MANAGEMENT AND CONTROL OF INSECTICIDE-RESISTANT PEAR PSYLLA (*Cacopsylla pyri*)

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A B S T R A C T

The efficacy of different insecticides on adults and nymphs of *Cacopsylla pyri* from two localities in the Czech Republic was evaluated in biological tests. Resistance of *C. pyri* populations originated from an orchard intensively treated by: Nomolt 15 SC (teflubenzuron), Dimilin 48 SC (diflubenzuron), Zolone 35 EC (phosalone) and Trebon 30 EC (etofenprox) was proved in the laboratory tests. Population of *C. pyri* from an untreated locality was susceptible to the all tested insecticides. The highest efficacy on *C. pyri* nymphs was shown in tests in net slives when Calypso 480 SC (thiacloprid) and Vertimec 1.8 EC (abamectin) were applied. The efficacy of the tested insecticides against *C. pyri* adults in tarsal test was sufficient except of Cascade 5 EC (flufenoxuron) and Zolone 35 EC, when the C. pyri population from the chemically treated orchard was tested. The level of resistance of nymphs to phosalone was much higher than in adults of the overwintering generation. The efficacy of Sanmite 20 WP (pyridaben) and Calypso 480 SC on new hatched nymphs of *C. pyri* showing multiple resistance in field experiments in two different localities was excellent. On the basis of results, Sanmite 20 WP, Calypso 480 SC and Cascade 5 EC were recommended for antiresistant strategy against *C. pyri.* Sanmite 20 WP was recommended for the registration in the Czech Republic against *C. pyri* in pear orchards.

Key words: *Cacopsylla pyri*, pear psylla, resistance, antiresistant strategies

INTRODUCTION

Psyllids are among the most serious pests in pear orchards, which have been intensively treated with pesticides. The species, which causes the most damage in central Europe, is *Cacopsylla pyri.* In the Czech Republic, *C. pyri* has caused economically important damage since the 1990s. The main agents used to control psyllids in pear orchards are non-selective insecticides and pyrethroids.

Consequently, chemical control against psyllids has become ineffective in many parts of the country because of the selection of populations resistant to organophosphates and pyrethroids. Psyllids easily develop resistance to insecticides. Insecticide-resistant populations of *C. pyricola* were detected in the 1960s (Harries and Burts, 1965). Since the mid 1980s, populations of *C. pyricola* in North America and *C. pyri* in Europe were found to be resistant to a broad spectrum of insecticides (Berrada et al., 1995). At the beginning of the 1990s, Nomolt 15 SC was approved for use against psyllids in pear orchards in the Czech Republic. Nomolt was highly effective against psyllids and was used in combination with other selective insecticides to ensure effective pest control in pear orchards.

In 2003, Nomolt failed to control psyllids in several localities at ones. It was suspected that *C. pyri* developed resistance to Nomolt after ten years of repeated exposure.

The aims of this study were to evaluate *C. pyri* populations from treated and untreated orchards in terms of their resistance to insecticides with different modes of action and to determine which insecticides might be useful in controlling insecticide-resistant *C. pyri* populations on the basis of laboratory and field trials.

MATERIAL AND METHODS

Four experiments were carried out.

In the first experiment, mean fertility was evaluated in two *C. pyri* populations.

The first population was insecticide-resistant and came from a pear nursery in Litoměřice in which intensive pest management was carried using Nomolt 15 SC (teflubenzuron), Dimilin 48 SC (diflubenzuron), Zolone 35 EC (phosalone) and Trebon 30 EC (etofenprox). The second population was non-resistant and came from an abandoned pear orchard in Doksany. This population was susceptible to all of the insecticides tested.

The evaluations were carried out in net sleeves. The average number of eggs laid per female was calculated for seven replicates of 56 females in 2004 and 8 replicates of 70 females in 2005 (Tab. 1).

The second experiment was carried out in 2004 and 2005. Seven insecticides were evaluated in the laboratory in terms of their efficacy against *C. pyri*. The insecticides were tested on both the resistant and non-resistant populations of *C. pyri.* The insecticides evaluated were:

- Calypso 480 SC (thiacloprid);
- Zolone 35 EC (phosalone);
- Cascade 5 EC (flufenoxuron);
- Vertimec 1.8 EC (abamectin);
- Vaztac 10 SC (alpha-cypermethrin);
- Nomolt 15 SC (teflubenzuron); and
- Dimilin 48 SC (diflubenzuron).

The insecticides were applied at the rates recommended by the manufacturers and in increasing concentrations according to FAO procedures (Anonymous, 1974) (Fig. 1). The insecticides were applied against newly hatched nymphs on May 5 in 2004 and on April 19 in 2005. They were evaluated on May 15 in 2004, and on April 28 and May 5 in 2005.

Fourteen adults of *C. pyri* were introduced into each net sleeve. Data recorded included the total number of eggs, the number of surviving nymphs and the number of dead nymphs (Tab. 1). Efficacy was calculated based on the number of nymphs which survived after the insecticide treatment and the number of nymphs in the untreated control (Fig. 1).

In the third experiment, the contact toxic effect of insecticide residues on adults of the resistant strain of *C. pyri* was tested in the laboratory using the tarsal test. Adults were contaminated with filter paper impregnated with the seven insecticides. After 10 to 15 minutes, they were transferred to Petri dishes containing a pear bud or leaf. Mortality was evaluated after 24 hours. The insecticides were tested at the rates recommended by the manufacturers and in increasing concentrations (Tab. 2).

The fourth experiment was carried out in 2005. A field trial was carried out to determine the efficacy of Sanmite 20 WP (pyridaben) and Calypso 480 SC against *C. pyri* (Tab. 3 and 4). The experiment was carried out in the pear nursery in Litoměřice and in a commercial pear orchard in Slaný. Application rates were 0.75 kg/ha for Sanmite and 0.25 l/ha for Calypso.

At Litoměřice, Sanmite was applied on April 18, April 25, May 30 and June 8. Calypso was applied on April 18 and May 30.

At Slaný, Sanmite was applied on April 22, June 2, and June 13. Calypso was applied on April 22 and June 2.

The first treatment was directed against the first generation of *C. pyri*, and was carried out when the nymphs were beginning to hatch. The second treatment was carried out seven days after the first treatment. The third treatment was directed at the second generation of *C. pyri*. The fourth treatment was carried out eight or eleven days after the third treatment.

For each variant, eggs and nymphs was counted on one 5.6 m length of pear branch and 28 leaf rosettes and recorded as the number of insects per meter of pear branch and per ten leaves (Tab. 3 and 4).

Biological efficacy was recorded as a percentage and was calculated according to the following formula:

$$x = 100 - [(z/y-k)*100]$$

where x is the biological efficacy, z is the number of surviving nymphs in the treated combinations, y is the total number of eggs and nymphs in the untreated control, and k is the total number of eggs in the treated combinations (Tab. 3 and 4).

RESULTS AND DISCUSSION

The insecticide-resistant population of *C. pyri* was about twice as fecund as the non-resistant population (Tab. 1). This is probably not due to genetic differences, but because the food quality in the intensively treated pear nursery was higher than in the untreated abandoned orchard. The non-resistant population might also have been less fecund because of the higher numbers of parasitic wasps in the abandoned orchard.

Table 1. Mean fecundity in *C. pyri* females in net sleeves in 2004 and 2005 (total number of eggs per female for the given period)

Population	2004	2004	2005	2005
	egg-laying period	total number of eggs	egg-laying period	total number of eggs
Insecticide-resistant (Litoměřice)	March 23 to May 5 (43 days)	52.7	March 18 to April 19 (31 days)	33.5
Non-resistant (Doksany)	March 23 to May 5 (43 days)	20.3	March 18 to April 19 (31 days)	17.0

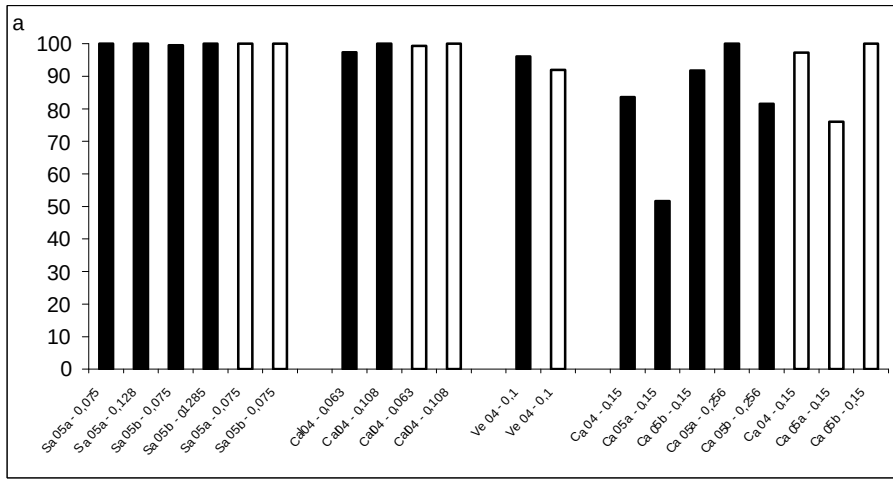
The most effective insecticides against both the insecticide-resistant and non-resistant populations were Sanmite, Calypso and Vertimec (Fig. 1). The efficacy of these insecticides ranged from 92 to 100%. The efficacy of Cascade ranged from 51 to 100 %.

The efficacy of Zolone, Trebon, Dimilin and Nomolt differed between the two populations. These insecticides were significantly less effective against the insecticide- resistant population than against the non-resistant population (Fig. 1). Several of these insecticides were completely ineffective or only slightly effective against the insecticide-resistant population (Fig. 1, arrows). The efficacy of a given insecticide varied from year to year and from testing date to testing date within the same year.

The contact toxic effect of the insecticides on adults of *C. pyri* was low except in the case of Cascade (Tab. 2). With some insecticides, mortality was noted after 24 hours. For example, when Nomolt was applied in Slaný in 2005, mortality reached 64% after five days (Tab. 2).

C. pyri nymphs were much more resistant to Zolone than adults of the overwintering generation. Etiene et al. (1992) found that summer adults of *C. pyri* were less resistant to Avermectin B1 than winter adults. The overwintering stages of *C. pyri* were more resistant to the insecticide than the summer stages. The relative differences in resistance between populations is subject to seasonal variation (Bues et al., 1999). Resistance to deltamethrin among populations of *C. pyri* differed by a factor of 31 at the adult stage and by a factor of 135 at the last larval stage (Bues et al., 2003).

a



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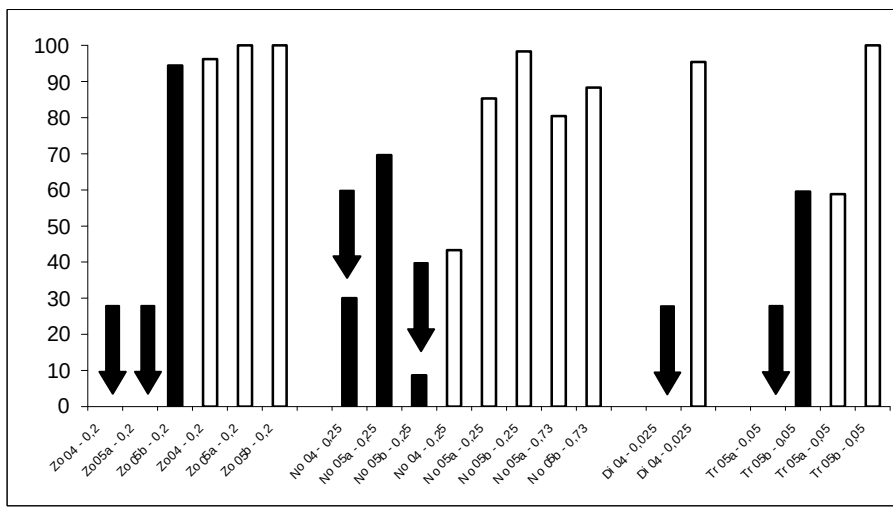

Figure 1a, b. Toxicity of insecticides against *C. pyri* nymphs populations from Litoměřice and Doksany in 2004 expressed in percentage of relative mortality to untreated control (04 – evaluated 10 days after the treatment) and in 2005 (05a – evaluated 10 days after treatment, 05b – evaluated 17 days after treatment). Black column – Litoměřice, white column – Doksany. Sa – Sanmite, Cal – Calypso, Ve – Vertimec, Ca – Cascade, Zo – Zolone, No – Nomolt, Di – Dimilin, Tr – Trebon

The biological efficacy of Sanmite and Calypso generally ranged from 96 to 99%. Sanmite and Calypso were effective against the insecticide-resistant population of *C. pyri* in the field (Tab. 3 and 4).

Table 2. Mortality in insecticide-resistant *C. pyri* adults 24 hours after insecticide treatment under laboratory conditions

Insecticide treatment	Origin of insect population			
	Litoměřice March 23 (after Cascade March 18)	Litoměřice April 19 (after Oleoekol and Cascade May 7)	Litoměřice April 19	Litoměřice May 4 (after Neem Azal)
Untreated control	0	35.4	20	53.3
Calypso 0.25%	50	-	60	93.3
Zolone 0.2%	92.8	-	60	66.7
Cascade 0.15%	32	-	-	-
Cascade 0.25%	89.3	95.2	100	80
Vertimec 0.1%	-	35.1	-	-
Vaztac 0.15%	33.3	-	26.7	46.7
Nomolt 0.25%	18.5	40.7	-	-
Nomolt 0.43%	35.3	-	-	-
Nomolt 0.73%	54.8	-	13.3	33.3
Nomolt 1.248%	-	69	-	-
Dimilin 0.025%	11.5	-	13.3	53.3
Dimilin 0.043%	25	-	-	-

Table 3. Number of *C. pyri* eggs and nymphs and biological efficacy of Sanmite and Calypso in samples of pear branches or leaf rosettes collected three or ten days after spraying at Litoměřice in 2005

Treatment	Number of *C. pyri* per meter of branch length			Biological efficacy [%]
	Eggs	Nymphs	Total	
Untreated control (April 21)	194.3	24.5	218.8	x
Sanmite (April 21)	22.9	7.3	30.2	96.6
Calypso (April 21)	14.3	1.4	15.7	99.0
Untreated control (April 25)	23.2	137.5	160.7	x
Untreated control (April 25)	4.6	6.17	10.7	96.3
Sanmite (April 25)	6.4	0.9	7.3	99.5
	Number of *P. pyri* per 10 leaves			
Sanmite (May 5)	2.1	0.1	2.2	99.9
Sanmite (May 27)	13.7	0.4	14.1	99.9
Untreated control (June 2)	34.8	15.4	51.9	x
Sanmite (June 8)	9.7	10.9	20.6	79.0
Calypso (June 8)	35.6	1.3	36.9	97.5

Cross resistance to organophosphates, pyrethroids and amitraz has been found in populations of *C. pyri* in Europe (Bues et al., 1999). After many years of exposure to insecticides such as Nomolt and Zolone, a population of *C. pyri* can develop resistance to several insecticides at the same time, including growth regulators such as Nomolt and Dimilin, organophosphates

such as Zolone, and pyrethroids such as Trebon. On the basis of our results, the following insecticides are recommended for controlling insecticide-resistant populations of *C. pyri*: Sanmite 20 WP, Calypso 480 SC and Cascade 5 EC.

Table 4. Number of *C. pyri* eggs and nymphs and biological efficacy of Sanmite and Calypso in samples of pear branches or leaf rosettes collected three or ten days after spraying at Slaný in 2005

Treatment	Number of *C. pyri* per meter of branch length			Biological efficacy [%]
	Eggs	Nymphs	Total	
Untreated control (April 21)	398.3	5.3	403.6	x
Sanmite (May 2)	59.6	7.3	72.4	99.8
Calypso (May 2)	85.8	4.8	180.7	99.9
Number of *C. pyri* per ten leaves				
Untreated control (May 27)	36.8	0.5	37.3	x
Sanmite (June 9)	12.9	2.0	14.9	97.4
Calypso (June 9)	10.7	1.7	12.4	97.5
Sanmite (June 21)	0.8	0.06	0.86	99.9
Calypso (June 21)	0.0	0.01	0.01	99.8

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TAKTYKA ZWALCZANIA POPULACJI MIODÓWKI GRUSZOWEJ PLAMISTEJ (*Cacopsylla pyri*) ODPORNEJ NA INSEKTYCYDY

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S T R E S Z C Z E N I E

Na podstawie testu biologicznego dokonano oceny efektywności różnych insektycydów w odniesieniu do owadów dorosłych i larw *Cacopsylla pyri* pochodzących z dwóch różnych miejsc Czech. Odporność osobników populacji *C. pyri* pochodzących z sadu intensywnie opryskiwanego preparatami: Nomolt 15 SC (teflubenzuron), Dimilin 48 SC (diflubenzuron), Zolone 35 EC (fosolon) i Trebon 30 EC (etofenproks) zostało potwierdzone w teście laboratoryjnym. Osobniki populacji *C. pyri* pochodzące z nieopryskiwanego sadu były wrażliwe na wszystkie testowane insektycydy. Największą efektywność w wyniszczaniu larw *C. pyri* wykazano w teście wykonanym w izolatorach z zastosowaniem preparatu Calypso 480 SC (tiachlopryd) i Vertimec 18 EC (abamectin). Efektywność testowanych insektycydów w odniesieniu do owadów dorosłych *C. pyri* była wystarczająca z wyjątkiem preparatu Cascade 5 EC i Zolone 35 EC, w przypadku populacji pochodzącej z sadu intensywnie opryskiwanego. Odporności larw w stosunku do preparatu Zolone 35 EC była znacznie wyższa niż owadów dorosłych generacji zimującej. Efektywność preparatu Sanmite 20 WP (pyridaben) i Calypso 480 SC – była znakomita w stosunku do nowo wylęgniętych larw populacji *C. pyri* wykazującej zwielokrotnioną odporność w doświadczeniach polowych w dwóch różnych lokalizacjach. Na podstawie wyników Sanmite 20 WP, Calypso 480 SC i Cascade 5 EC były polecane przeciwko *C. pyri* w strategii antyodpornościowej. Sanmite 20 WP był rekomendowany do zarejestrowania przeciwko *C. pyri* w sadach gruszowych w Czechach.

Słowa kluczowe: *Cacopsylla pyri,* odporność, insektycydy, sady gruszowe