

Evidence for Resistance to Carbaryl in Poultry Red Mites from the Republic of Serbia and Montenegro

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Abstract

The objective of this research was to examine the efficiency of carbaryl under laboratory conditions, based on field populations of poultry red mites from throughout the Republic of Serbia and Montenegro over a period of 6 years (2001-2006). In 2001 samples, an excellent efficiency level of 95.7% at 0.1% carbaryl concentration after 30-minute exposure was found. The total pharmacological profile of carbaryl in relation to *D. gallinae* mites resulted in adequate control. However, by 2003 a significant decline in carbaryl's efficiency was apparent. By 2005, a population of *D. gallinae* was discovered which showed no apparent susceptibility to carbaryl. Poultry red mite populations had by then developed extreme resistance.

Keywords: carbaryl, poultry red mites, resistance

1. Introduction

The poultry red mite, *Dermanyssus gallinae* (de Geer, 1778) is a hematophagous poultry ectoparasite. We first described the presence of *D. gallinae* in poultry farms in Serbia and Montenegro in 2002 [1]. Intensive poultry farming is currently facing a prevalence of poultry red mite to such extent that in some countries such as UK, Italy, Serbia, Morocco, Montenegro, Japan, France and the Netherlands [2] it has reached 80-90% infestation levels of poultry systems and even up to 100% in Poland [3]. Over the past decade, the main method of *D. gallinae* control was by using insecticide. Over 35 substances are listed for the control of *D. Gallinae* [4]. Carbaryl ranked among the most frequently applied products. The aim of this paper is to discuss the efficiency of carbaryl under laboratory conditions on field populations of poultry red mite *D. gallinae* collected throughout Serbia and Montenegro over a 6-year period (2001-2006).

2. Materials and methods

The examined material included 99 samples of field mite populations. All poultry farms were producing egg layers in battery systems. 1 cm³ sample units of *D. gallinae* were placed in test tubes (5 tubes from each farm) capped to prevent mites escaping, whilst permitting tube ventilation, i.e. air exchange was possible. Under laboratory conditions, these tubes were placed at the points of isolation and uncapped (although caps were porous), so that mites could adapt. After 24 hour adaptation *D. gallinae*, mites were exposed to the ectocide. We used working active substance concentrations of 0.001%, 0.005%, 0.025%, 0.01%, 0.1%, 0.5% and 1% for carbaryl by using serial dilution from a commercial product (Karbaril 10% WP, Zorka "Zastita Bilja", Sabac, Srbija).

For all the tests, we exposed mites to the ectocide for 5 min., 15 min. or 30 min using glass Petri dishes. After exposure, specimens of mites were transferred into glass vials and the knock-down effect was read and recorded, and subsequently after 24 hours as well. In each trial we used 4

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repetitions on 25 specimens (100 specimens per exposure, totalling 300 specimens for each concentration), plus a negative control group of 25 specimens. The surface of the Petri dishes with the ectocide was directly dried up before exposing the mites. In residual effect examinations, after the preparation and application of the ectocide, Petri dishes were left open for a certain number of days (1 to 70), after which they were used for examination. Examination was carried out at the average temperature of 20°C and average humidity of 89%. Mites were examined under magnified glass under artificial light. The mites that did not move were considered as dead. Such mites, in most cases, lie on their backs with their legs in rigour folded and their cuticle showed a slight change of form.

The mean efficiency was compared using one-way ANOVA, followed by the Tukey test for paired post-hoc comparison.

3. Results and discussion

Zeman and Železny (1985) [5] established the highest carbaryl efficiency ($LC_{50}=5.0 \mu\text{g}/\text{m}^2$) in trials with 14 selected acaricides as early as 1985. In our 2001 and 2002 trials, we confirmed the high efficiency of carbaryl on the territories of Serbia and Montenegro (Figures 1 and 2; Table 1). In 2001, 0.5% carbaryl concentration already achieved 100% efficiency in all exposures (Figure 1). Significant efficiency was also recorded for 0.01% carbaryl concentration, which is as little as 100 times lower than therapeutic concentration (Figure 1). In order to distinguish between strains and exposures, we chose a concentration that would enable the best analysis (Figure 1), which was 0.1% carbaryl. The efficiency of 0.1% carbaryl was 95.7% in 2001, which declined to 87% by 30 minutes post exposure (Table 1; Figure 2).

Alongside with the examination of the extended ectocide effect, the high efficiency provided a more accurate pharmacological profile. Only by testing both these characteristics enabled us to evaluate the ectocide effect for poultry red mite control.

As a consequence of the biology and behaviour of poultry red mite, effective management through insecticides can be problematic. A large percentage of the mite population are hidden in cracks and crevices with short feeding periods and

long periods of starvation [6] and may alternate their major food sources. This emphasises that the residual effect of ectocides is the major decisive factor in its impact on the entire mite population. The trials conducted in 2002 especially established the high residual action of carbaryl (60-80%) over the first 14 days, but to a certain extent the action continued for up to 70 days (Figure 3). We determined that there was a noticeable residual effect, creating preconditions for eradication. However we had no opportunity to more extensively this finding as we were unable to use the same samples throughout the entire period. This has led to some unexpected data in terms of increased efficiency in cases of prolonged residual action. In subsequent years, in parallel with the initial decrease in carbaryl efficiency, a reduction in its residual action was observed as well.

The high efficiency of carbaryl, however, was not long lasting and was significantly decreased within 1 year and to a greater extent over subsequent years. Following all exposures, resistance developed in *D. gallinae* between carbaryl efficiencies established in the 2001 and 2006 trials ($p<0.05$) (Table 1). Our data indicates that a short time span is sufficient to highlight efficacy variations; by 2005 we observed a population of *D. gallinae* mites showing no susceptibility to carbaryl, with a 0% lethal effect. Poultry red mite population had already developed an extreme resistance to the insecticide.

The unexpected data for 2006 (Table 1; Figure 2), where carbaryl efficiency is somehow higher than in the previous year (2005), is accounted for by the small number of samples ($n=5$). However, even in these samples only 3% carbaryl efficiency was determined by only 15-minute exposure. With other parameters, there was no mite mortality.

Other authors highlighted the development of poultry red mite resistance to carbaryl. Kilpinen [7] tested the susceptibility of *D. gallinae* collected from four poultry farms, but no resistance to carbaryl was reported. However, somewhat higher resistance levels of carbaryl (on 3 of 10 trial sites) were recorded in Germany the following year [8]. Furthermore, some years later in Italy a high degree of resistance to carbaryl was found in 6 out of 7 examined populations of *D. gallinae* [9].

The resistance seems to have developed fast and not even the excellent pharmacological profile of carbaryl efficiency is sufficient for the efficient

control of *D. gallinae*. The current incidence situation therefore points to worldwide misuse and the need for a radically different approach to *D.*

gallinae control. We have observed a significant margin for improvement utilizing program-based approaches to control [10-12].

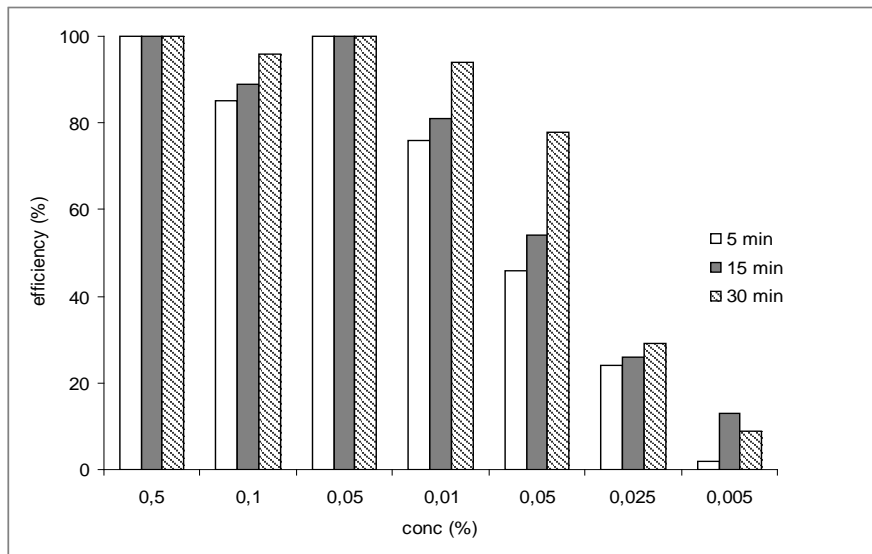


Figure 1. Representation of efficiency of growing carbaryl concentrations for 2001

Table 1. Comparison of the mean efficiency of carbaryl at the concentration of 0.1% for six years of examinations after 5 min, 15 min and 30 min exposure

year	exposure			ANOVA P
	5 min	15 min	30 min	
2001	85.00 ^{abcd}	88.67 ^{ab}	95.78 ^{abcd}	0.089
2002	60.83 ^e	72.17 ^{cd}	87.17 ^e	0.183
2003	42.45 ^a	50.73	61.59 ^a	0.164
2004	36.49 ^b	54.59	69.19 ^{bf}	0.001
2005	13.43 ^{ce}	20.86 ^{ad}	26.00 ^{cef}	0.556
2006	25.40 ^d	35.00 ^b	51.20 ^d	0.448
ANOVA P	0.000	0.000	0.000	

Means not sharing a common letter are significantly different (P < 0.05)

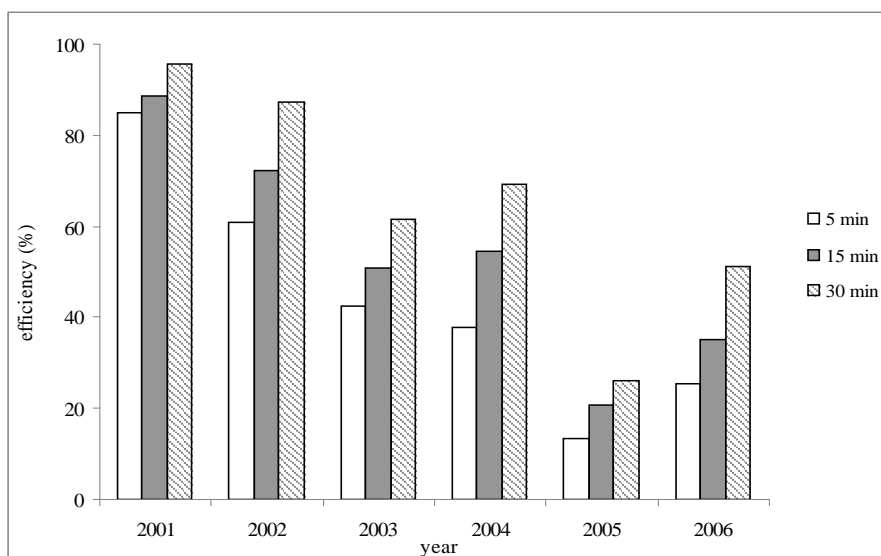


Figure 2. Comparative representation of carbaryl efficiency at the concentration of 0.1% for all years (2001-2006)

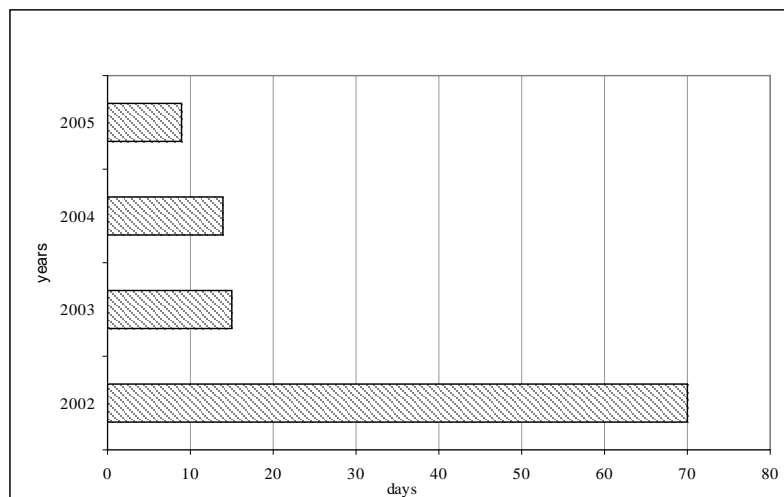


Figure 3. Cumulative graphic presentation of the efficiency of residual carbaryl effect at the concentration of 0.1% for 2002- 2005

4. Conclusions

In the period 2001-2006 was carried out testing the efficiency of carbaryl under laboratory conditions, based on field populations of red poultry mites from throughout the Republic of Serbia and Montenegro. In 2001 samples, an excellent efficiency level of 95.7% at 0.1% carbaryl concentration after 30-minute exposure was found. The total pharmacological profile of carbaryl in relation to *D. gallinae* mites resulted in adequate control. However, by 2003 a significant decline in carbaryl's efficiency was apparent. By 2005, a population of *D. gallinae* was discovered which showed no apparent susceptibility to carbaryl. Poultry red mite populations had by then developed extreme resistance.

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