IN VITRO EFFECTIVENESS OF SELECTED ACARICIDES AGAINST RED POULTRYMITES (DERMANYSSUS GALLINAE, DE GEER, 1778) ISOLATED FROM LAYING HEN BATTERY CAGE FARMS LOCALISED IN DIFFERENT REGIONS OF POLAND

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Abstract

Investigation was carried out on red poultry mites Dermanyssus gallinae collected from 32 battery cage farms of laying hens localised in 14 voivodships. The following insecticides were used: Alfasekt (α-cypermethrin), Blaxime (phoxim), ByeMite (phoxim), Ficam (bendiokarb), Galltox B (fenitrotion, dichlorphos, α-cypermethrin), Knox-out (diazinon – microcapsule form), Master (chloropyrifos – microcapsule form), Skorpion (sevin, α-cypermethrin), Sumition (fenitrotion – microcapsule form). The efficacy of the acaricides was investigated on the plates using the veneer disc as the ground. The insecticides were used in concentrations and volumes recommended by producers of preparations. Efficacy study showed that the most effective against most of red mite populations were phoxim Blaxime and Bye Mite (89%-100% in 13 voivodships) and one carbamate preparation – Ficam (92%-100% in 11 voivodships). Relatively effective turned out to be also another carbamate acaricide with α-cypermethrin supplement – Skorpion. Phosphororganics in microcapsule form and acaricides containing only α-cypermethrin demonstrated low effectiveness.

Key words: Dermanyssus gallinae, acaricides, effectiveness, in vitro experimentation.

Dermanyssus gallinae (De Geer, 1778) – red poultry mite - is one of the most dangerous ectoparasites of poultry. It is classified to phylum Arthropoda, class Arachnoida, order Acarina, suborder Mesostigmata, family Gamasidae, and genus Dermanyssus. Red mite is the plague parasite of fowl but it attacks also other birds (5, 6, 9, 17, 18), mammals (8), and even people (1, 2). Body of this parasite is pear-shaped, gray (after blood feeding the colour of the body changes to red or brown). It is covered by chitin shell and a single dorsal shield occurs dorsally. Length of adult mites ranges from 0.7 to 1.0 mm and width from 0.4 to 0.5 mm. Legs are hard ended with lap and two little claws. This enables the parasite to move efficiently on every type of surface. The mites feed the blood after puncturing the birds’ skin by long daggered cheliceras (5). They are typical periodic parasites, which attack birds at night and during day they hide in hen-house environment. Red mites are very resistant to hunger and can persist even several months without feeding. They are active in wide range of temperatures: from 2 to 45°C. The life cycle is very short; it lasts about 7 d under favourable conditions.

The infection with red mites is a serious problem in poultry farms worldwide. Data from research literature (21) show, that the percentage of poultry farms in China infected with these parasites was 64.1%. Sparagano et al. (19) demonstrated D. gallinae in 74.1% battery cage farms in Italy, while data from Great Britain (10) showed 58% farms with red mites in this country. According to Chauve (7), D. gallinae occurred almost in all regions of France.

In Poland, up to the half of nineties of the XX century, D. gallinae infection was a problem only in small farms. Situation changed in half of the nineties when cages, often contaminated with colonies of D. gallinae imported from the European Union, started to be used. This fact and the import of hens to reproductive flocks from Czech Republic and Germany became the beginning of the serious problem with D. gallinae infection in large industrial poultry farms in Poland.

Investigation carried out by Wójcik (22) showed the high prevalence of red mites in poultry farms near Toruń. Similarly, in Silesian region, a high prevalence of these parasites was found in laying hens (about 70% of farms) and very intensive contamination in flocks of broiler ducklings and goslings (4).

Control of D. gallinae infection in poultry farms is necessary because of large economical losses and the possibility of transmission of the pathogen (12, 16). The most popular method to control the red mite infection in poultry farms is the usage of varied acaricides, applied in the form of aerosol between production cycles. The following acaricides were used so far: most often carbamates and pyrethroids and relatively rare phosphoroorganics, chloro-nicotine, juvenile hormones, and acaricides based on amitraz.
Difficulties in acaricide application into slim slits of walls and cages (places of mites’ gathering) cause a survival of the pest control by some part of the parasites. Frequent use of these acaricides and not fully effective red mite control cause that the resistance of these parasites to acaricides quickly appears (3, 20, 23). Rate of resistance produced by mites depends, among others, on frequency of acaricide application.

The aim of this investigation was to estimate the resistance of poultry red mite populations from different regions of Poland to commonly used acaricides.

**Material and Methods**

The investigation was carried out on red poultry mites *Dermanyssus gallinae* collected from 32 battery cage farms of laying hens localised in 14 Polish voivodships. Mean number of birds in the examined farms was about 70,000 (5,000–385,000) and in a single hen-house about 20,000 birds (5,000–70,000). There were three to six levels of cage systems in the farms (mostly four levels). Age of hens ranged from 25 to 82 weeks. The interview concerning occurrence of red mites and control methods was made in each farm.

Six samples of mites (per 1-3 g of parasites) were collected from each farm into tightly closed 150 ml plastic containers.

The list of insecticides used in the study and their concentrations and working dilution volumes recommended by producers is presented in Table 1. Efficacy of the acaricides was estimated by own method. Examination was carried out on the plates made according to own design (patent No. P-376067) using the veneer disc as the ground (imitating a rough surface).

**Fig. 1.** The plate used for examination of the efficiency of acaricides against *D. gallinae*.

The veneer disc (diameter of 90 mm) was cemented in place with aquarium silicon to the central field of the plate (Fig. 1). Then, an appropriate amount of acaricide solution was distributed on the surface of the disc and the disc was dried for 24 h. Then *D. gallinae* mites (about 80-100 mites per disc) were put on the surface of the dripped discs. The grooves of each plate were filled with edible oil up to 1 mm lower than surface of plate (oil is a barrier for mites, which does not allow to move them outside the veneer disc).

Efficacy of each acaricid was examined on four plates (four replications). Moreover, four plates constituted the control group with moistened discs with water without acaricides. After 24 h, the dead mites were counted (using a stereoscopic microscope and reflected light at 5–20x magnification).

Next, all mites were counted for the second time, after immobilising possible living parasites through sticking them to the surface of the disc with transparent shrink-wrap. It is assumed that the number of living mites is the result of subtraction between the number of dead mites (found during first counting) and the total number of mites found on the plate after sticking the shrink-wrap. In calculation, only nymph and adult forms were taken into consideration. For each plate containing the disc dripped with a solution of acaricide, a mortality rate of mites was calculated, with the correction taking the mortality in the control group into consideration (Abbott correction). An average constituted the final count around four repetitions.

The significance of relations between the efficacy of the respective groups of insecticides used earlier for the control of red poultry mite infestation in farms, defined on the basis of interviews obtained from farmers, and efficacy of acaricides used in the experiment, was determined with the use of ANOVA rank test Kruskal-Wallis and test of median analysis.

**Results**

Intensive infection with *D. gallinae* was observed in all examined farms. According to the interviews, red poultry mite infestation lasted in individual farms from 1 to 12 years. Different methods of control of *D. gallinae* were used in the farms. Carbamates and pyretroids were used the most often (26 and 25 farms, respectively). Phosphoroorganics and other preparations based on different active substances (chloro-nicotine, amitraz, juvenile hormones) were used much more rarely. It must be pointed out that preparations with unknown ingredients were admitted to use in as many as 16 farms. Moreover, actions to eliminate red mites with physical methods were additionally applied: the spraying of cages and hens with commercial surface-active agents (15 farms) and silicon compounds (20 farms).

Efficacy study of nine commercial acaricides showed that the most effective against most red mite populations were compounds based on phoxim (Blaxime and ByeMite) and on one carbamate preparation – Ficam. Weaker efficacy was demonstrated by Skorpion and Galtox – acaricides used most often in the last years. However, phosphoroorganics in microcapsule form and acaricides containing α-cypermethrin appeared useless for red mite eradication.

The mean results for the efficacy of individual acaricides are presented in Table 2 (because of a large range of results, and occurrence of results, which significantly differed from average values, median was regarded as more representative).
### Table 1
Acaricides used in experiment estimating their efficiency against *D. gallinae*

<table>
<thead>
<tr>
<th>Preparation (producer)</th>
<th>Recommended concentration</th>
<th>Volume of working dilution /m²</th>
<th>Active substance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ficam (BAYER ENVIROMENTAL SCIENCE, France)</td>
<td>0.6%</td>
<td>4 l/100 m²</td>
<td>80% bendiokarb (carbamate)</td>
</tr>
<tr>
<td>Blaxime (BROS, Poland)</td>
<td>0.4%</td>
<td>5 l/100m²</td>
<td>48% phoxim (phosphoroorganic)</td>
</tr>
<tr>
<td>Skorpion (ASPLANT-SKOTNICCY, Poland)</td>
<td>4.0%</td>
<td>5 l/100m²</td>
<td>40% sevin (carbamate), 0.8% α-cypermethrin (pyrethroid)</td>
</tr>
<tr>
<td>Sumition (SUMITOMO CHEMICAL, Japan)</td>
<td>2.5%</td>
<td>5 l/100m²</td>
<td>20% fenitrothion (phosphoroorganic) - microcapsule form</td>
</tr>
<tr>
<td>Knox-out (Cerexagri, France)</td>
<td>4.0%</td>
<td>5 l/100m²</td>
<td>23% diazinon (phosphoroorganic) - microcapsule form</td>
</tr>
<tr>
<td>Alfasekt (ASPLANT-SKOTNICCY, Poland)</td>
<td>1.0%</td>
<td>5 l/100m²</td>
<td>5% α-cypermethrin (pyrethroid)</td>
</tr>
<tr>
<td>Master (MAKHTESHIM AGAN, Izrael)</td>
<td>2.0%</td>
<td>10 l/100m²</td>
<td>25% chlorpyrifos (phosphoroorganic) - microcapsule form</td>
</tr>
<tr>
<td>Galtox B (ASPLANT-SKOTNICCY, Poland)</td>
<td>3.0%</td>
<td>5 l/100m²</td>
<td>20% fenitrothion (phosphoroorganic), 7% dichlorphos (phosphoroorganic), 2% α-cypermethrin (pyrethroid)</td>
</tr>
<tr>
<td>ByeMite (Bayer Pharma Division Sante Animale, France)</td>
<td>0.4%</td>
<td>5 l/100m²</td>
<td>50% phoxim (phosphoroorganic)</td>
</tr>
</tbody>
</table>

### Table 2
Efficiency (%) of acaricides tested on mites collected from 32 farms

<table>
<thead>
<tr>
<th>Efficacy</th>
<th>Alfasekt</th>
<th>Blaxime</th>
<th>Bye Mite</th>
<th>Ficam</th>
<th>Galtox B</th>
<th>Knox-out</th>
<th>Master</th>
<th>Skorpion</th>
<th>Sumition</th>
</tr>
</thead>
<tbody>
<tr>
<td>The lowest</td>
<td>0.00</td>
<td>71.20</td>
<td>59.00</td>
<td>75.20</td>
<td>17.90</td>
<td>0.00</td>
<td>0.20</td>
<td>8.10</td>
<td>1.70</td>
</tr>
<tr>
<td>The highest</td>
<td>99.10</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>90.40</td>
<td>75.90</td>
<td>100.00</td>
<td>98.60</td>
</tr>
<tr>
<td>Mean</td>
<td>22.27</td>
<td>96.48</td>
<td>95.97</td>
<td>95.56</td>
<td>66.29</td>
<td>26.04</td>
<td>23.57</td>
<td>74.65</td>
<td>27.56</td>
</tr>
<tr>
<td>Median</td>
<td>7.30</td>
<td>99.00</td>
<td>98.85</td>
<td>98.15</td>
<td>68.90</td>
<td>15.90</td>
<td>15.00</td>
<td>91.55</td>
<td>17.60</td>
</tr>
</tbody>
</table>
Figure 2 shows that highly effective acaricides demonstrated reduced efficacy against *D. gallinae* collected from farms localised in some voivodships: ByeMite and Blaxime against mites from central and south-western voivodships, and Ficam against mites from some southern and one western voivodship. Scorpion, in spite of common long term usage, demonstrated relatively high efficacy against mites from eight voivodships. Galtox B, the second preparation with respect to commonness of usage, demonstrated satisfactory efficacy only against mites from north-western Poland. Remaining acaricides were not sufficiently active in any region of Poland.

Statistical analysis made with the use of non-parametrical ANOVA Kruskall-Wallis rank test and test of median analysis did not demonstrate significant relations between acaricides routinely used in farms (according to owners’ declaration) and efficacy of individual preparations used in the experiment. Only in the case of Master, the statistically significant (P=0.0278 and P=0.0493) reduction of efficacy was noted in farms where earlier phosphoroorganics were used routinely.

**Discussion**

Interviews made during investigation among owners of hen farms in Poland showed that, the most common methods of red mite eradication in hen-houses were the use of different acaricides in spray or physical actions (spraying with surface-active agents or silicon compounds). Phosphoroorganics, pyrethroids, and carabamates were the most often used acaricides. Procedures of mite control and kinds of acaricides used in Poland were similar as in other European countries (3). However, in Western Europe the resistance of red poultry mites for these substances could have developed considerably earlier, taking under consideration the fact that the *D. gallinae* problem occurred earlier and acaricides used to control the infections were used much longer. Our study showed that acaricides containing phoxim were the most efficient against Polish populations of *D. gallinae*. Similarly, high efficacy of phoxim against these parasites was demonstrated by Keita (11) and Mayer-Kuhling (14). Blaxime and ByeMite were new products on Polish market and they were used by hen breeders until recently. The investigation demonstrated their high effectiveness (94%-100%) in farms in almost all regions of Poland - with exception of one centrally localised voivodship where the efficacy was 77%. It pointed out that the resistance to these preparations in Polish populations of red mite might have started to develop. Carbamate acaricides: Scorpion and Ficam turned out to be relatively effective. Scorpion was efficient in more than a half of the country (80%-99%) despite of the long period of its usage. The second preparation, Ficam (lately introduced in Poland), demonstrated high efficiency in Polish farms (91.6%-100%), except two southern and one south-western voivodships (84%-87%). The efficiency of carbamate acaricides
acaricides were confirmed in laboratory investigation by Zeman (23). Effectiveness of this group of acaricides against *D. gallinae* was completely different in Western Europe - according to literature it was very low. Marangi (13) showed that acaricides used in Italy in the highest concentrations were efficient only in one of six farms where they were applied.

Among the examined acaricides, phosphoroorganics in microcapsule form and acaricide containing only *α*-cypermethrin demonstrated the lowest efficiency. The results found confirmation in the literature (23). According to Murano (15) efficiency of acaricide Sumition was only 18% after 24 h. During investigation carried out in France (3), low efficiency of dichlorphos was demonstrated and the first case of resistance to pyrethroides in this country was noted in one of the five examined farms. This case indicates the development of resistance of the given population to the acaricide.

In our investigation, the dependence between efficacy of acaricides used in the experiments and preparations earlier used routinely in farms was not found. The reason of this situation could be the introduction of red mite populations with already developed resistance to some groups of acaricides from European Union countries to Polish farms. Other reason of the red mite resistance observed in half of the farms could be the use of dissection preparations containing unknown ingredients, which was noted during the interviews with the farmers. The reliability of answers of the farmers also should be taken into consideration.

The significant differences between efficiencies of the examined acaricides in individual regions of Poland were demonstrated. It could be the consequence of distribution of insecticides by local wholesales or custom of dissection teams for using only acaricides known for them.

Summarising, the investigation demonstrated high efficiency of acaricides based on phoxim (Bye Mite and Blaxime) and bendiocarb (Ficam), which have a relatively short usage period on the Polish market. Nevertheless, some signs of the development of the regional red mite resistance to these acaricides pointed out the necessity of monitoring this situation and, if necessary, replacing them by new preparations.

### References