to issues of resistance in this province (Fig. 2).

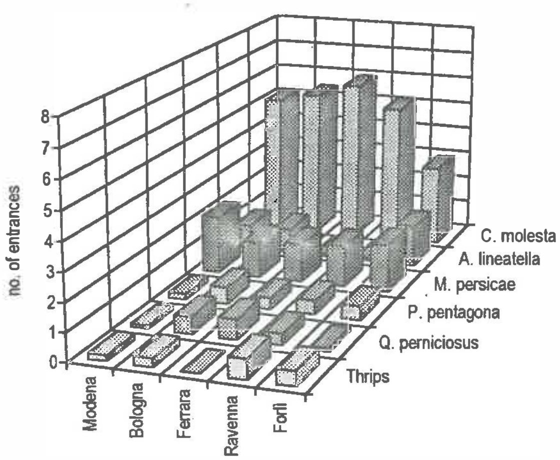

Fig. 2 - Peach, 1995 - "pilot" plots. "Number of entrances" against pests. Provincial data.

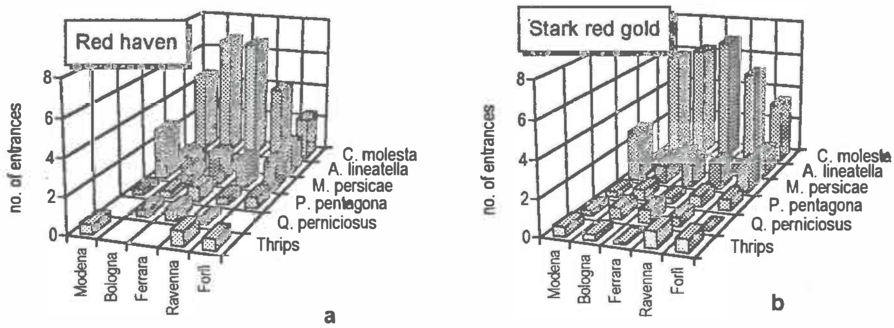

Fig. 3 - Peach, 1995 - a) Red haven and b) Stark Red Gold "pilot" plots. "Number of entrances" against pests. Provincial data.

The number of entrances against the most important pests within orchards of peach cvs. Stark red gold and Red haven are shown in Figure 3. As pointed by the pooled data (Fig. 2), the greatest number of treatments are against *C. molesta*. On Red haven, a few entrances against thrips have also been reported. As thrips are not usually a serious pest on this cv. it is believed that these treatments were actually applied in response to aphid damage.

The detailed data concerning treatments applied against pathogens show that powdery mildew, peach leaf curl and prunus blossom blight were the most serious stone-fruit diseases (Figs. 4 and 5). The importance of prunus blossom blight in particular has increased in recent years, even though it was considered to be a solved problem.

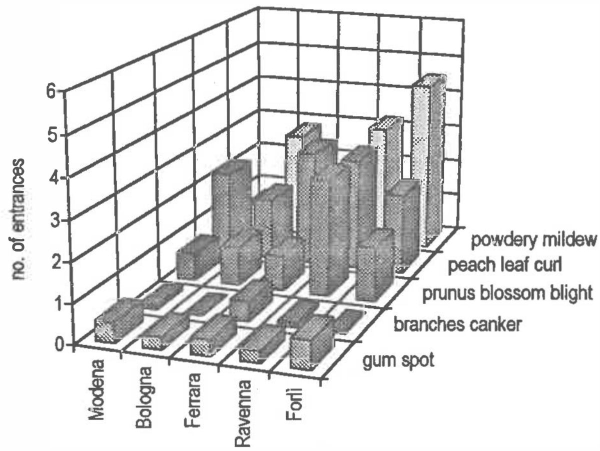

Fig. 4 - Peach, 1995 - "pilot" plots. "Number of entrances" against diseases Provincial data.

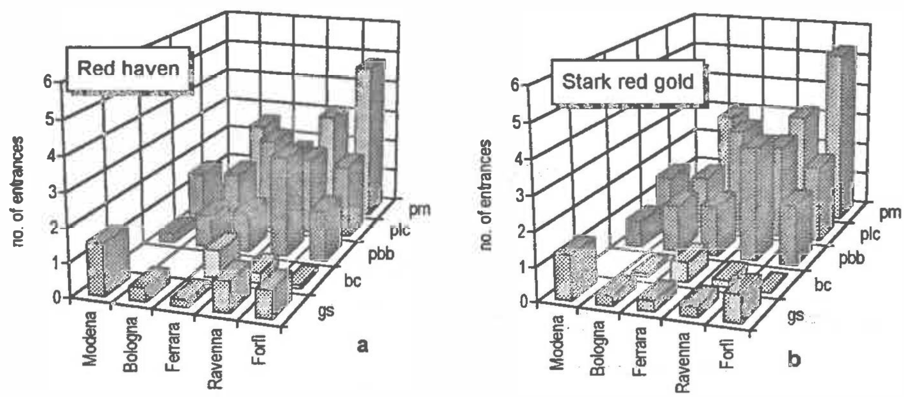

Fig. 5 - Peach, 1995 - a) Red haven and b) Stark Red Gold "pilot" plots. "Number of entrances" against diseases. Provincial data. Legend: pm: powdery mildew; plc: peach leaf curl; pbb: prunus blossom blight; bc: branches canker; gs: gum spot

Prunus blossom blight is a significant pre-harvest problem and in 1995 severe damage was suffered. It can be necessary to spray up to 3 times, but there are problems with many products because their latency periods are long and, moreover, because post-harvest treatments are not allowed in Italy. Powdery mildew appears to be a greater problem in hilly areas.

PLUM

Treatments applied to plum are shown in Figs. 6 and 7. *Cydia funebrana* is the most widely treated pest, however, in different provinces aphids and San José scale are also important. The disease which received most treatments was prunus blossom blight.

As with peach, the technicians in the province of Forlì seem to use fewer treatments for pest management on plum.

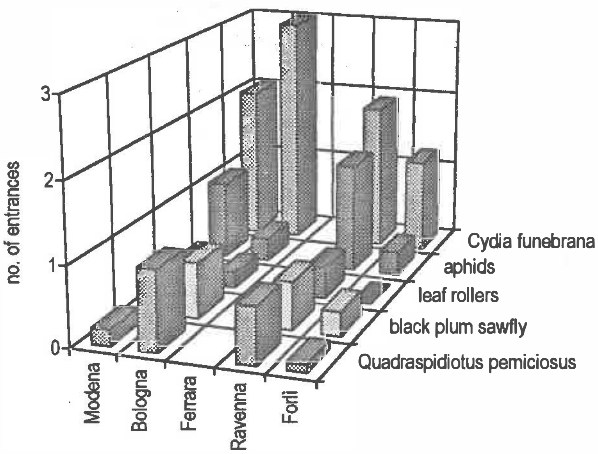

Fig. 6 - Plum, 1995 - "pilot" plots. "Number of entrances" against pests. Provincial data.

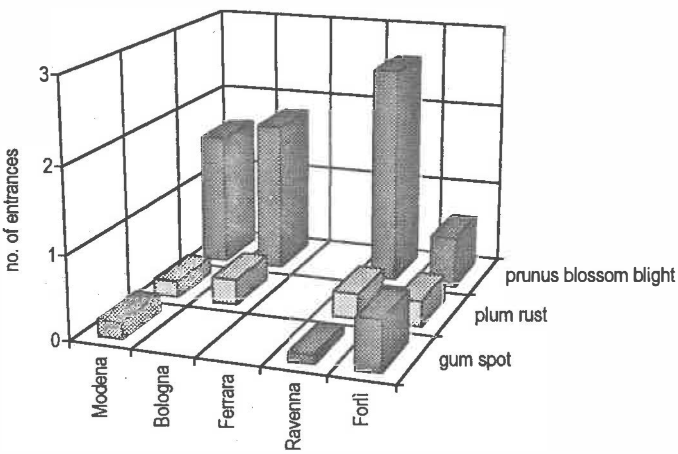

Fig. 7 - Plum, 1995 - "pilot" plots. "Number of entrances" against diseases. Provincial data.

APRICOT

Apricot was of comparatively marginal importance in the integrated pest management project. However, data collected in the few orchards visited showed that the most important insect pest was *Anarsia lineatella* and the most important diseases were prunus blossom blight and powdery mildew (Fig. 8).

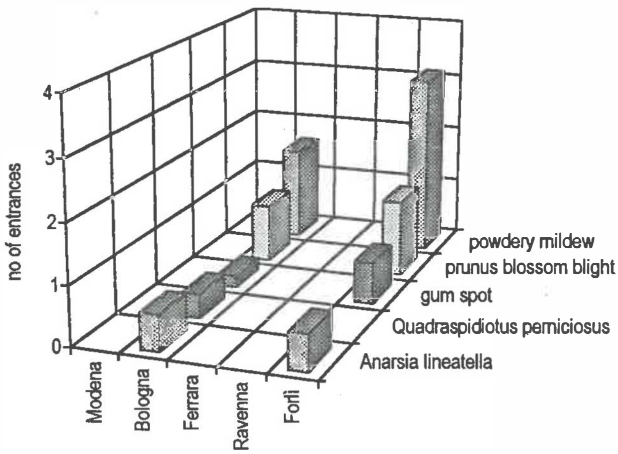

Fig. 8 - Apricot, 1995 - "pilot" plots. "Number of entrances" against pests and diseases. Provincial data.

MOTH FLIGHTS

Figure 9 shows the number of moth flights, plotted using the number of males caught/week/pheromone trap in Emilia-Romagna during 1995.

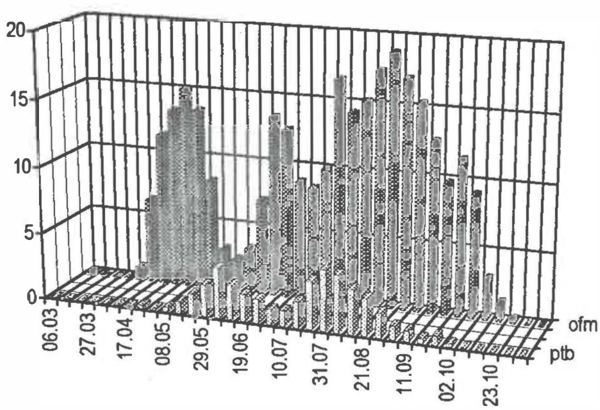

Fig. 9 - Peach - 1995 - "pilot" plots. Pheromone trap catches of males *Cydia molesta* (ofm) and *Anarsia lineatella* (ptb).

Cydia molesta was always present and was more abundant than *Anarsia lineatella*, which occurs much more sporadically. The sporadic occurrence of *A. lineatella* is both temporal (between seasons) and spatial (within and between seasons).

ACTIVE INGREDIENTS

The database has been analyzed to show the active ingredients used most commonly against the most important peach pests; *Cydia molesta* and *Myzus persicae*.

Data concerning treatments against *C. molesta* were grouped into the following categories; chemical pesticides, *Bacillus thuringiensis* and mating disruption (Table 4). *Bacillus thuringiensis* formulations have gained some interest in all provinces, however, the mating disruption method has only been used in Forlì.

The most frequently used active ingredient against aphids was acephate, which is also effective against thrips.

Pyrethroids were of greater importance than specific aphicides. In Modena province a high number of treatments were recorded.

Because both peaches and nectarines were present in some orchards, pest management could not be differentiated. Such orchards were treated as for nectarines, as nectarines are more susceptible to aphids and thrips than peaches.

Table 4 - Peach - "pilot" plots. Active ingredients and number of treatments against *Cydia molesta* in 1995. Provincial data.

	Modena	Bologna	Ferrara	Ravenna	Forlì
organic-phosphates	3.5	3.5	4.3	2.7	1.5
carbammates	1.2	1.4	0.9	2.0	1.0
IGR	0.2		0.1	0.0	
mating disruption					0.2
Bacillus thuringiensis	0.2	0.5	0.6	0.1	0.2
Total:	5.1	5.4	5.9	5.1	2.9

Table 5 - Peach - "pilot" plots. Active ingredients and number of treatments against *Myzus persicae* in 1995. Provincial data.

	Modena	Bologna	Ferrara	Ravenna	Forlì
acephate	1.1	0.3	0.3	0.7	1.0
ethiofencarb	0.3	0.1	0.2	0.0	0.1
fluvalinate	0.2	0.6	0.6	0.4	
methamidofos	0.4	0.1	0.2	0.2	0.4
mineral oil			0.1		0.1
pirimicarb	0.1	0.1	0.1	0.0	0.1
piretrins					0.0
Total:	2.1	1.3	1.5	1.5	1.8

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IOBC/WPRS Working Group Meeting "Integrated plant protection in stone fruit"
Zaragoza (Spain) 24-26 September 1996

INTEGRATED PRODUCTION OF STONE FRUITS IN EUROPE: THE DISCUSSION ABOUT IOBC TECHNICAL GUIDELINE III

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The development and implementation of integrated production have been important objectives of IOBC/WPRS since its foundation. During the 1980's, the strong demand from the Integrated Production (IP) organization convinced IOBC into preparing an endorsement procedure for regional IP guidelines which sought international recognition of their achievements.

After this decision, IOBC reactivated the Commission on "IP guidelines and endorsement" in 1990 with the aim of establishing a framework of general standards for IP which complied with the official IOBC principles put down in the declarations made at Ovronnaz (1976) and Veldhoven (1991).

This work produced the general procedures for IOBC endorsement as well as two general technical guidelines:

- Guidelines I: defines the legal status of the IP-organisations seeking for IOBC endorsement
- Guidelines II: provides the general rules and minimum requirements to be met by all endorsed farmers, on all types of farm and in all IOBC/WPRS regions.

All these documents were published in IOBC/WPRS Bulletin Vol. 16(1) 1993.

In order to give a complete scheme of reference, it was also decided that Guideline III (prepared on the same basis as general technical guidelines I and II) was necessary. The guidelines have to be prepared and published by the IOBC Working groups.

The first Guidelines approved and published after 1990 were the 2nd Edition of the Pome fruit guidelines (IOBC/WPRS Bulletin Vol. 17(9) 1994). This work was conducted by a joint group of IOBC and ISHS (International Society for Horticultural Science) technicians in order to achieve comprehensive coverage of all agronomy topics.

As a result of pome fruit Guidelines III, the preparation of the stone fruits guidelines was made simpler. The composition of the joint group was changed in order to include a number of stone-fruit specialists.

The first draft of the stone-fruit guidelines was presented in Cedzyna (Poland, August-

September 1995). The first meeting of the joint group was held in Piacenza (Italy, February 1996). This first draft was modified as a result of discussions at the two meetings and other comments from national experts who had contacted members of the joint group directly.

The second draft was accepted by the Commission on "IP guidelines and endorsement" and, after its approval, will now be published as an official document of IOBC.

This definitive edition, presented in Zaragoza (Spain, September 1996), contains several modifications specific to stone-fruit. The differences, compared to pome-fruit, are generally the result of the different climatic conditions (largely mediterranean) and other specific factors, e.g. 2-3 harvest periods. No post-harvest treatments are permitted, thereby avoiding long discussions on this topic. The use of undesirable pesticides (e.g. pyrethroids) is permitted in specific conditions (e.g. to combat resistant aphids or as pre-harvest treatments against fruit fly) with tight restrictions.

The common principles allowed the preparation of stone-fruit guidelines are essentially homogenous with those for pome-fruit, thereby aiding IP-organizations in the preparation of regional guidelines.

The stone-fruit guidelines have the objective of setting out general principles, minimum standards and guidelines for Integrated Production in Europe and are intended as a framework for formulation of regional or national guidelines and standards with the recognition of IOBC. However, it is also important to remember the no less important goal of achieving the technical co-operation throughout Europe, independent of any commercial purpose, which is fundamental to the production of effective IP guidelines.

Resistance to insecticides
(President: R. Olszak)

IOBC/WPRS Working Group Meeting "Integrated plant protection in stone fruit"
Zaragoza (Spain) 24-26 September 1996

PROBLEMS RELATED TO THE CONTROL OF THE PEACH-POTATO APHID, *MYZUS PERSICAE* SULZ. (HEMIPTERA:APHIDIDAE) IN CROATIA

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ABSTRACT - The paper reviews results of monitoring aphid populations (Aphididae) and their natural enemies on peaches and nectarines, and the appearance of persistant populations of *Myzus persicae*. Tests to control *Myzus persicae* showed resistance to pyrethroids and other aphicides. These studies also tested the efficacy of some new active ingredients which have different modes of action, such as imidacloprid, pimetrazine, triazomete.

INTRODUCTION

Aphididae are a significant problem for peaches and nectarines. Several aphid species attack peaches, in particular *Myzus persicae*, but also *Hyalopterus pruni*, *Brachycaudus pruniceae*, *B. persicae, B. amygdalinus* and *M. varians*.

Although other species such as *H. pruni* may appear in large populations, the most dominant species on peach-trees has been *M. persicae*, particularly during the later stages of vegetation growth. This aphid pest is very injurious to peaches and nectarines because its attacks debilitate plants, deform the growth of shoots and leaves, and in severe cases result in the desiccation of shoot tips.

Myzus persicae excretes honeydew abundantly which results in the appearance of sooty moulds. Significant damage is also caused by *Myzus persicae* as a vector of virus diseases.

A severe aphid attack was recorded in 1994 to all peach-trees in orchards with intensive growth of peaches and nectarines, particularly in Southern Croatia and Dalmatia.

Populations of the aphid were already large in spring and, as a result, considerable damage in the form of deformed shoots, abundant honeydew and occasional drying of tips occurred during the summer.

Control measures used against *M. persicae* demonstrated that standard aphicides, such as pirimicarb, metildemetone, vamidotione, timedotione and other insecticides, such as pyrethroids, did not affect *M. persicae*.

Resistance was recorded in Croatia for the first time in 1994. It had been previously recorded in the U.S. and Western Europe. Although many natural enemies and antagonists of *M. persicae* have been identified, it is difficult to control it without efficient aphicides. However, its presence within orchards does not become apparent until after damage has occurred.

The problem of *M. persicae* resistance appeared several years ago (Wachendorff- Neumann, 1984).

Myzus persicae first became resistant to organo-phosphorous insecticides and then later pyrethroids (Leclant, 1970; Robert, 1984) and some selective aphicides. Resistance of *M. persicae* is the result of individuals possessing increased carboxylesterase activity (Devonshire & Moores 1984; Furk & Murray, 1988).

Methods

The resistance of *M. persicae* was investigated during 1995 and 1996 on two different crops.

Trial 1995.

Locality: Zadar (Raštane Gornje) Croatia
Pest: *M. persicae*
Plant: fruit tree; Nectarine cv. Red June
Number of replicates: 3

Trial 1996.

Locality: Pula (Istria) Croatia
Pest: *M. persicae*
Plant: capsicum
Number of replicates: 3

The efficacy of the tested insecticides against *M. persicae* was calculated in percent. The results of the insecticide treatments were classified into categories using Duncan's multiple range test.

The presence of beneficial species was investigated using beat-sampling and direct observation techniques

Results

The results are shown in Figures 1 and 2. The figures show that the new active ingredients were effective in controlling *M. persicae*; imidacloprid proved to be 100% efficient, pymetrazin 100% and triazamate 81.3%, while pirimicarb proved to be only 36.0% efficient on peach-trees in 1995.

These new active ingredients were effective against those *M. persicae* populations which had proved resistant to pyrethroids.

The aphid natural enemies which were found on peach-trees are as follows:

Coleoptera	Coccinellidae	*Stethorus punctillum* *Exochomus quadripustulatus* *Adalia bipunctata* *Cocinella 7-punctata* *Propilea quatordecimpunctata*
Neuroptera	Hemerobiidae Chrysopidae	*Hemerobius sp.* *Chrysopa sp.*
Diptera	Syrphidae	*Episyrphus baleatus* *Syrphus sp.*

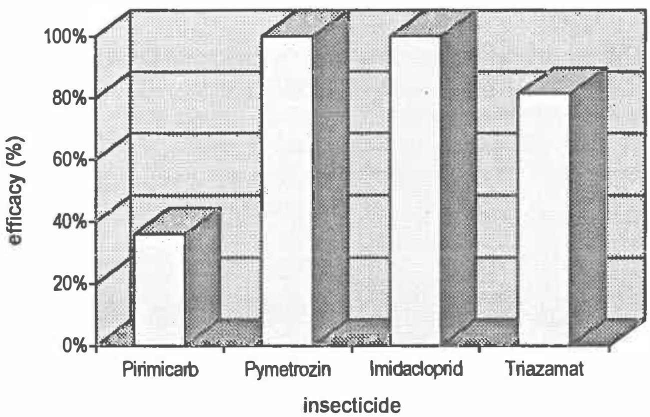

Fig. 1. Efficacy of insecticides against *Myzus persicae*. Zadar. 1995

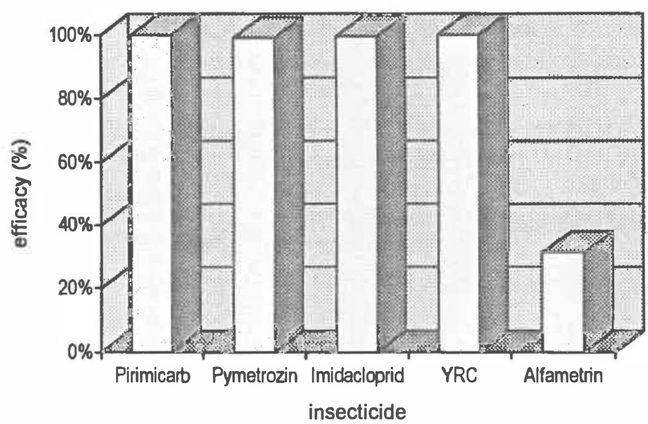

Fig. 2. Efficacy of insecticides against *Myzus persicae*. Pula. 1996

CONCLUSIONS

The impact of numerous insecticides and aphicides on *M. persicae* has been inadequate for several years. Severe damage caused by *M. persicae* was recorded in Croatia, especially in 1994, even though pyrethroids, pirimicarb and some other organo-phosphorus insecticides were also used for its control.

Testing of new active substances has demonstrated their effectiveness against *M. persicae*.

The insecticides imidacloprid, pimetrozine, triazamate and some other active ingredients proved to have a high efficiency in controlling *M. persicae*.

The following natural enemies of *M. persicae* were also found on peach and nectarine trees: *Exochomus quadripustulatus*, *Stethorus punctillum*, *Adalia bipunctata*, *Propylea quatuordecimpunctata*, *Hemerobius sp.*, *Chrysopa sp.*, *Episyrphus sp.*, *Syrphus sp.*

However, large populations of natural enemies only appear after the aphid population has peaked and the re-establishment of the natural equilibrium is slow.

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IOBC/WPRS Working Group Meeting "Integrated plant protection in stone fruit"
Zaragoza (Spain) 24-26 September 1996

RESISTANCE TO INSECTICIDES IN THE GREEN PEACH APHID AND INTEGRATED FRUIT PRODUCTION GUIDELINES

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ABSTRACT - The level of resistance in a population of *Myzus persicae* determines the efficacy of a treatment, knowing how it changes under different conditions would be useful in order to understand the phenomenon and to set up rules to be followed to prevent the spread and increase of resistant pest populations. Suggestions for defence strategies are given by regional IPM programmes in Italy. The IOBC guidelines will aid the control of the green peach aphid in the field.

INTRODUCTION

The decreased efficacy of chemical treatments, due to the selection of resistant individuals, is one of the best known consequences of the misuse of insecticides.

The environmental issue tends to play a predominant role among the various reasons for the growing interest in the realization of IPM programmes. The guidelines supplied by several technical services emphasize the use of some active ingredients while vetoing or restricting the use of others. One aspect often neglected is how best to prevent the onset of resistance to such active ingredients. The very fact that there is a restriction in the choice of active ingredients and in the possibility of alternating them, leads to a rising concern over the exacerbation of such a problem.

As for the green peach aphid, *Myzus persicae*, research knowledge about resistant populations is currently good. The analysis of some of the guidelines may provide examples supporting the introduction of strategies motivated by the results of opposite surveys.

HOW TO IDENTIFY THE LEVEL OF RESISTANCE IN POPULATIONS OF *MYZUS PERSICAE*

Observations and research carried out in the last few years have shown that populations of *M. persicae* respond differently to specific insecticidal treatments.

The genetic characteristics of a population depend upon its previous history, i.e. the treatments it has received in previous months and years, and on its environment, which is important because of the immigrations and emigrations that take place in peach orchards during summer and autumn.

The methods of analysis now available make it possible to gauge the level of resistance of single individuals and, therefore, the degree of heterogeneity of the population during the different stages of the aphid's life-cycle and the peach tree's development. The biochemical analyses currently in use are based on colorimetric techniques which estimate the concentration of esterases; the enzymes responsible for the aphids' resistance to carbamates and organophosphates (Devonshire, 1977). On the other hand, the biological tests make it possible to gauge the response of a population of reared or naturally-occurring aphids to different doses of a certain insecticide or to different active ingredients. Such tests allow the calculation of LD_{50} and LD_{95}, which are useful for the characterization of the population and in the choice of control treatment to be used in the orchard. Resorting to a discriminant dose of the different a.i. may prove of great advantage for a quick and reliable laboratory test.

Recent research has shown an increase in the degree of resistance during springtime in populations of *M. persicae* exposed to repeated treatments (Cravedi & Cervato, 1995).

To this purpose the chemical companies and their controlling agencies play a major role in setting up rules on which products to use and when to use them, as they influence the pressure of selection.

The results obtained in the laboratory would have to be considered every time a decision has to be taken in the field, so that treatments can be more effective and less likely to cause resistance phenomena.

THE GUIDELINES ISSUE

Several Italian regions have devised environment-friendly production programmes which have had the seal of approval of the European Commission, however, there are differences and contradictions amongst them (Cravedi *et al.*, 1996). The guidelines on integrated production supplied by the IOBC will help to provide a source of authority.

Considerable differences become apparent when comparing the regulations approved for the implementation of EC Regulation no. 2078 and the integrated production projects of several Italian regions, such as Emilia Romagna, Veneto, Piedmont, Lombardy, Basilicata (Malavolta *et al.*, 1995). According to EC Regulation no. 2078, the products to be used to control *M. persicae* on peach are those based on acephate, pirimicarb and etiofencarb, whereas the regional programme of IPM envisages a wider selection of active ingredients, including metamidofos (up to two treatments per year), fluvalinate and lambda-cialotrine (up to one treatment per year during pre-flowering).

The available information sets out restrictions which take the environment into consideration, however, they do not suggest strategies for the prevention of resistance.

To this purpose, local authorities should begin research into cases of resistance to insecticides by means of laboratory analyses and biological tests. Any recommended course of action should be based on reliable and verifiable data that is specific to a well-defined area.

CHOOSING THE RIGHT STRATEGY

Once the level of resistance of the aphid populations and the variations caused by different selection pressures are known, it is possible to modify control strategies accordingly.

An important step that can be taken to prevent the onset and the increase of resistance problems, is to alternate active ingredients with different modes of action, provided a sufficiently long interval is left between consecutive applications of the same active ingredient. As a matter of fact, resistance to a specific active ingredient tends to lessen over time. Insecticides which are effective, but not highly specific against aphids, can also be used successfully to eliminate the first resistant individuals.

Insecticides should be used at the recommended dose and should be applied efficiently. Tank-mixes of different active ingredients should be made using the full dose of each compound. The persistence of products in mixes should also be considered since the ingredient with the longer activity will be acting in isolation for a certain period of time and thereby carrying out a specific selection.

The above suggestions, together with continuous monitoring of the levels of resistance in aphid populations, could contribute considerably to putting control strategies into practice as a response to real problems.

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DISEASES
(PRESIDENT: R. OLSZAK)

OILB/SROP Reunion du Groupe de Travail "Protection intégrée en vergers de fruit à noyau".
Zaragoza (Espagne) 24-26 September 1996

TAXONOMIE DE L'*AMPELOMYCES QUISQUALIS* PRESENTE SUR *SPHAEROTHECA PANNOSA* SUR VAR. BAILEY ET CONTRIBUTION A L'ETUDE SUR SON UTILISATION CONTRE L'OIDIUM DU PECHER A GOTHERON (MOYENNE VALLEE DU RHONE)

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RESUME - Dans le cadre d'une concertation avec L. Kiss (chercheur hongrois) spécialisé dans l'étude du genre *Ampelomyces*, un travail sur la taxonomie moléculaire de la souche présente sur la variété Bailey à Gotheron a été entrepris au cours du printemps 1996. Les travaux engagés ont permis d'identifier et de classer notre souche qui porte la référence AQ.INRA Goth.95=Groupe 3, Type II. Les résultats concernant l'utilisation de l'*Ampelomyces quisqualis* en pulvérisation contre l'oïdium du pêcher sur la variété Bailey de très grande sensibilité indiquent un effet significatif de la protection réalisée avec 4 traitements par rapport au témoin et à 2 autres situations que ce soit au niveau des pourcentages fruits sains ou des pourcentages de fruits oïdiés restants (non parasités). Il faut signaler qu'une régression des taches d'oïdium sur fruits oïdiés parasités par *A. quisqualis* a été constatée mais pas quantifiée.

INTRODUCTION

L'*Ampelomyces quisqualis* (A.Q.) est signalé depuis de nombreuses années comme un champignon hyperparasite des oïdiums, mais il existe au sein du genre Ampelomyces un grand nombre d'espèces. Depuis plusieurs années, nous travaillons sur une souche d'*A. quisqualis* présente sur l'oïdium du pêcher (sur la variété Bailey) avec comme objectif de voir son éventuelle utilisation dans la lutte contre cet oïdium. L'opportunité d'identifier notre souche s'est faite au cours de la campagne 95-96.

En ce qui concerne son utilisation, notre objectif était de voir d'une part l'effet de traitements précoces sur le développement des attaques d'oïdium sur fruits et d'autre part de différencier dans les fruits oïdiés ceux dont la présence d'A.Q. était observée.

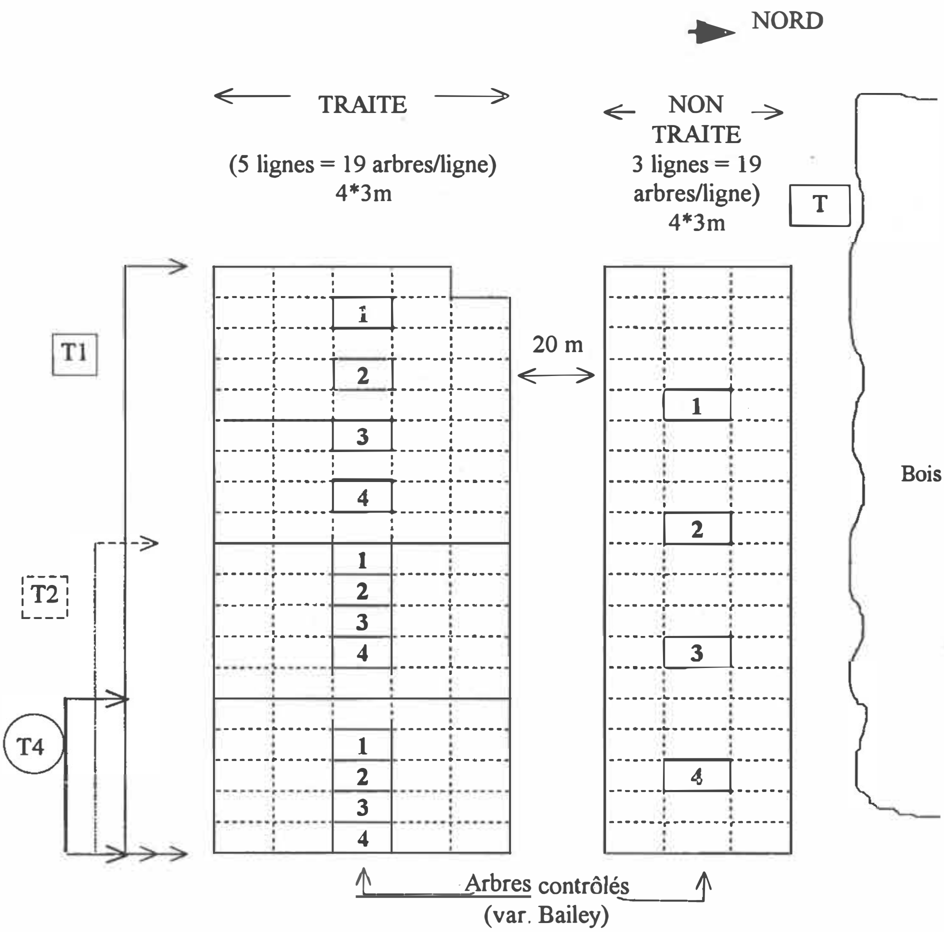
MATERIEL ET METHODE

1) TAXONOMIE DE L'*AMPELOMYCES QUISQUALIS*
- prélèvement de la souche
- étude taxonomique (empreinte génétique et caractérisation morphologique + physiologique)

2) UTILISATION CONTRE L'OIDIUM DU PECHER
- préparation et production de la solution Ampelomyces

- dispositif (voir schéma ci-dessous)
- 4 arbres repérés par situation (4)
- 10 rameaux identifiés par arbre et 5 fruits contrôlés/rameau (200 fruits/situation)
- observations phénologiques
- notations d'oïdium hebdomadaires et diamètre des fruits
- traitements réalisés avec pulvérisation ATOM 2000

Schéma du dispositif



4 situations 96 :

T (non traité A.Q.) mais Ampelomyces présent (suite manip. 93, 94, 95)
T1 (1 traitement)
T2 (2 traitements)
T4 (4 traitements)

RESULTATS

TAXONOMIE

Les travaux récents engagés (Kiss, 1995; Kiss et Vajna, 1995) au niveau de l'empreinte génétique de ce champignon et sur l'étude des caractères morphologiques et physiologiques (sur isolats) ont permis de mettre en évidence de nouvelles approches dans l'étude du genre Ampelomyces. Plus de 35 souches d'*Ampelomyces spp* ont été étudiées, classées en 6 groupes et répartis en 2 types : I = croissance rapide ; II = croissance lente (Kiss, 1996 ; com. pers. publication à paraître).

La souche d'*Ampelomyces quisqualis* de Gotheron a été prélevée le 14 avril 1995 sur des bourgeons oïdiés primaires (bourgeons à bois) de la variété Bailey. Elle a été isolée puis réensemencée par scarification toutes les 3 semaines, en boîte de Pétri, sur milieu V8 préférable à d'autres (Marboutie *et al.*, 1995).

La souche provenant de Gotheron se classe dans le groupe 3 et appartient au type II.

UTILISATION DE L'AMPELOMYCES QUISQUALIS

Les résultats sont consignés dans les tableaux 1 et 2.

Tableau 1. Pourcentages de fruits sains et fruits oïdiés parasités

		TRAITEMENTS				CONTROLES				
	Dates	11/04	19/04	25/04	06/05	15/05	22/05	29/05	05/06	12/06
PHENO		G	G-H	H-I	I					
SITUATIONS	T	Non	Non	Non	Non	**89.4** 5.3	**74.9** 20.2	**38.7** 21.8	**3.7** 36.2	**3.2** 66.5
	T1	Oui	Non	Non	Non	**81** 9.5	**35.3** 42.2	**6.9** 49.1	**4** 75.3	**0** 87.1
	T2	Oui	Oui	Non	Non	**76.4** 12.3	**43.4** 36.8	**15.1** 44.3	**6.7** 63.2	**2.8** 77.4
	T4	Oui	Oui	Oui	Oui	**94.3** 5.1	**75.7** 16.7	**39.1** 30.1	**39.1** 38.5	**14.1** 64.7

Analyse = Données transformées en ARC SIN RAC%
Fruits sains = Coef. de variation : 16.58 % - Probabilité : 99.94%
Classement : Test N et K = T4 > T > T2 > T1

Tableau 2. Pourcentages de fruits oïdiés restants (non parasités)

Dates		TRAITEMENTS				CONTROLES				
Dates		11/04	19/04	25/04	06/05	15/05	22/05	29/05	05/06	12/06
PHENO		G	G-H	H-I	I					
SITUATION	T	Non	Non	Non	Non	**5.3** (12.9)	**14.9** (17.8)	**39.5** (22.9)	**60.1** (26.7)	**30.3** (28)
	T1	Oui	Non	Non	Non	**9.5** (12)	**22.5** (16.6)	**44** (21.4)	**20.7** (24.2)	**12.9** (24.9)
	T2	Oui	Oui	Non	Non	**11.3** (12.1)	**19.8** (17.2)	**40.6** (22.3)	**30.1** (25.1)	**19.8** (26.1)
	T4	Oui	Oui	Oui	Oui	**0.6** (11.9)	**7.6** (16.6)	**30.8** (21.3)	**22.4** (24.5)	**10.2** (25.6)

(Nbre) = Diamètre moyen en mm
Analyse = Données transformées en ARC SIN RAC %

Fruits oïdiés (non parasités) = Coef de variation : 20.86%
Probabilité : 92,22%
Classement : T > T4
T2 > T4

CONCLUSION

Dans le cadre de cette expérimentation dont l'objectif était de voir l'incidence de traitements Ampelomyces sur le développement des attaques d'oïdium sur fruits, il est intéressant de constater l'effet significatif du champignon parasite sur la réduction de ces attaques occasionnées sur la variété Bailey connue comme extrêmement sensible à l'oïdium.

Cette étude devrait être reconduite les prochaines années sur des variétés commerciales, en plus de Bailey, selon 2 stratégies de lutte (une, de la nouaison au durcissement du noyau, l'autre avec une cadence de traitements plus espacée et adaptée à la lutte chimique.

Les travaux menés conjointement sur la taxonomie moléculaire (empreinte génétique, étude des caractères) de notre souche d'Ampelomyces issue du verger de Marquet ont permis de l'identifier. Elle est répertoriée dans le groupe 3 (les différentes souches d'*Ampelomyces spp*. étant classées en 6 groupes) et correspond au type II (croissance lente) contrairement au type I (croissance rapide).

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IOBC/WPRS Working Group Meeting "Integrated plant protection in stone fruit"
Zaragoza (Spain) 24-26 September 1996

EARLY DIAGNOSIS OF FUNGAL DISEASES IN STONE FRUIT CROPS

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ABSTRACT - A chemical indicator was developed which allowed the diagnosis of *Cocomyces hiemalis* Higg., *Clasterosporium carpophilum* Aderch. and other fungal diseases affecting stone fruit several days before the appearance of visible symptoms, thus allowing fungicides to be applied earlier with increased effectiveness. Trees are tested by applying the indicator to 40-50 leaves, after 2 hours lesions are dyed an intensive colour which can be easily seen with the naked eye.

INTRODUCTION

The main diseases in Russian stone fruit orchards are *Cocomyces hiemalis* Higg. and *Clasterosporium carpophilum* Aderch.

Cocomyces hiemalis is the most important disease in cherry and sour-cherry orchards. During favourable conditions all leaves are affected, causing them to fall by the end of July.

In addition, affected fruits are of lower quality. Cases of complete destruction of cherry orchards have been reported (Fomenko, 1990).

Clasterosporium carpophilum causes the most severe damage to plum, apricot, peach and almond. During favourable conditions this disease can affect 70-80 % of the trees (Skiba, 1986).

It is usually recommended that fungicide treatments against *C. carpophilum* are applied following a calendar system; twice in the autumn (at the beginning and the end of leaf-fall) and three times in the spring (at pink bud, post-blossom and at the beginning of fruit formation.

A few fungicide applications are recommended for use against *Cocomyces hiemalis*, usually during bud-burst, once or twice post-blossom (with 10-14 day intervals) and twice post-harvest. These treatments, applied on the calendar system, are often unnecessary.

In recent years, a forecasting system based on weather conditions has been developed (Smolyakova *et al.*,1995). However, temperature and humidity vary greatly during the course of a day and as a result such theoretical applications are not particularly accurate. However, the targeting of treatments is more important than the choice of fungicide.

We prepared a chemical indicator (and method of application) for the accurate diagnosis of infection by these fungal diseases.

MATERIALS AND METHODS

The trials were carried out in a stone fruit orchard in Voronezh region during 1995 and 1996. Within the orchard there were apricot, plum, cherry and sour-cherry trees.

Half of the trees were sprayed with fungicides on calendar system in both years. The remaining trees were left unsprayed.

Each week, 100 leaves from five trees of each fruit type were analysed visually and with the aid of the chemical indicator (the composition of this indicator is currently the subject of patent applications). After visual analysis the same leaves were wetted with the indicator. After 2 hours the dyed lesions caused by fungal attack were clearly visible with the naked eye.

RESULTS

In 1995 and 1996, the months of May and June were very hot and without precipitation. Visible symptoms of *C. hiemalis* and *Clasterosporium carpophilum* on leaves began to appear in late-July (after harvesting) and at the same time on both untreated and sprayed trees. The application of fungicides by the calendar system proved to be unnecessary during both of these years

Visible symptoms of disease first appeared on 25 July 1995 and 31 July 1996. The indicator allowed the diagnosis of both diseases at the incubation stage, 5-6 days before the appearance of visible symptoms. The indicator showed high sensitivity (Table 1).

Table 1. Results of the evaluation of lesions on leaves with "indicator" (25th July 1996).

Fruit	Pathogen	leaves infected (%)	
		before indicator	after dip indicator
Apricot	*Clasterosporium carphophilum*	0	53
		0	81
		0	62
		2.3	45
		0	32
		5.0	74
		0	38
Plum	*Clasterosporium carphophilum*	0	21
		0	36
		0.7	42
		0	28
		0	47
Cherry	*Cocomyces hiemalis*	1.5	23
		0	34
		0	28
		0	18
		0	12

The application of fungicides against both pathogens, as a result of diagnosis of the diseases at the incubation stage using the indicator, prevented the development of disease and the appearance of visible lesions on the leaves later in the season.

Conclusion

The indicator developed during this study allowed the identification of lesions on leaves and fruit caused by *Cocomyces hiemalis* and *Clasterosporium carpophilum* some days before the appearance of visible symptoms. This early diagnosis allows the a more timely and effective application of fungicide treatments and the possibility of a reduced number of applications.

The indicator has the potential for the early diagnosis of other fungal diseases.

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Natural enemies in stone fruit ecosystems
(President: R. Olszak)

IOBC/WPRS Working Group Meeting "Integrated plant protection in stone fruit"
Zaragoza (Spain) 24-26 September 1996

APHID NATURAL ENEMIES IN UNITED KINGDOM PLUM ORCHARDS

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ABSTRACT - Relationships between several plum aphid species and their natural enemies were investigated in a UK plum orchard. A variety of techniques was used to monitor population densities of the damson-hop aphid (*Phorodon humuli* (Schrank)), the leaf-curling plum aphid (*Brachycaudus helichrysi* Kaltenbach), and the mealy plum aphid (*Hyalopterus pruni* Geoffroy), and their natural enemies, which included predators, parasitoids and entomopathogenic fungi. The most abundant natural enemies were the polyphagous predators *Forficula auricularia* (Dermaptera) and spiders (Araneae). The most numerous aphid-specific predators included Coccinellidae, Syrphidae, Anthocoridae, Miridae and Chrysopidae. The intensity of predation was dependent upon the degree of synchrony between the population development of individual plum aphid species and their major predators. Thus, differences in aphid phenology resulted in populations of *B. helichrysi* increasing unchecked in early spring, whereas the mid- to late- season populations of *P. humuli* were predated heavily. Methods to conserve the natural enemies, and incorporate them into a future IPM programme for plum aphids, are discussed.

INTRODUCTION

Aphids are the most important pests in UK plum orchards (Gratwick, 1992). Three potentially damaging aphid species overwinter on a range of both wild and cultivated *Prunus* species; the leaf-curling plum aphid, *Brachycaudus helichrysi*; the damson-hop aphid, *Phorodon humuli*; and the mealy plum aphid, *Hyalopterus pruni*.

Uncontrolled plum aphid infestations reduce plant vigour, resulting in a reduction of shoot growth, undersized fruit and, in the case of *B. helichrysi*, the eventual defoliation of those areas colonized by the aphid. In addition, all three aphid species contaminate fruit and foliage as a result of sooty mould (*Cladosporium* spp.) development on honeydew. Of the three species, *B. helichrysi* is the commonest pest, and causes the most severe damage (Alford, 1984). In the spring, aphid populations build-up rapidly, often causing significant damage to plum trees before the pest problem is detected. This threat of aphid damage has encouraged the prophylactic use of tar oil winter washes and broad-spectrum insecticide sprays. While these insecticides sprays control both *B. helichrysi* and *H. pruni*, they are of limited value against *P. humuli* which is resistant to all the pesticide groups currently registered for use against plum aphids (see Campbell & Hrdý, 1988). Moreover, these non-selective pesticides destroy natural enemies, allowing populations of the pesticide-resistant *P. humuli* to increase uninhibited.

The absence of an effective pesticide for *P. humuli* highlights the need to develop an alternative control strategy for plum aphids. The manipulation of indigenous natural enemies offers a possible solution. Comprehensive monitoring studies of pests and natural enemies are necessary in order to identify the availability and potential effectiveness of any predator complexes in the field. To date, such detailed knowledge of aphid-natural enemy population dynamics within UK plum orchards has been limited to a one-season study by Ward (1969).

MATERIALS AND METHODS

Field experiments were carried out during 1994 in a plum orchard (cv. "Victoria") at East Malling. The orchard was surrounded by a 3m wide grass verge, bounded on three sides by cereal fields, and on the southerly side by an alder windbreak (*Alnus glutinosa* (L.) Gaertner). The prevailing wind at East Malling is from the south-west. No pesticides were applied during the course of these experiments.

LEAF SAMPLES

Samples of 100 leaves were collected and examined at weekly intervals. Counts were made of aphids and their natural enemies (including parasitized aphids and aphids infected with entomopathogens) present on the leaves.

BEATING TRAY SAMPLING

Aphid predators were monitored within the plum orchard with a beating tray (*c.* 110 cm x 86 cm). A total of 25 random beat samples was taken at weekly intervals.

STICKY TRAPS

Double-sided sticky cards (20 cm x 20 cm) covered with "Oecotak" (Oecos Ltd., Kimpton, Herts., UK) were hung in the orchard, *c.* 2 m above the ground. The relative attractiveness of blue, white and yellow traps to aphid predators flying within the orchard was compared using a randomised block design. Traps were collected and examined, and their replacements rerandomised, on a weekly basis.

PREDATOR REFUGIA

A total of 16 predator refugia was placed within the orchard at the beginning of October. The refugia were made from 1.5 l plastic soft-drink bottles with the bottoms removed and packed with corrugated cardboard. Each refugia was securely attached to the main trunk of a tree, *c.* 2 m above the ground. The refugia were emptied after 12 weeks and all overwintering insects were identified.

RESULTS

APHID PHENOLOGY

Populations of *B. helichrysi* were the earliest to build-up. Peak aphid abundance occurred on 18 May, and was larger than the subsequent peak populations of both *P. humuli* and *H. pruni* combined. Rapid and complete decline of *B. helichrysi* populations followed over the next three weeks. The overall population levels showed fewer fluctuations than those for *P. humuli* or *H. pruni* (Figure 1c). *Phorodon humuli* populations built-up slowly from mid-May, peaked on 1 June, and declined over the following 6 weeks. Population levels of *H. pruni* were erratic and generally too low to interpret accurately.

ENTOMOPATHOGENIC FUNGI

Between April and late May the numbers of aphids infected with fungal pathogens increased, reaching a peak in early June when the nearly 25% of the total number of plum aphids in leaf samples were infected with entomopathogenic fungi. The fungal pathogens involved were not identified.

PARASITOIDS

During 1994 a total of 13 aphid mummies were found in leaf samples (Table 1).

Table 1. Plum aphid parasitoids within leaf samples.

APHID HOST	MUMMY-TYPE	PARASITOID SPECIES
Brachycaudus helichrysi	5 *Ephedrus* spp.	1 ♀ *Ephedrus persicae* 2 *Dendroceras* spp.* 2 Not emerged
	4 *Aphidius* spp.	2 ♀ *Aphidius matricariae* 2 Not emerged
Phorodon humuli	3 *Ephedrus* spp.	1 ♀ *Ephedrus persicae* 1 *Asaphes vulgaris** 1 Not emerged
Hyalopterus pruni	1 *Praon* spp.	Not emerged

*Hyperparasitoids

APHID PREDATORS

Aphid predators from 7 arthropod taxa were identified from beat samples (Figure 1b(i) and 1b(ii)). The anthocorid, *Anthocoris nemorum* L., the 10-spot ladybird, *Adalia decempunctata* L., and the 14-spot ladybird, *Propylea quatuordecimpunctata* L., dominated catches of aphid-specific predators in beating-tray samples. However, during the period of aphid infestation polyphagous Araneae and *Forficula auricularia* (Dermaptera) were the most abundant predators.

Sticky trap catches allowed the activity of highly mobile predator groups, e.g. adult Syrphidae, to be monitored more effectively. The most numerous adult syrphids (with predatory larvae known to be associated with aphid colonies) included; *Episyrphus balteatus* Degeer, *Eupeodes (Metasyrphus) corollae* F., *Syrphus ribesii* L. and *Platycheirus peltatus* Meigen. These aphidophagous syrphid species all occur from late June to August (Figure 1a). The colour of the sticky traps influenced catches of certain predator species. For example, yellow sticky traps were significantly more attractive than either blue or white for the coccinellid *A. bipunctata* ($p<0.01$) and the anthocorid *Anthocoris nemorum* ($p<0.001$).

PREDATOR REFUGIA

The 16 refugia contained a total of; 527 Forficula auricularia (517 ♂, 10 ♀), 91 spiders, two female *A. nemorum*, two female *Chrysoperla carnea* Stephens and one female *Coccinella undecimpunctata* L.

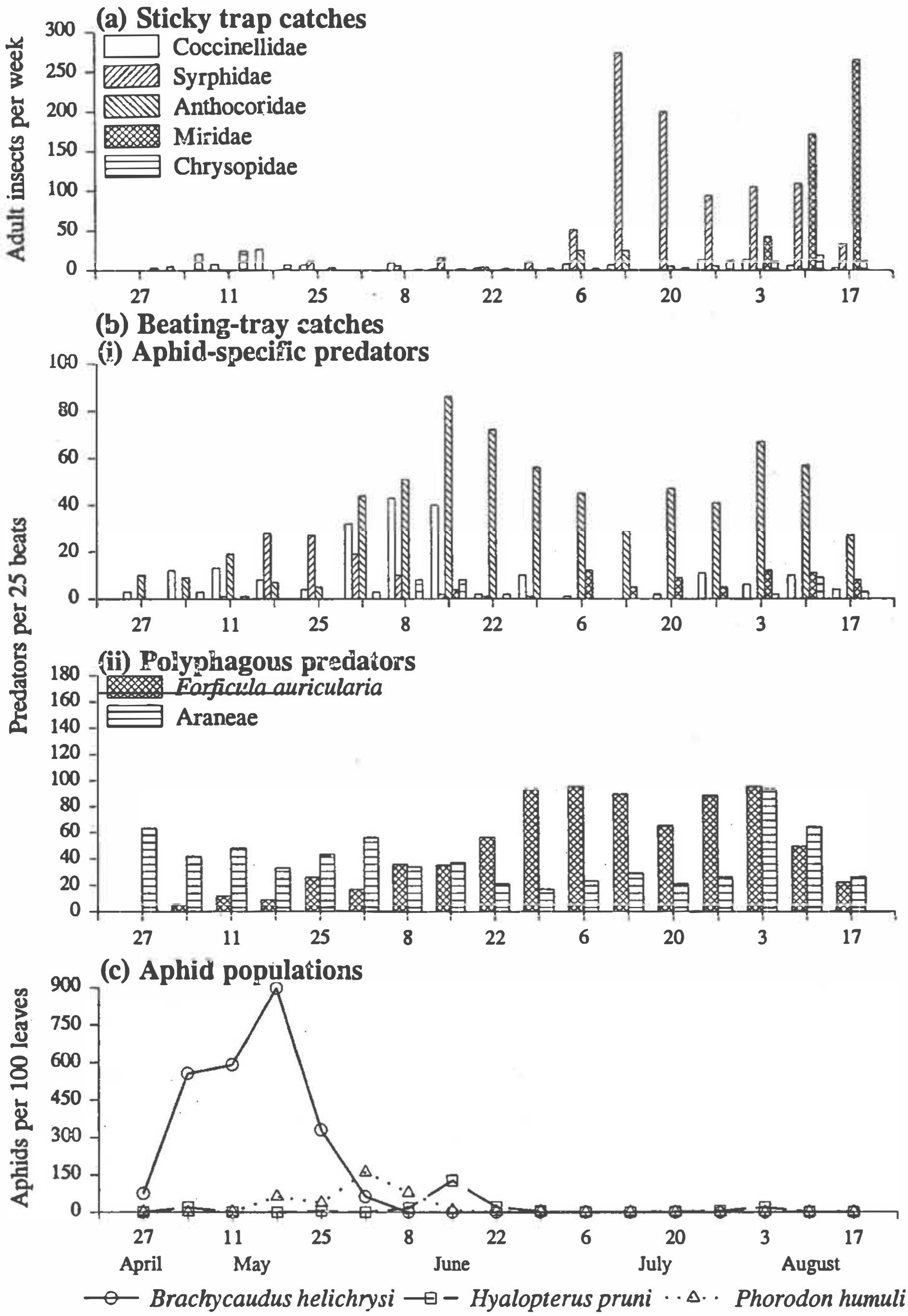

Figure 1. Changes in aphid and predator populations on plum during 1994.

DISCUSSION

The development of aphid populations on plum during spring 1994 followed the pattern observed by Ward (1969), where *B. helichrysi* builds up into larger numbers earlier than either *Phorodon humuli* or *H. pruni*.

Entomopathogenic fungi and aphid parasitoids appear to be of limited importance in the regulation of aphid numbers on plum. The peak of entomopathogenic infection occurs well after populations of *B. helichrysi* had peaked, while the effectiveness of parasitoids as control agents may be hindered by high levels of hyper-parasitism.

Although anthocorids and ladybirds appeared early in the spring, the majority of aphid-specific predators became abundant after populations of *B. helichrysi* had peaked. There was a greater synchrony between the build-up of *P. humuli* populations and that of certain aphid-specific predators, e.g. coccinellids and syrphid larvae (Figure 1b(i)). Studies in the same orchard have shown that in the absence of broad-spectrum pesticides the indigenous natural enemies are capable of controlling these mid- to late- season populations of *P. humuli* (Hartfield & Campbell, 1996). However, this natural enemy complex develops too late in the season to be able to control *B. helichrysi*.

Polyphagous predators, such as *Forficula auricularia* and the Araneae, are potentially important aphid natural enemies because they are often relatively abundant in the orchard during periods of the year when the aphid-specific predators are scarce. However, because both *F. auricularia* and Araneae often eat other predators, their importance within the natural enemy complex is questionable. This is particularly relevant within the overwintering predator refugia where it was evident that *F. auricularia* was feeding upon less robust predatory species, such as adult chrysopids.

The colour yellow is clearly an important visual cue for predatory coccinellids. The visual ecology of plum aphid predators needs further study so that appropriate visual stimuli can be incorporated into monitoring programmes and strategies to improve predator abundance, this might include sowing ground cover crops that attract in aphid predators.

These studies have demonstrated the wide range of predators, and other natural enemies, available as biological control agents against plum aphids. In orchards, natural enemy populations like this are often the major form of biological control available for IPM (Luck *et al.*, 1988). Although effective natural control of *B. helichrysi* is unlikely, due to its lack of synchrony with predator populations, the results presented here show that natural enemies have the potential to regulate *P. humuli* populations in plum orchards. However, the full impact of these natural enemies will only be realised in orchards where broad-spectrum insecticides are not used.

ACKNOWLEDGEMENTS

This work was funded by the Horticultural Development Council.

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IOBC/WPRS Working Group Meeting "Integrated plant protection in stone fruit"
Zaragoza (Spain) 24-26 September 1996

BIO-ETHOLOGICAL OBSERVATIONS ON *ARCHIPS ROSANUS* L. (LEPIDOPTERA: TORTRICIDAE) ON CHERRY IN APULIA (SOUTHERN ITALY) AND POSSIBILITIES FOR ITS INTEGRATED CONTROL

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ABSTRACT - *Archips rosanus* L. (Lepidoptera, Tortricidae), the European leafroller, is one of the most injurious insects on cherry in Apulia. Its biology and behaviour were studied in 1993 and 1994 in order to obtain parameters useful for rational control. Egg batches (2-3 masses per female) were laid mainly on branches, at an average height of 150-160 cm above the soil. They should be sampled during February, after the period of the maximum perdition which was observed from November to January. Eggs hatched from mid-March to April, peaking between the end of March and the beginning of April. First and second instar larvae, which are more susceptible to insecticides, were present during early-April. Approximately 10% of pupae were parasitized; *Itoplectis maculator* (Fabricius) (Hymenoptera: Ichneumonidae) was the most common parasitoid. Adult *A. rosanus* started to fly during mid-May, with a peak flight period during the first week of July. Pheromone traps were not particularly specific.

INTRODUCTION

The increase in the number of monocultures and careless pesticide applications has simplified the agricultural ecosystem. The result has been a decrease in natural enemy populations and an increase in the importance of some secondary pests which previously caused only occasional problems. Damage caused to cherry orchards by *A. rosanus* has been often reported in Apulia, one of the most important areas for the cherry production in Italy. This pest has only one generation per year and overwinters at the egg stage. The eggs are laid in small groups called egg masses. Larvae hatch in early spring (March-April) and feed on leaves, flowers, young stems and fruits. Larval development takes 28-55 days and pupation lasts 10-20 days. After mating, females lay 2-5 egg masses.

The purpose of this study was to identify some of the parameters concerning the population dynamics of *A. rosanus* in the Mediterranean environment and to obtain useful information for the rational control of the species.

MATERIALS AND METHODS

Laboratory and field studies were conducted during 1993 and 1994.
Field observations were carried out in a cherry orchard (cv. Ferrovia) located at Turi (Province of Bari). The orchard was rectangular, flat, *c.* 0.6 ha in size, with trees spaced at a distance of

c. 6 x 4 m. During the research, the orchard was not irrigated and received no insecticide treatments, but the usual cultural practices were applied.

A sample of 300 egg masses, laid on branches, was located during the winter of 1993. The following parameters; a) size (length and width), b) distance from the soil, c) circumference of the infested branch, and d) orientation, were determined for each egg mass *in situ*.

The egg masses were checked weekly to monitor colour changes, damage or any other modifications of notable interest.

In early February 1994, 80 egg masses were collected, the eggs were counted and placed individually into glass vials. These were checked, using a binocular microscope, every two days to determine the rate of parasitism and to observe egg-hatch. In addition, twenty-five larvae were reared individually in glass vials and checked every two days in order to monitor growth and the duration of each instar. All the vials were maintained in a rearing box outside under natural conditions.

Twenty-five days after the start of egg-hatch, samples of 100-120 larvae were collected from the field at fortnightly intervals. These larvae were measured to estimate the larval instar and reared in boxes to obtain parasitoids and determine the rate of parasitism.

The flight periods of male *A. rosanus* were investigated using two pheromone traps (pheromone: Z-11-TDA + Z-11-TDCL) located in the orchard. In late March 1994, 27 plastic-net cages were placed over infested branches in order to investigate larval and pupal parasitism, sex-ratios and the flight activity of male and female moths. The cages and pheromone traps were checked weekly.

In 1994, 30 pairs of moths were reared individually in boxes in order to determine the number of egg masses laid per female.

Maximum and minimum daily temperatures were recorded throughout 1993 and 1994.

RESULTS AND DISCUSSION

The circumference of infested branches varied between 3 and 75 cm, with an average value of 21 cm. Approximately 80 % of the egg masses were found on branches with a circumference between 5 and 35 cm.

This data contrasts with that of Balachowsky (1966) and Inserra (1980), who found eggs located more frequently on the trunk and larger branches (the size of which they did not refer to). Our observations show greater parity with those of Benfatto (1973), who reported egg-laying on branches of more than 6.2 cm in circumference.

Egg masses were laid between 40 and 305 cm above the soil, with an average of *c.* 160 cm (Table 1). This data indicates that the egg masses are laid more frequently in a position which is easier to see while sampling.

Table 1. Size of the branches with egg masses; distance of egg masses above the soil. Both in cm.

	Circumference	Distance above the soil
Average	21	157.5
Max	75	305
Min	1	40
St.dev.	13.52	47.22

Table 2. Size of the egg masses (mm) and number of eggs per masse

	Width	Length	Eggs
Average	3.7	5.3	47
Mode	4	5	53
Max	8	10	89
Min	1	1.5	10
St.dev.	1.09	1.56	18.55

There was no preferential orientation in the position of egg-masses.

The egg masses were elliptical in shape, with an average size of 3.7 mm wide by 5.3 mm long. Between 10 and 89 eggs were laid per group. These results agree with those of Balachowsky (1966) and Inserra (1980), but differ from those of Benfatto (1973) who recorded larger egg masses (3-5 mm wide, 5-15 mm long, 40-50 eggs per group).

Egg predation (9.8% in 1993 and 45.0% in 1994) (Fig. 1) was highest in December and January. As a consequence, egg masses should be sampled during late winter, just before hatching. Earlier samples could overestimate the extent of the infestation as the impact of predation would be incomplete.

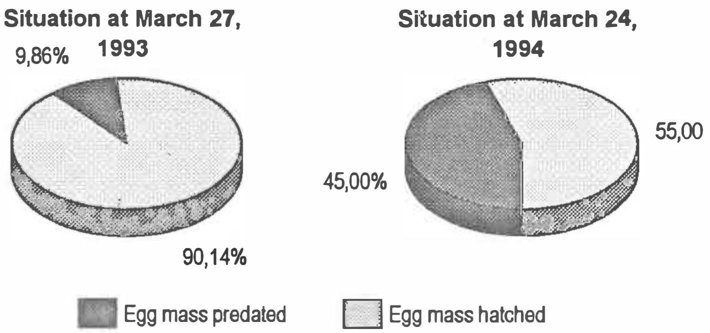

Fig. 1. Egg mass predation

In our observations the level of egg parasitism was low, contrary to the reports of Baggiolini (1958) and Maini & Mosti (1987).

Eggs within the same group hatch in 7-12 days, the overall hatching period for all the egg masses lasted 20-25 days (Fig. 2). In 1993 the eggs started to hatch in early-April, while in 1994 it began around 15 days earlier due to the influence of temperature (Fig. 3).

Commonly, the first hatch takes place during late-March and the beginning of April. There was no apparent relationship between the beginning of the egg-hatch and the developmental stage of the cherry trees. Neonate larvae were positively phototropic and, therefore, moved to the new growth and fed on flowers, just set fruits and young leaves, which were tied to each other by means of silk webbing. First and second instar larvae, which are the more critical instars, each lasted 12-16 days. The peak number of larvae were observed during mid-April, when they fed inside their foliar shelters which protected them from insecticide treatments. Similar behaviour was observed by Gentilucci (1951).

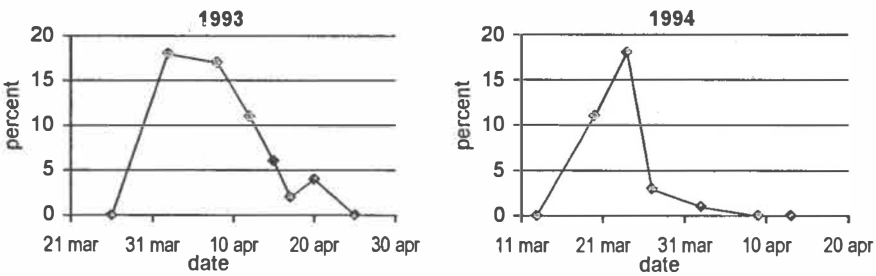

Fig. 2. Egg hatching (1993-1994).

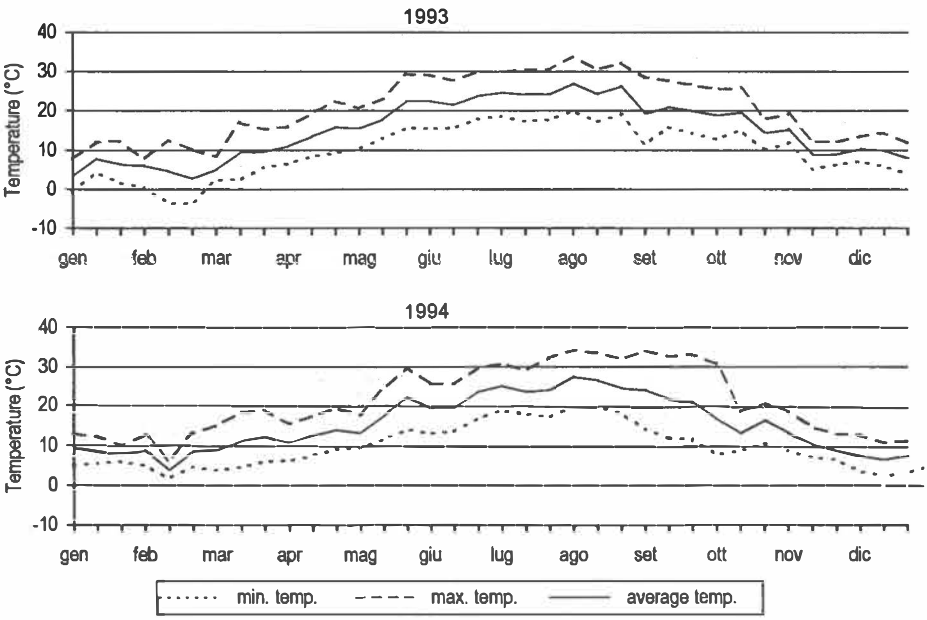

Fig. 3. Temperatures in Turi (Prov. Bari) in 1993 and 1994.

On the basis of our observations and data (Table 3) larval development took approximately 60 days (range: 33-91 days) under natural conditions. This agreed with the study by Balachowsky (1966), although its was a shorter duration than that reported by Benfatto (1973) in Sicily. Larvae were present in the orchard for approximately 70 days. The timing of larval activity more or less paralleled that of cherry-fruit development. Thus, when there is a high level of infestation the pest can attack the fruits directly.

Pupation took place within the foliar shelters and lasted 7-15 days. It started in early May and reached a peak during the second half of May. These results agree with those of Balachowsky (1966). The rate of pupal parasitism was approximately 10%. Two parasitoid species were identified: *Itoplectis maculatus* and *Trichoma enecator* (Rossi), although the former was most commonly encountered.

In 1994, the first adult *A. rosanus* emerged in the rearing cages during mid-May (Fig. 4). Most of the adult flight (87%) occurred from this date until early June, with a peak of activity during the first week of June. Flights continued, with fewer adults, up until June.

The pheromone traps caught high numbers of male *A. rosanus* during early May and continued to catch a few males up until mid-August. The genital structures of males caught in the traps were examined and some *Adoxophyes* spp. were identified. As pointed out by Benfatto and Sichel (1989), these traps showed little selectivity. Knowledge of the presence and number of adults is not particularly useful because flight takes place a long time before the appearance of the injurious larval stage.

The sex-ratio was 0.81. The number of eggs laid varied from 15-191, deposited in 2-5 masses.

Table 3. Lenght (mm) and duration (days) of each larval instair.

	Larva I			Larva II			Larva III			Larva IV			Larva V			Total duration
	length		duration	length		duration	length		duration	length		duration	length		duration	
	beginning	end		beginning	end		beginning	end		beginning	end		beginning	end		
Average	1.5	3.1	16.4	3.6	4.5	12.1	5.2	7.9	8.9	9.4	13.2	8.9	13.1	19.1	10.0	56
Minimum	1.2	2.6	11	3.1	3.4	8	3.8	4.3	4	5.2	6.3	4	7.2	7.7		27
Maximum	1.9	3.5	27	4.2	5.3	16	6.65	11.6	16	14.3	21.1	16	16	23.7	16	91
Mode	1.6	3	13	3.6	4	10	5	6	8	10	13.2	6	14.6	19	12	
St. Dev.	0.18	0.18	4.18	0.31	0.56	2.69	0.72	1.77	2.86	2.57	3.6	3.52	2.35	3.32	3.3	
C.V.	0.12	0,06	0.25	0.09	0.12	0.22	0.14	0.22	0.29	0.27	0.27	0.39	0.18	0.17	0.33	

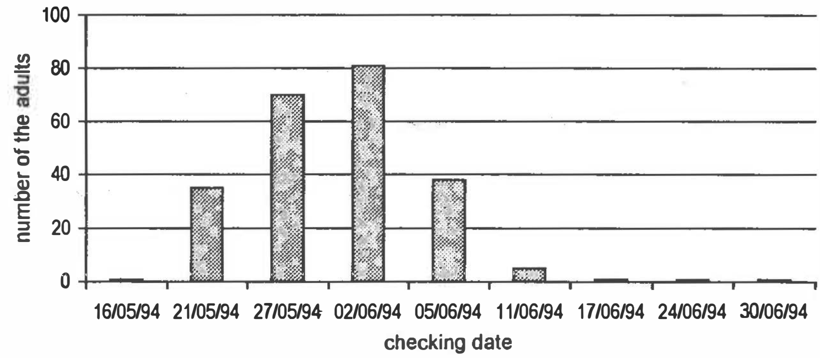

Fig.4. Flight trends of the adults emerged in 1994.

CONCLUSIONS

The rational control of *A. rosanus* on cherry in Apulia should take into account the following points (see Fig. 5):

1. egg masses should be sampled during late-February and early-March;
2. a single insecticide treatment, applied against the first and second larval instars during early April, should be sufficient to control populations of *A. rosanus*;
3. egg predation reaches the maximum in the winter (during December and January), no egg parasitism was revealed
4. larval and pupal parasitoids, even if able to reduce the population density, had a delayed action and were ineffective in controlling *A. rosanus* before damage occurred to the fruits;
5. pheromone traps were relatively unselective in catching the pest species.

ACKNOWLEDGEMENTS

We wish to thank Dr. K. Horstmann, Biozentrum, Zoologie III, Würzeburg, Germany, for the Ichneumonid identification.

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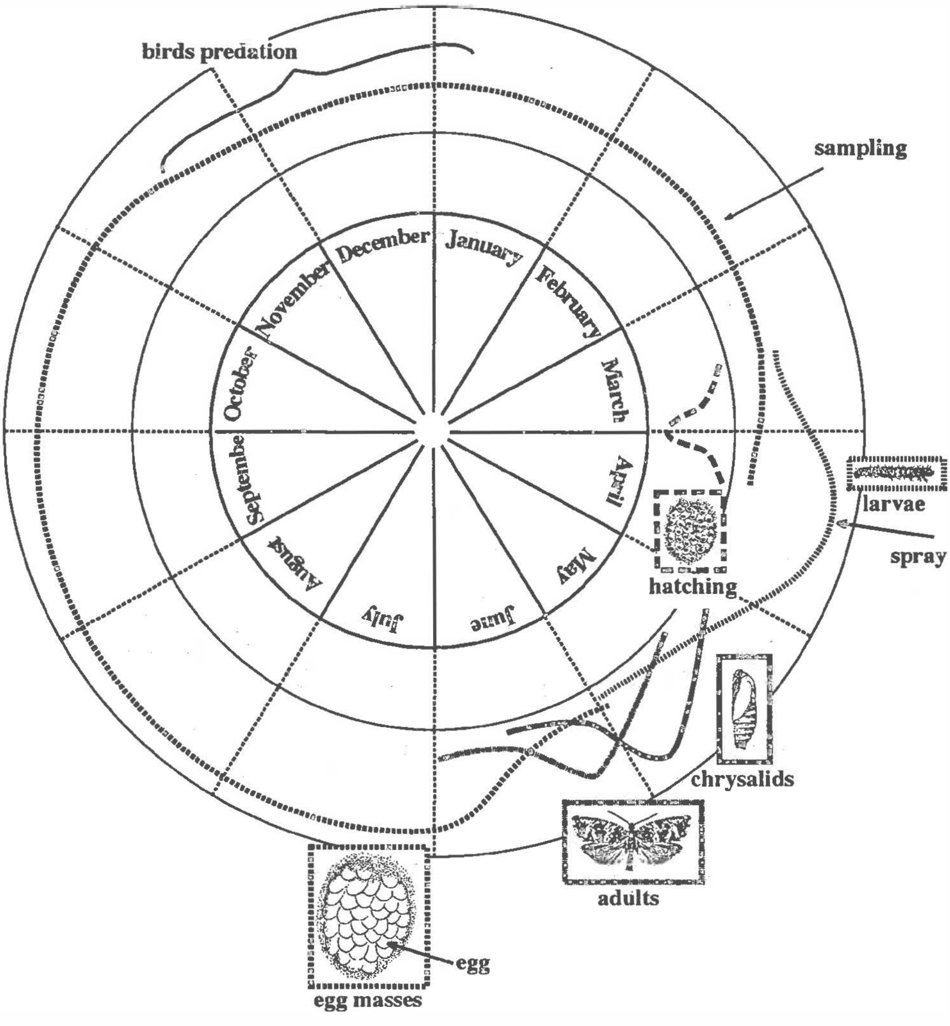

Fig. 5. Life-cycle of *Archips rosanus* .

PHYTOSANITARY SITUATION IN NEW COUNTRIES
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IOBC/WPRS Working Group Meeting "Integrated plant protection in stone fruit"
Zaragoza (Spain) 24-26 September 1996

PESTS AND DISEASES OF STONE-FRUIT IN THE UNITED KINGDOM: THE CURRENT STATUS

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INTRODUCTION

Plum (*Prunus domestica* L.) and sweet cherry (*P. avium* L.) are the only widespread commercially grown stone-fruit in the UK. The cropped areas of plum and cherry in the UK have declined by more than 80% in the past 30 years. In 1995 the total area of stone-fruit production was 1719 ha for plum, and 611 ha for sweet cherry (Anon, 1996a). The major problem facing the UK stone-fruit industry has been the inability to supply fruit of consistently high quality (particularly in terms of size) and quantity from season to season.

Aphids are the major pest in UK plum and cherry orchards. On cherry, aphids can be controlled easily by insecticides. However, on plum the key pest - damson-hop aphid (*Phorodon humuli* (Schrank)) - is resistant to all the groups of pesticides approved currently for use on stone-fruit (Muir, 1979; Campbell & Hrdý, 1988). In attempting to combat the problem of the resistance of *P. humuli* to insecticides, growers rely on the prophylactic use of tar-oil washes applied in the winter. Unfortunately, the use of such tar-oil washes can severely compromise prospects for integrated pest management (IPM).

Diseases of plum and cherry are limited to a small number of potentially severe pathogens. Blossom wilt, brown rot and bacterial canker are evident in most seasons. Control of these diseases depends upon good orchard hygiene and routine, accurately timed, applications of fungicide.

PESTS AND DISEASES OF PLUM

PESTS

APHIDS

Plum is host to three common aphid species: the damson-hop aphid (*P. humuli*), the leaf-curling plum aphid (*Brachycaudus helichrysi* Kaltenbach), and the mealy-plum aphid (*Hyalopterus pruni* Geoffroy). *Phorodon humuli* is a common and serious pest in all the major growing areas of the UK. However, *B. helichrysi* is the most widespread and damaging species. While *H. pruni* can cause serious damage, its patchy and localised distribution result rarely in pest problems. The three species are known vectors of plum pox virus (PPV) (Conti, 1986), but *B. helichrysi* is considered to be the most important vector of PPV in the UK (Gratwick, 1992). Current control measures for aphid pests include tar-oil winter washes and spring-applied insecticide sprays (Table 1). Tar-oil washes are reasonably effective for controlling the overwintering eggs of *P. humuli* (Umpleby, 1996) but appear to have little effect on *B. helichrysi* (R. Umpleby, ADAS Worcester, pers. comm.). In spring, *B. helichrysi* and *H. pruni* can be controlled with the approved insecticides

(Table 1) but these chemicals are ineffective against insecticide-resistant *P. humuli*. The absence of an effective insecticide for *P. humuli* makes this pest a key concern for growers. In addition, there is growing concern over the broad-spectrum toxicity of many of the approved compounds. The recent approval (1996) for the use of the selective aphicide pirimicarb on plum in the UK has improved this situation and has provided opportunities for exploiting biological control strategies within future IPM programmes (Hartfield & Campbell, 1996).

LEPIDOPTERAN PESTS

Of the many caterpillar species which attack plum foliage, winter moth caterpillars (*Operophtera brumata* L.) are the most common and often need to be controlled (Table 1). The main damage to fruit is caused by the plum fruit moth (*Cydia funebrana* (Treitschke)), commonly known as 'red plum maggot'. Infestation by *C. funebrana* causes fruits to ripen prematurely and can cause severe losses in years of light fruit set. Pheromone traps, used to monitor the activity of male *C. funebrana*, can indicate the likely severity of attack and optimal timing for insecticide application.

PLUM SAWFLY

Plum sawfly (*Hoplocampa flava* L.) is a locally common and occasionally serious fruit-damaging pest. The main plum cv. Victoria, is susceptible to attack and, in extreme cases, crop losses can exceed 90% (Alford, 1984). The activity of adult *H. flava* can be monitored using white, non-ultraviolet reflective sticky traps (Gratwick, 1992). Chemical control of *H. flava* can be effective provided the insecticide is accurately timed to coincide with egg hatch.

MITE PESTS

Two mite species are found commonly in plum orchards: the fruit-tree red-spider mite (*Panonychus ulmi* (Koch)) and the plum rust mite (*Aculus fockeui* (Nalepa & Trouessart)). When present in high numbers, *P. ulmi* causes bronzing of leaves. *Panonychus ulmi* is generally considered to be resistant to all currently available organophosphorous pesticides (Table 1). However, some control can be achieved using ovicides (e.g. clofentezine). Damage caused by *A. fockeui* is becoming increasingly common. Again, the main plum cv. (Victoria) is particularly susceptible to damage by rust mites. The success of *A. fockeui* is favoured by modern techniques of orchard management as these encourage the vigorous new growth preferred by the mites.

Mite pests on apple are controlled naturally by predatory mites, particularly by *Typhlodromus pyri* (Scheuten) (Solomon, 1992). However, the use of broad-spectrum pesticides on plum destroys populations of such predators.

LEAFHOPPERS

Recent evidence suggests that damage by leafhoppers (speckling of leaves) is becoming increasingly common in UK plum orchards (Umpleby, 1996). This trend is of particular concern because of the possible role of leafhoppers in the transmission of viruses (Giunchedi *et al.*, this bulletin). At present insecticides are not approved for use in the UK against leafhoppers.

Other arthropods which are occasional pests of plum include around 20 moth species, two species of foliar-feeding sawflies, scale insects, leaf weevils and other mite pests including gall mites.

BIRDS

In plum orchards close to hedgerows and wooded areas, birds can cause considerable damage to buds during winter. Bullfinches (*Pyrrhula pyrrhula* L.) are the major culprit, removing buds cleanly and systematically from branches. In susceptible orchards, more than 30% of buds have been removed (Hartfield, unpublished data). Other than avoiding, or removing, areas which provide cover, there are no satisfactory methods of control.

DISEASES

VIRUSES

Plum pox ("Sharka disease") is the most serious virus disease affecting plum and occurs widely in UK orchards. Schemes for controlling PPV rely upon effective control of aphids and on the availability of certified virus-free stock (Anon, 1980). Because of the schemes' dependence on certified virus-free stock, PPV remains a notifiable disease in nurseries.

Other virus diseases of plum, such as prunus necrotic ringspot virus and prune dwarf virus, are considered to be of minor importance in UK orchards. However, no national surveys have been undertaken to determine the actual incidence and impact of these diseases.

SILVER LEAF

Silver leaf, caused by the fungus *Chondrostereum purpureum* (Pers.) Pouzar, is one of the more commonly occurring serious diseases of plum. It affects the main cv. (Victoria) particularly severely. Attempts have been made to control *C. purpureum* biologically by treating trees either protectively or therapeutically with inoculum of *Trichoderma viride* Pers., a fungus known to be antagonistic to the pathogen (Corke, 1974). Although promising in trials, results in practice with *T. viride* have been rather erratic. Chemical control of *C. purpureum* relies on the use of protectant paints which must be applied to wounds immediately after pruning (Table 1). The simplest and most effective means for controlling silver leaf is to remove either infected branches or whole trees, and burn them before the sporocarps develop. Pruning trees in summer, when conditions are less favourable for infection of wounds by silver leaf and callus formation is more rapid, reduces the risk of attack.

BACTERIAL CANKER

Bacterial canker (*Pseudomonas syringae* pv. *morsprunorum* (Wormald)) is found commonly in plum orchards, particularly those of the main cv. (Victoria) (Umpleby, 1996). The disease is most serious in young plum orchards and is the main cause of losses of trees in the first five years of establishment. Control is based upon routine post-harvest applications of copper fungicides (Berrie & Cross, 1995) (Table 1). Control is less effective in plum than in cherry.

BROWN ROT/BLOSSOM WILT

The fungus *Monilinia laxa* (Aderh. & Ruhl.) Honey attacks plum blossoms and fruiting shoots as well as the fruit itself. Brown rot of fruit and blossom wilt occur commonly and may cause considerable losses in some seasons (Anon, 1961). Control relies on fungicides applied at blossom time and pre-harvest, but very few suitable chemicals are available in the UK (Berrie & Cross, 1995). Effective fruit-thinning to reduce fruit clusters can reduce the spread of brown rot. Tar oil also gives some control of *Monilinia* spp.

RUST

Rust fungus (*Tranzschelia discolor* (Fuckel) Tranzschel & Litv.) commonly occurs in plum orchards where its incidence can be severe and results in premature defoliation (Umpleby, 1996), although there is no published information on its economic importance. There are no fungicides recommended for its control in the UK.

PESTS AND DISEASES OF CHERRY

PESTS

APHIDS

Cherry is host to a single species of aphid: cherry blackfly (*Myzus cerasi* (Fabricius). This aphid is a common and serious pest in all the major growing areas of the UK, particularly on young trees (Brunner, 1996). As with plum, the current control measures used commonly against *M. cerasi* include tar-oil winter washes and spring-applied insecticide sprays (usually with pirimicarb, Table 1).

LEPIDOPTERAN PESTS

Foliage-feeding winter moth (*Operophtera brumata* L.) caterpillars occur commonly on cherry and often require control measures (Table 1). Cherry fruit moth (*Argyresthia pruniella* (Clerck)) damages flowers and developing fruitlets and can cause considerable crop losses in cherry orchards (Alford, 1984). Minor lepidopteran pests of cherry include the cherry bark tortrix moth (*Enarmonia formosana* (Scopoli)) and a number of other Tortricidae.

Other occasional minor arthropod pests include rust mites and sawflies.

BIRDS

Sweet cherries are especially prone to damage by birds. Starlings (*Sturnus vulgaris* L.) often cause major damage to ripening and ripe cherry fruit in the UK (Pennell & Webster, 1996). Protective netting provides the most effective method of controlling bird damage. As a result, an increasing number of cherry growers are netting orchards in the UK, despite the high costs involved.

DISEASES

VIRUSES

Plum pox virus also infects cherry. As with plum, PPV infection is of greatest relevance in nurseries concerned with the provision of certified virus-free stock. Again, as with plum, no national surveys have been undertaken to determine the actual incidence of other virus diseases in cherry orchards.

There is a growing concern in the UK over the incidence of disease called little cherry (A. Adams, HRI East Malling, pers. comm.). This disease is associated with a clostero-like virus (Kliem-Konrad & Jelkmann, 1996) and can be spread by the apple mealybug (*Phenacoccus aceris* Signoret). Little cherry disease has had a devastating impact on cherry production in British Columbia (Eastwell *et al.*, 1996).

BROWN ROT/BLOSSOM WILT

Blossom wilt (*Monilinia laxa*) can be a serious problem in spring if the fungicide carbendazim is not applied at blossom time. Brown rot of fruit can cause serious losses in wet years when there is a heavy fruit-set. Brown rot can be controlled by applying fungicides two-weeks pre-harvest (Berrie & Cross, 1995). Fungicidal products recommended for control of *M. laxa* are limited in the UK.

SILVER LEAF

The silver leaf fungus, *Chondrostereum purpureum*, is not a particularly serious problem in UK cherry orchards.

BACTERIAL CANKER

Pseudomonas syringae pv. *morsprunorum* causes cankers on cherry branches and eventually dieback when the cankers girdle the affected branches. The introduction of scions expressing a level of resistance to canker has limited the prevalence of this disease in recent years. Control is achieved by the routine use of copper fungicide sprays (Table 1) applied post-harvest to reduce bacterial populations on the tree surface and to protect leaf scars.

Table 1. List of pesticides approved for use on plum and cherry in the UK[1].

<table>
<tr><th colspan="2">PESTICIDE
ACTIVE INGREDIENT</th><th>PLUM</th><th>CHERRY</th></tr>
<tr><th colspan="2"></th><th colspan="2">DISEASES</th></tr>
<tr><td colspan="2">Bordeaux mixture</td><td></td><td>bacterial canker</td></tr>
<tr><td colspan="2">Carbendazim</td><td colspan="2">brown rot[2]</td></tr>
<tr><td colspan="2">Copper oxychloride</td><td colspan="2">bacterial canker</td></tr>
<tr><td colspan="2">Octhilinone (wound protectant paint)</td><td colspan="2">pruning wounds and silver leaf</td></tr>
<tr><td colspan="2">Trichoderma viride</td><td colspan="2">silver leaf</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td></tr>
<tr><th>ACTIVE INGREDIENT</th><th>GROUP</th><th colspan="2">PESTS</th></tr>
<tr><td>Chlorpyrifos</td><td>organo-phosphorous (OP)</td><td>aphids, FTRSM[3], tortricids, winter moth</td><td></td></tr>
<tr><td>Clofentezine</td><td>tetrazine</td><td colspan="2">FTRSM[2]</td></tr>
<tr><td>Cypermethrin</td><td>pyrethroid</td><td colspan="2">aphids, caterpillars, tortricids, winter moth</td></tr>
<tr><td>Deltamethrin</td><td>pyrethroid</td><td>aphids, caterpillars, plum fruit moth, sawflies</td><td></td></tr>
<tr><td>Demeton-S-methyl</td><td>OP</td><td colspan="2">aphids, FTRSM, sawflies</td></tr>
<tr><td>Diflubenzuron</td><td>benzonylurea</td><td>plum fruit moth, tortrix moths, winter moth</td><td></td></tr>
<tr><td>Dimethoate</td><td>OP</td><td>aphids, FTRSM, sawflies</td><td>aphids, cherry fruit moth, FTRSM</td></tr>
<tr><td>Fenitrothion</td><td>OP</td><td>aphids, caterpillars</td><td></td></tr>
<tr><td>Malathion</td><td>OP</td><td colspan="2">aphids, FTRSM</td></tr>
<tr><td>Pirimicarb[4]</td><td>carbamate</td><td>aphids[2]</td><td>aphids</td></tr>
<tr><td>Tar oils</td><td>hydrocarbon oils</td><td colspan="2">aphids, scale insects, winter moth</td></tr>
<tr><td>Tetradifon</td><td>bridged-diphenyl</td><td colspan="2">FTRSM</td></tr>
</table>

[1] after Anon (1996b)
[2] off-label approval only
[3] fruit-tree red-spider mite, *Panonychus ulmi*
[4] compatible with IPM strategies.

ACKNOWLEDGEMENTS

I would like to thank Tony Adams, Angela Berrie, Colin Campbell and Tony Webster for their helpful comments on this manuscript.

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IOBC/WPRS Working Group Meeting "Integrated plant protection in stone fruit"
Zaragoza (Spain) 24-26 September 1996

STONE FRUIT PRODUCTION IN POLAND. MAIN PEST AND DISEASE PROBLEMS

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INTRODUCTION

The development of large scale fruit production in Poland has taken place since 1956, with scientific research playing a very important role.

Although among fruit produced in Poland apples take the first place, others, especially plums and cherries, are also important. Table 1 illustrates the number of different stone fruit trees (in millions) and the area of commercial stone fruit orchards (in thousands of ha). Without doubt, the area occupied by plums and cherries is the largest in central and northwestern Europe.

Table 1. Commercial fruit growing; number of trees (in millions) and their area (in thousand ha) - 1994

SPECIES	NUMBER OF TREES (MILLIONS)	AREA (THOUSAND HA)
Plums	13.5	36
Sour cherries	15.7	39
Sweet cherries	3.2	8
Others*	2.5	6
Total	34.9	89

* Peaches, apricots, walnuts

Table 2 shows the average yields from each species during the period 1986-1994. The highest yields were obtained from sour-cherry and plum orchards.

Table 2. Yields of the fruits, harvested from fruit trees (in thousand tons)

SPECIES	1986-1990 (AVERAGES)	1991	1992	1993	1994
Plums	74	67	98	99	77
Sour cherries	68	80	119	147	119
Sweet cherries	16	16	26	32	29
Others*	6	4	10	14	10
Total	164	167	253	292	235

* Peaches, apricots, walnuts

Sour-cherry and plum trees are attacked by several pests and diseases.

The following account briefly details the phytosanitary situation of stone fruit orchards in Poland.

Pests

Occurrence and control of pests attacking plums, peaches and apricots.

The main pests associated with plum orchards are:

- plum moth (*Cydia funebrana*), found throughout the whole country. The life cycle of plum moth consists of two generations per year, with the flight of second generation moths being the largest. Populations are monitored mainly using sticky traps which release pheromone. This pest is controlled by application of insecticides, mainly organophosphates and recently acylureas.
- plum sawflies (*Hoplocampa minuta* and *H. flava*) occur in all plum orchards. Relatively high populations are recorded every year and fruits in unprotected orchards are severely damaged. In recent years, populations in many orchards have been monitored using white sticky traps. Populations exceeding the economic threshold are controlled by application of organophosphates (mainly phosalon and diazinon) at the end of petal fall, or by some fungicides (cyproconazole+captan and fenarimol) during the pink-bud stage.
- plum gall mite (*Aculus fockeui*) causes economically significant damage in both nurseries and fruiting orchards. Populations are controlled by applications of acaricides such as amitraz, fenbutation-oxide, brompropylate. Sometimes, especially before flowering, a synthetic pyrethroid (bifentrin) is also used.
- a complex of aphid species (*Phorodon humuli*, *Hyalopterus pruni*, *Myzus persicae*, *Brachycaudus helichrysi* and some others) occur throughout the whole country. Populations are monitored mainly by visual inspection of trees and controlled as soon as possible at the beginning of pest occurrence. For control, two selective aphicides are recommended: pirimicarb and triazamate.
- brown scale (*Parthenolecanium corni*) occurs in high populations in some orchards, but very often populations are significantly reduced by the parasitoid *Blastotrix confusa.*
- european red mite (*Panonychus ulmi*) and two spotted mite (*Tetranychus urticae*) occur commonly in plum, peach and apricot orchards, but only occasionally cause economically significant damage. Mite populations are monitored mainly by visual inspection of leaves. If it is necessary, mite populations are controlled by application of acaricides such as clofentezine and hexytiazox (before flowering) and amitraz, fenbutation-oxide, tetradifon, bromopropylate, propargite and pyridaben (after flowering).

Occurrence and control of pests attacking sour and sweet cherries.

The main pests associated with cherry orchards are:

- cherry fruit fly (*Rhagoletis cerasi*), an especially important pest on sweet cherry. In recent years, populations have been monitored using yellow sticky traps and controlled mainly with organophosphates (fenitrotion and diazinon) or synthetic pyrethroids (deltamethrin, alfa-cypermethrin and others). Late-ripening varieties of sweet cherry are particularly vulnerable to this pest.
- cherry fruit moth (*Argyrestia ephippiella*) is an important pest in some sour cherry orchards. The last three years have seen an increase in the size of its populations, the monitoring of which is a difficult task due to the size of the eggs and larvae and the biology of the pest. Severe damage has been observed in some orchards. Chemical control relies on the application of insecticides such fenithrothion, fenpropathrin or alphacypermethrin.
- aphids (mainly *Myzus cerasi*) occur with variable intensity, especially during May or June. Aphid populations are monitored by visual inspection of trees and controlled by the

application of selective aphicides, e.g pirimicarb or triazamate.

DISEASES

FUNGAL AND BACTERIAL DISEASES

The main diseases of stone fruit are: brown rot caused by *Monilinia laxa* and less commonly by *M.fructigena*, cherry leaf spot caused by *Blumeriella jaapii* (Rehm) Arx., silver leaf disease caused by *Chondrostereum purpureum* and bacterial canker caused by *Pseudomonas syringae*.

- brown rot is a commercially important disease all over the country and can cause serious crop losses on prune and sour cherry in some seasons. *Monilinia laxa* causes blossom wilt and brown rot of fruit. *Monilinia fructigena* occurs less commonly and causes brown rot of fruit. Once *M. laxa* has colonised the blossom, it frequently moves into the shoot. Protective fungicidal treatments, applied before and during blossom, provide good control (e.g. Topsin, Baycor, Delan, Punch, Ronilan, Rovral).
- cherry leaf spot is the most important fungal disease on sour and sweet cherry across the whole country. It can cause leaf drop in orchards and nursery plantings. Cherry leaf spot is controlled by fungicides such as dodine dithianon and ergosterol biosynthesis inhibitors. Applications should begin at petal fall and repeated subsequently 2-3 times at 14 day intervals.
- silver leaf disease occur on apples, plums, peaches and cherries. In Poland it most destructive following harsh winters. The disease also occurs in fruit tree nurseries. Control is difficult. Trees should be pruned when they are less susceptible (summer to autumn). Trees with fruiting bodies should be burned.
- bacterial canker occurs on several species of fruit tree, but it is most important for sweet and sour cherries. Cankers develop on twigs, at the base of the flower and leaf buds, in pruning wounds and at the base of infected sunken areas. Gum often exudes from cankers, especially early in the growing season. Terminal shoots or twigs of infected trees may die back. Like silver leaf, the disease is most serious after harsh winters. Soil factors can also favour the expression of the disease. Chemical control of bacterial canker in Poland is based primarily on protective copper sprays, applied in early spring during blossom and in the autumn.

VIRUS DISEASES

Three important virus diseases occur in Polish stone fruit orchards and, undoubtedly, they are responsible for significant levels of damage. The most damaging viral disease is sharka, caused by the plum pox virus (PPV).

This virus infects plums, peaches and apricots, and occurs throughout Poland. The disease causes damage to fruits, which includes malformation, browning and stony cells in the flesh. The fruits on infected trees ripen unevenly and drop early. In the case of sensitive varieties up to 80% of fruits drop and rot.

The danger of plum pox is that it spreads very quickly as the virus is transmitted by aphids. Practically all aphid species feeding on plum, peach and apricot are able to transmit the PPV. Only a short feeding time (1-2 minutes) is required for the aphid to transmit the virus to the plant.

Two other viruses which occur in Polish stone fruit orchards are: Prunus necrotic ringspot virus (PNRSV) and prune dwarf virus (PDV). They also occur widely and on all stone fruits, however, the greatest damage occurs to sweet and sour cherries. Both viruses are transmitted by pollen and therefore every infected tree is currently considered to be a potential source of further infection when it flowers. Both viruses are also transmitted by seeds, therefore the seedling rootstocks, which are widely used in Poland for propagation of cherries, are often the source of virus infection for nursery trees.

The production of trees from virus-free scions and rootstocks, as well as removing all infected trees from orchards, are the only ways of reducing the damage caused by these viral diseases.

In the case of PPV, only virus tolerant cultivars should be planted in regions where the disease is common. Wild stone fruit trees are always a potential source of infection. The recommend isolation distance from such sources of infection is about 700-1000 m.

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PLANT HEALTH STATUS OF STONE-FRUIT SPECIES IN HUNGARY AND POSSIBILITIES FOR INTEGRATED PEST MANAGEMENT

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INTRODUCTION

The geographical situation and ecological conditions of Hungary are favourable for the production of stone-fruit species (cherry, sour-cherry, plum, apricot, peach). After some years of economic uncertainty, the production possibilities have been stabilised, the detrimental effects of the change of ownership have gone and the number of new plantations (mainly sour-cherry and cherry) has increased. In Hungary, the production of stone-fruits meets the domestic requirements. Sour cherry and apricot are also important export crops, both as fresh produce and as processed fruits (frozen foods). A portion of the sweet cherries produced is also processed and exported.

PEST CONTROL PROBLEMS OF THE STONE FRUIT SPECIES

The most important pests and diseases which damage stone fruits are those which tend to attack all stone fruit species, however, some seriously damaging pests are specific to only certain fruit species.

PATHOGENS

PATHOGENS OCCURRING ON ALL STONE-FRUIT SPECIES

Plum pox virus (Sharka)

The most serious virus disease, causing damage of economic importance, is plum pox virus (Sharka). In Hungary, the most aggressive forms of PPV induce infections which show symptoms on the leaves and fruits of apricots, plums, peaches and nectarines.

Despite the disease-prevention program in Hungary (e.g. new orchards planted with certified virus-free propagating materials, regular preventive measures to control insect vectors, etc.), this disease causes significant economic losses. Re-infection can occur easily because PPV is a potyvirus which can be transmitted by various aphid species. The virus also attacks both wild and cultivated *Prunus* species. Wide-ranging research programs are studying possibilities for the preventative control of PPV and the maintenance of vector populations at low levels

Monilinia disease of stone fruits - (Pathogens: *Monilinia laxa* (Aderh. & Ruhl.) Honey & Denis, *Monilinia fructigena* (Shroet ex Aderh. & Ruhl.) Honey & Denis).

The disease is caused by two fungal species, *M. laxa* and *M. fructigena*. Infection of the fruit occurs with all stone-fruit species and causes significant losses. It is impossible to store and transport the fruits for more than 1 or 2 days after harvest.

Monilinia laxa can infect sour-cherry and cherry through the flower stigma. Fungal hyphae enter shoots via the pedicel, then reach the branch and cause its death. During the period when risk of infection is high (i.e. cool, rainy weather during flowering) significant damage (brown flowers and dead parts of branches) can be seen in sour-cherry and apricot orchards. Infection of fruits by *M. fructigena* and *M. laxa* occurs mainly via wounds (insect damage, fruit cracking, etc.).

Early dieback of stone fruits - (Pathogens: *Pseudomonas syringae pv. syringae* van Hall., *Leucostoma cincta* (FR.), *Leucostoma rubescens*)

Early dieback of pre-producing and fruiting trees of most stone fruit species (apricot, peach, sour-cherry, cherry, plum) causes symptoms of apoplexy and sudden death. The leaves turn yellow, then brown and desiccate and then the tree dies. Similar symptoms can be caused by environmental traumas (e.g. drought stress, severe mechanical injuries etc.). On apricot, *P. syringae pv. syringae* is the most frequent species, whereas on cherry and sour-cherry, *L. cincta* occurs most frequently. These pathogens are always wound parasites, therefore the infection requires a damaged area through which to enter the plant, e.g a mechanical injury, pruning wounds, pest damage or cracks caused by frost.

PATHOGENS OCCURRING ON SOME STONE-FRUIT SPECIES

Gnomonia leaf spot - (Pathogen: *Gnomonia erythrostoma* Pers.)

In Hungary, this disease occurs mostly on apricot. There is some literature which reports its presence on cherry and sour-cherry, but such damage has only been observed only rarely. On apricot, the disease appears every year, but the intensity of infection depends greatly upon the level of spring precipitation. If there is plenty of rain after apricot has flowered, ascospore release is quick and abundant, causing acute infection which can lead to defoliation in most cases. Control of the disease is dependant upon the accurate forecast of the date of ascospores release.

Taphrina leafcurl of peach - (Pathogen: *Taphrina deformans* (Berk.) Tul.)

Peach leafcurl can cause severe damage during cold and wet springs. It regularly causes leaf drop. The fungal infection requires more than 95 % relative humidity. Considering that, in most areas of Hungary, it is cold and wet during the flowering period of peach, it could be argued that infection is frequently the result of poorly located orchards.

Blumeriella leaf spot of cherry and sour-cherry - (Pathogen: *Blumeriella japii* (Rehm) v. Arx.)

The first symptoms of this disease appear at the end of May. Severe infection is caused by the conidial form of the fungus during summer, after large quantities of conidia have developed on the already infected leaves. Windy, rainy weather improves conditions for infection.

Control measures are important features of cherry and sour-cherry production, with breeding for resistant and tolerant varieties a priority.

PESTS OF STONE FRUIT SPECIES

INSECT PESTS OCCURRING ON SEVERAL STONE-FRUITS

Fruit moth species

Oriental fruit moth - (*Cydia molesta* Busck.)

The host-plants of this pest include peach, apricot, plum and cherry. The spring damage is similar to that caused by *Anarsia lineatella*; the moth damages the inside of shoots causing stunting. The two types of damage can be differentiated only by the date of their appearance, with *A. lineatella* attacking earlier (second half of April).

Oriental fruit moth has three or four generations a year in Hungary depending on the host-plant and the weather conditions. The summer generations are merged, the larvae attack within the fruits. The first flight starts during late-April or early-May, it is difficult to differentiate the summer generations.

Peach twig borer - (*Anarsia lineatella* Zeller)

Attacks have been observed mainly on peach and apricot. The overwintering larvae enter the buds (at bud-break), then 2-3 cm of the shoot, thereby killing the shoot. *Anarsia lineatella* attacks earlier than *C. molesta*. First flight can be observed from late-May. The summer generations enter the fruit via the pedicel and cause internal damage. There are 3-4 generations a year, with a partial fourth generation.

Although both *C. molesta* and *A. lineatella* have caused significant damage in past years (some 20 years ago), levels of infestation have been reduced recently.

Plum fruit moth - (*Cydia funebrana*) Treischke

Attacks all plum varieties. It develops three generations a year, with the summer generations causing the most significant economic damage. In some cases, the number of infested fruit exceeds 50%. In such cases, significant fruit drop occurs. The second and third summer generations are not distinct and the infesting larvae may belong both or either generation.

Complex of leaf-rollers

Characteristic damage (attacked young shoots and chewed young fruits) is observed during spring. Damage can be caused by the following Lepidopteran species: *Spilonota ocellana* Fabr., *Pandemis heparana* Den. et Schiff., *P. ribeana* Hb., *Adoxophyes reticulana* Hb. and *Recurvaria nanella* Hb.

Monitoring Lepidoptera using sex-pheromone traps

Control of Lepidopteran (and some cases Coleopteran) species can be made easier by using sex-pheromone traps. In Hungary, "home-made" pheromone formulations are used in these traps. Csalomon traps are made at the Entomology Department of the Research Institute for Plant Protection of Hungarian Academy of Sciences. More than 50 kinds of the traps are available, mainly for lepidopterous pests, but also for some coleopteran species.

Aphids attacking stone-fruits
Peach
Brachycaudus prunicola ssp. Schwartzi CB.
Green peach aphid (*Myzus persicae* Sulcz.)

In addition to inhibiting shoot growth, aphids are responsible for re-infection of PPV.

Sour-cherry and cherry
Myzus cerasi Fabr. (on sour-cherry)
Myzus cerasi ssp. Pruniavium CB. (on cherry)

This species changes host plant during the summer, thus damage (inhibition of growth of young shoots) is caused by the spring generations during May.

Scale insects attacking stone-fruits

Quadraspidiotus perniciosus Court.

It has a general distribution with dispersed attacks.

Pseudaulacaspis pentagona (Targioni-Tozzetti)

This pest appeared during the 1980's and was responsible for severe attacks to plum and peach trees. Two generations develop each year.

Cherry fruit fly (*Rhagoletis cerasi* L.)

At some sites, *R. cerasi* occurs on cherry and sour-cherry every year and infests 80-100% of fruit. Efficient control is aided by the use of yellow sticky traps.

INTEGRATED PEST MANAGEMENT IN STONE FRUIT ORCHARDS IN HUNGARY

The introduction of integrated fruit and grape management has a fairly long history in Hungary. Research into environmentally-friendly pest control technologies has been conducted for some 20 years. The communiqué which appeared in the Official Agricultural journal during 1993, which is based upon these results and experiences, makes recommendations for integrated management (in fruit and grape production) as well as for international standards and requirements on organic farming. In accordance with the EU directives, these standards specified the following objectives:

- reducing the environmental pollution caused by harmful chemicals,
- maintenance of biodiversity in vineyards and orchards, as well as in their surrounding habitats,
- maintenance of soil fertility and a decrease in the level harmful compounds in the soil
- making efforts to minimize residue levels in end-products,
- making it a priority to use selective pesticides which have less impact on natural enemies of pests and pathogens.

In Hungary, one basic condition of the IPM recommendations is that the pesticides used are classified into three categories, which are, according to the international practice;

- <u>green list</u> - includes active ingredients without any prohibitions for environmental and public health aspects, (e.g. cooper fungicides, captan, folpet, chlortelonyl, bupirimate, iprodione, pirimicarb, diflubenzuron, teflubenzuron, Bt. agent, flufenoxuron etc.),

- yellow list - contains formulations which can be used in integrated production with some restrictions (e.g. mancozeb, propineb, metyram, sulphur, cyproconazol, diniconazol, miclobutanyl, phosalon, endosulphan),
- red list - contains products which are prohibited for use in integrated production (their application is only recommended for the prevention of significant plant damage).

The widespread use of IPM techniques is hindered by a lack of organisation which is necessary to bring about cooperation between farms participating in this technology. Therefore, the only results come from isolated incentives which are realised on individual fruit species. IPM has been introduced in apricot and peach. Control of the pathogens is managed by using pesticides on the green or yellow lists, where their use is limited (e.g. only 3-4 kg/ha cooper can be applied during one season).

For the control of fruit moths (*C. molesta* and *A. lineatella*) formulations of *B. thuringiensis var. Kurstaki* can be used with success. Aphids are controlled using formulations containing pirimicarb.