INSECTICIDE RESISTANCE IN THE CODLING MOTH (*Cydia pomonella*)

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A B S T R A C T

Resistance of *Cydia pomonella* to insecticides was tested in 2004 and 2005 on larvae of *C. pomonella* collected from two localities in the Czech Republic. L_5 larvae of *C. pomonella* were trapped in corrugated paper bands in 2004 in an experimental apple orchard of RICP in Prague-Ruzyně (assumed susceptible strain of *C. pomonella*) and in an intensive chemically treated apple orchard in Velké Bílovice (assumed resistant strain of *C. pomonella*). For the purpose of resistance tests, laboratory tests were conducted for determination of discriminating concentrations of insecticides when applied on the L_5 larvae of *C. pomonella* from laboratory colony. High level of resistance to organophosphates was detected in codling moth population from Velké Bílovice. When the preparation Zolone 35 EC (phosalone) was applied in discriminating concentration 0.34% against L_5 larvae from Velké Bílovice, 25.7% to 75.7% of tested larvae were resistant according to term of collection of larvae for the experiment in orchard. Resistance to insect growth inhibitors Dimilin 48 SC and Nomolt 15 SC was also detected in part of codling moth population from Velké Bílovice. Resistance to preparation Nomolt 15 SC only was detected in 31.3% of tested part of population from Ruzyně.

Key words: *Cydia pomonella*, codling moth, resistance, apple orchard

INTRODUCTION

The codling moth (*Cydia pomonella* L.) is a major pest in apple and pear orchards all over the world except in Japan and few other regions of Asia (Croft, 1982). The codling moth has recently developed simple, cross and multiple resistance to various pesticides.

The codling moth was reported to have become resistant to azinphos-methyl in 1991 in California, and in 1994 in South Africa (Welter et al., 1991; Blomefield, 1994).

In Europe, resistance to several organophosphates, pyrethroids and insect growth inhibitors, mainly diflubenzuron, was detected at the beginning of the 1990s in northern Italy and southern France (Waldner, 1993; Bouvier et al., 1995; Sauphanor et al., 1998 and 2000).

Since 1996, resistance to diflubenzuron, fenoxycarb, chlorpyrifos-methyl, tebufenozide, phosalone and indoxacarb has been increasing in Switzerland (Sauphanor et al., 1996; Charmillot and Pasquier, 2002a). Even though pyrethroids are not approved for use against the codling moth in Switzerland, cross-resistance to deltamethrin and azinphos-methyl has also been detected (Charmillot and Pasquier, 1999). There was a high level of cross-resistance between diflubenzuron, tebufenozide and phosalone (Charmillot and Pasquier, 2002b).

In the Czech Republic, resistance to several organophosphates and insect growth inhibitors has recently been detected among codling moths in several intensive apple growing regions, mainly in southern Moravia.

The aim of this experiment was to evaluate two populations of codling moth in terms of their resistance to selected insecticides.

MATERIAL AND METHODS

In 2004 and 2005, resistance to three insecticides was assessed in two different field populations of the codling moth.

The first population was presumably resistant to insecticides and came from an intensive apple orchard in Velké Bílovice.

The second population was presumably susceptible and came from an experimental apple orchard belonging to the Research Institute for Crop Production in Prague-Ruzyně.

A laboratory strain of the codling moth served as the reference. The laboratory strain was susceptible to insecticides and came from the Crimea in Russia. It has been maintained at the Research Institute of Crop Production since 1992.

Both populations were evaluated in terms of their susceptibilities to the following insecticides:

- Zolone 35 EC (phosalone);
- Dimilin 48 SC (diflubenzuron); and
- Nomolt 15 SC (teflubenzuron).

Susceptibility was evaluated using a topical test on L_5 overwintering larvae.

In the autumn of 2004, overwintering larvae were collected using paper strip traps. The larvae were stored for three or four months in a temperature-controlled chamber at 6°C. Various concentrations of insecticides were applied to the backs of the larvae with a microsyringe (Pasquier and Charmillot, 2003).

Zolone was tested on larvae of the resistant strain collected on September 2 and October 19, 2004, and on a mixed sample of larvae of the susceptible strain collected from July to October, 2004.

Dimilin and Nomolt were tested on the larvae of the resistant strain collected on October 19, 2004, and on the mixed sample of larvae of the susceptible strain collected from July to October, 2004.

The discriminating concentration was defined as the concentration at which 81 to 90% of the susceptible larvae died (Charmillot and Pasquier, 2002b). For Zolone, the discriminating concentration was determined from the curve of concentration versus mortality. The curve was constructed by topically applying Zolone at five different concentrations ranging from 0.05 to 0.58% to L_5 larvae of the reference strain.

Dimilin and Nomolt were tested on L_5 larvae at the concentrations recommended by producer for use against L_1 larvae, and also at higher concentrations. Dimilin was tested at 0.025% and 0.075%. Nomolt was tested at 0.075% and 0.18%.

Increasing of rates was calculated according to FAO guidelines (Anonymous, 1974).

In all experiments, 17 to 20 larvae were tested in each of the treated combinations and in the untreated control. Mortality was evaluated when the moths emerged in the untreated control. Total mortality due to the insecticides tested was corrected using mortality in the untreated control as described elsewhere (Abbott, 1925).

RESULTS AND DISCUSSION

Table 1. Mortality of L_5 larvae of the susceptible laboratory strain of codling moth treated topically by Zolone 35 EC in concentrations ranging from 0.05% to 0.58%

Variant	Number of tested L_5 larvae	Survived		Tested/killed
		adults	Larvae	
Untreated control	20	12	8	20/0
Zolone 35 EC 0.05%	17	12	1	17/4
Zolone 35 EC 0.1%	20	6	7	20/7
Zolone 35 SC 0.2%	19	2	2	19/15
Zolone 35 EC 0.34%	20	1	1	20/18
Zolone 35 EC 0.58%	20	0	0	20/20

With Zolone, mortality in the laboratory strain ranged from 17.6 to 100%, depending on the concentration used (Tab. 1). Mortality in the untreated

control was zero. On the basis of the mortality curve, the discriminating concentration of Zolone was determined to be 0.34%.

With Zolone at 0.34%, mortality was 64.3% in resistant larvae collected on September 2, 14.3% in resistant larvae collected on October 19 and 93.3% in susceptible larvae and 90% in larvae of the laboratory strain (Fig. 1).

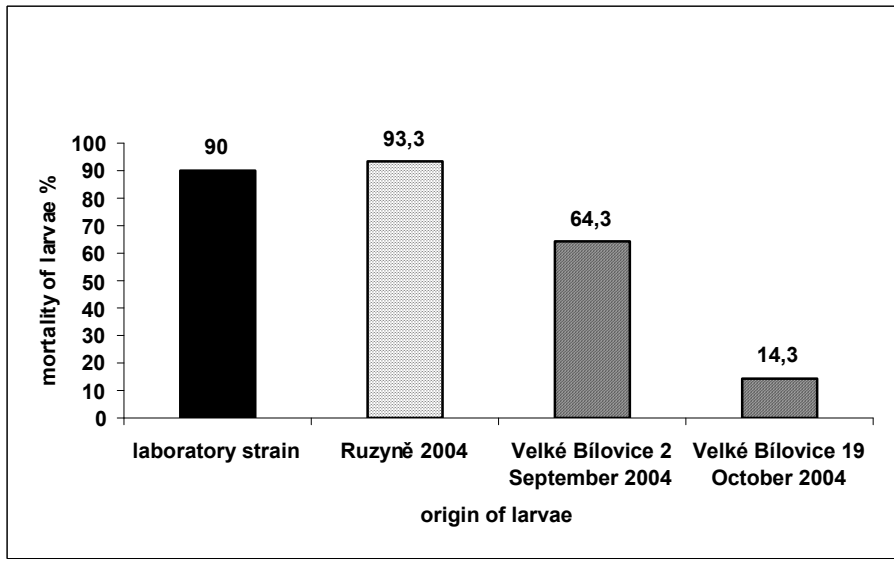

Figure 1. Mortality of L5 codling moth larvae after the topical application of Zolone 35 EC in concentration 0.34%

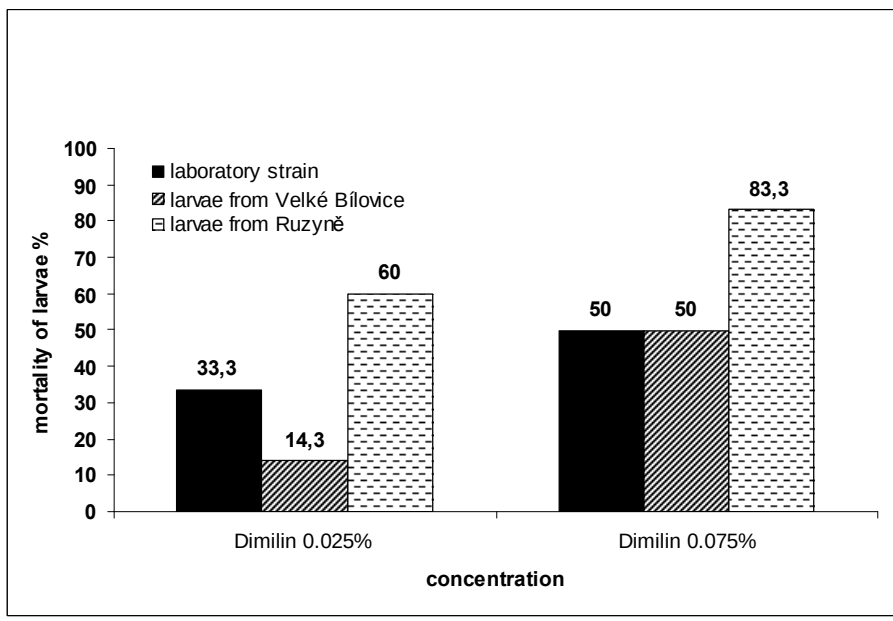

Figure 2. Mortality of L5 codling moth larvae after the topical application of Dimilin 48 SC in concentrations 0.025% and 0.075%

With Dimilin, mortality in the resistant strain was 14.3% at 0.025%, and 50% at 0.075%. Mortality in the susceptible strain was 60% at 0.025%, and 83.3% at 0.075%. Mortality in the laboratory strain was 33.3% at 0.025%, and 50% at 0.075% (Fig. 2)

With Nomolt, mortality in the resistant strain was zero at 0.075%, and 50% at 0.18%. Mortality in the susceptible strain was 46.7% at 0.075%, and 91.1% at 0.18%. Mortality in the laboratory strain was 77.8% at 0.075%, and 83.3% at 0.18% (Fig. 3).

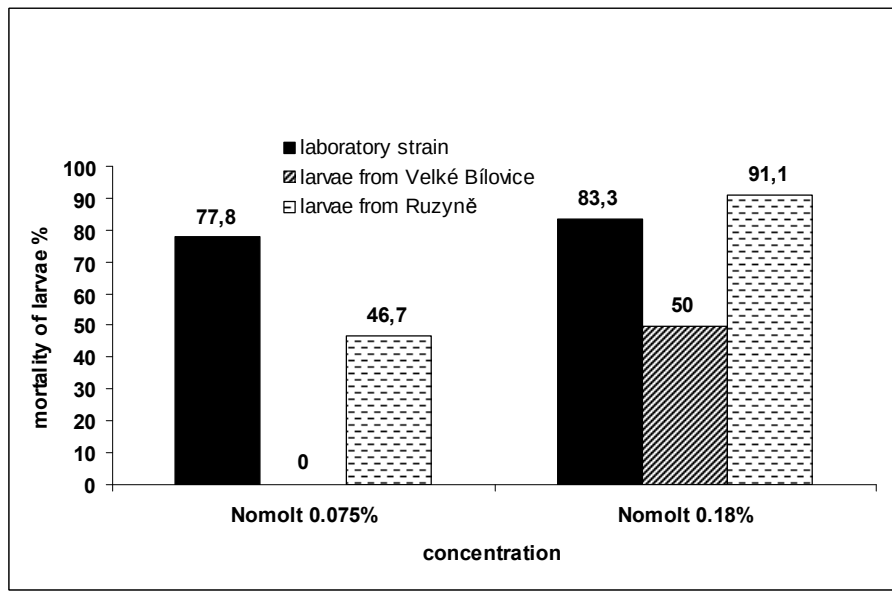

Figure 3. Mortality of L5 codling moth larvae after the topical application of Nomolt 15 SC in concentrations 0.075% and 0.18%

The resistant strain was highly resistant to Zolone. However, the level of resistance varied depending on the date on which the larvae were trapped. 25.7% of the larvae collected on September 2, and 75.7% of the larvae collected on October 19 were resistant to Zolone in comparison to the laboratory strain (Fig. 1). The temporal differences in the proportion of resistant individuals in population may be due to the fact that resistant and susceptible larvae develop at different rates. Boivin et al. (2001) reported that developmental time was significantly longer in the resistant strain than in the susceptible strain.

The susceptible strain was not at all resistant to Zolone. Mortality in the susceptible strain was even higher than in the reference strain.

The level of resistance in the two codling moth populations strongly reflected the history of pest management in the orchards.

In the orchard in Velké Bílovice from which the resistant population had been collected, organophosphate insecticides such as Zolone 35 EC and Reldan 40 EC (chlorpyrifos-methyl) have been heavily used to control the codling moth over the last ten years. This explains why most of the larvae collected in this orchard were resistant to Zolone in our experiments. The resistant population from Velké Bílovice was also partially cross-resistant to the insect growth inhibitors Dimilin 48 SC and Nomolt 15 SC, even though insect growth inhibitors had not been used in this orchard for the past five years. This agrees well with a previous study, in which cross-resistance to phosalone and diflubenzuron was high, with a correlation coefficient of 0.81 (Charmillot and Pasquier, 2002b).

Populations of codling moths also retain resistance to insecticides for a long time. In one study, for example, 20% of the codling moths in the population tested were still resistant seven years after the last treatment (Sauphanor et al., 2002).

In the experimental apple orchard in Prague-Ruzyně from which the susceptible strain had been collected, the only insecticide used against the codling was Nomolt 15 SC, which had been applied from 1998 to 2000. This explains why a small part of the population was resistant to Nomolt. The susceptible strain was not at all resistant to Zolone and Dimilin. No data are currently available about cross-resistance to Dimilin and Nomolt. On the basis of our results for the susceptible strain, the level of cross-resistance to Dimilin and Nomolt appears to be very low.

Mortality in the susceptible strain was always higher than in the reference strain, except with Nomolt at 0.075%. This may be due to a combination of many factors which influence the condition of the larvae collected in the orchard. In the orchard at Ruzyně, no insecticides have been applied since 2000. This allowed natural enemies to become established in this orchard. The larvae collected in this orchard were parasitized by hymenopterans and fungi to a high degree.

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ODPORNOŚĆ OWOCÓWKI JABŁKÓWECZKI (*Cydia pomonella*) NA INSEKTYCYDY

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

W latach 2004 i 2005 przeprowadzono badania odporności larw owocówki jabłkóweczki na wybrane insektycydy. Larwy L_5 odłowiono w 2004 roku z użyciem opasek z papieru falistego, w sadach jabłoniowych zlokalizowanych w dwóch miejscach Republiki Czeskiej. Założono, że w doświadczalnym sadzie należącym do RICP w Pradze-Ruzynie populacja owocówki była wrażliwa, natomiast w sadzie jabłoniowym intensywnie opryskiwanym w miejscowości Velke Bilovice odporna na stosowane insektycydy. Aby to zbadać, wykonano laboratoryjny test odporności dla określenia wyniszczających koncentracji insektycydów stosowanych na larwy L_5. Wysoki poziom odporności na preparaty fosforoorganiczne stwierdzono u osobników pochodzących z populacji występującej w sadzie w Velke Bilovice. Zastosowanie preparatu Zolone 35 EC (fosolon) w stężeniu 0,34% przeciwko larwom L_5 w sadzie w Velke Bilovice wykazało, że od 25,7 do 75,7% larw było odpornych. Wśród larw pochodzących z sadu w Velke Bilovice stwierdzono także odporność na inhibitory wzrostu owadów, takie jak Dimilin 48 SC i Nomolt 15 SC. W populacji pochodzącej z sadu w Pradze-Ruzynie stwierdzono odporność w części testowanych larw (31,3%) tylko na preparat Nomolt 15 SC.

Słowa kluczowe: odporność, *Cydia pomonella,* insektycydy