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Efficacy of spinosad against the poultry red mite, *Dermanyssus gallinae* (Mesostigmata: Dermanyssidae), in laboratory and field trials*

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Abstract

The poultry red mite, *Dermanyssus gallinae* (De Geer), is the most economically important ectoparasite in poultry houses in many countries around the world. The lack of efficacy of commercial products in its control results from poor application and/or from its resistance to active ingredients. A new insecticide, spinosad, was tested against mobile stages of the red mite in laboratory and field populations. Laboratory trials showed increasing efficacy five days (adults) and six days (nymphs) after exposure. Laboratory results were confirmed in a field trial conducted under commercial conditions. The trial was conducted in three separate houses on farms with high natural mite populations. The first and second houses were sprayed with concentrations of 2,000 and 4,000 ppm of spinosad (2 and 4 g/L), whereas the third house was used as an untreated control. Spraying was conducted using a sprayer (Stadikopumpe VA AR 252-200 LE, Dinklage, Germany) with a 200 L reservoir with permanent stirring, a 50 m long flexible tube with a double jet system, and jet size of 0.08 mm. The pressure used was 6–10 bar. Sampling was conducted immediately before the application and once a week for 56 days in the first house and 93 days in the second. In the first house, almost 100% reduction in mite numbers was observed until 28 days post treatment; 74.3% reduction was observed 49 days after treatment. In the second house, rates of reduction were higher than 90% until day 77. The untreated control house maintained high red mite infestations throughout the experimental period. The results showed effective control of all mobile stages of *D. gallinae* with spinosad.

Key words: Red Mite, *Dermanyssus gallinae*, control, spinosad, elector.

Introduction

The poultry red mite, *Dermanyssus gallinae* (De Geer) (Acari: Mesostigmata), is a parasite with wide host-range, including wild and domestic birds. It is known from 30 bird and 10 mammal species (Moss, 1968). The most commonly recorded hosts are the domestic fowl (*Gallus gallus*), turkey (*Meleagris gallopavo*), duck (*Anas platyrhynchos*), pigeon (*Columba livia*), house sparrow (*Passer domesticus*), starling (*Sturnus vulgaris*) and canary (*Serinus canarius*) (Evans & Till, 1966). In the absence of birds, *D. gallinae* will also attack mammals such as rodents, dogs, cats, horses, as well as humans (Evans & Till, 1966; Brockis, 1980; Hoffmann, 1987). The nocturnal feeding behaviour of *D. gallinae* disturbs the sleep of birds, leading to irritation and apathy. Being able to ingest relatively large amounts of blood, it often causes anaemia and even death of the host (Kirkwood, 1967; Urquhart *et al*., 1996), resulting in major decrease in egg production (Jungmann *et al*., 1970). *Dermanyssus gallinae* is a potential vector of the causal agents of several viral diseases, such as Equine Encephalitis (Sulkin *et al*., 1955, Zeman *et al*., 1982, Durden *et al*., 1993) and St. Louis Encephalitis (Smith *et al*., 1947). It can be a vector of bacteria such as *Salmonella* spp. (Valiente Moro *et al*., 2007), *Mycobacterium* spp. and *Erysipelothrix rhusiopathiae* (Brooke & Riley, 1999; De Luna *et al*., 2008; Chirico *et al*., 2003). It is also known to cause itching dermatosis in humans (Baselga *et al*., 1996).

The most frequently used acaricides against *D. gallinae* are organophosphates, carbamates and pyrethroids. Organophosphates and carbamates are toxic to arthropods and mammals by virtue of

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their ability to inactivate the enzyme acetylcholinesterase (Fukuto, 1990). Pyrethroids are neurotoxins, interacting with the sodium channel in the cell membrane (Salish, 1989). Organic farmers commonly use non-chemical methods, as chalk spraying of the walls and ceiling, to combat this mite. Other options involve mite desiccation with sorptive dusts (Kirkwood, 1974; Maurer & Perler, 2006; Saucke, 1998). The effect of entomopathogenic fungi is another approach under investigation (Steenberg & Kilpinen, 2003).

There are reports of *D. gallinae* resistance to permethrin and organophosphates (Murphy *et al*., 2002; Beugnet *et al*., 1997; Liebisch & Liebisch, 1998, 2001a, b). In order to prevent the development of resistance, groups of acaricides are suggested to be used in rotation (Chauve, 1998).

Spinosad is a new compound shown to be potentially effective against insects. This compound corresponds to a fermented product of the bacterium *Saccharopolyspora spinosa* (Mertz & Yao, 1990). The formulation of this compound contains a mixture of two of the most active metabolites, designated as spinosyn A and spinosyn D. In insects, the mode of action of spinosad is associated with excitation of the nervous system (Salgado, 1998), altering the function of nicotinic and GABA-gated ion channels, in a manner consistent with that observed in neuronal excitation. Spinosad does not interact with known binding sites for other nicotinic or GABAergic insecticides. The objective of this research was to evaluate the efficacy of spinosad for controlling *D. gallinae* under laboratory and field conditions.

Materials and Methods

Laboratory trials

The adopted experimental procedure for engorged nymphs and adults corresponded to the "Mite-Package-Test" (MPT), an adaptation of the "Larval-Package-Test" used to test resistance of the tick *Rhipicephalus* (*Boophilus*) *microplus* (Canestrini), Ixodidae (Stone & Haydock, 1962; Anonymous, 1971). The experimental unit for this procedure consisted of a bag made with a piece of filter paper (10 x 7.5 cm). The paper was folded across its mid length and then closed tightly along the margins, leaving the top open. For each test, 100 nymphs or adults of *D. gallinae* were placed in the bag through the open top. A total of 10 mL spinosad solution was then sprayed in the bag with a 10 mL bottle sprayer (Köhler, Art. No. 5024001, OMNILAB, Munich, Germany); two concentrations (2 and 4 g/L) of Elector® (480 g of spinosad/L, Elanco Animal Health), corresponding to 2,000 and 4,000 ppm, were used. The top of the bag was then closed with clips and placed onto a floating platform inside a bowl with water plus detergent, to prevent the mites from escaping. The test with adults had three replicates and a 5-day exposure period, while the test with nymphs had two replicates and a 6-day exposure period. At the end of each exposure period, the numbers of mites that were live and apparently healthy, moribund or dead were counted under a stereomicroscope. Response data of adults to spinosad were subjected to ANOVA.

Field trials

The study was conducted in two poultry layer houses of a commercial facility, where spinosad was applied; a third layer house in a different commercial facility was used as an untreated control. The first two houses were located in Immensen and the third in Lindhorst (Germany); the study was conducted between July and November 2009. The houses were of the aviary style or cage free birds, each 8.5 x 10.5 m in the first facility and 6.0 x 12.0 m in the second. Spinosad was applied once using a commercial application equipment (Stadikopumpe VA AR 252-200 LE, Dinklage, Germany) having a 200 L reservoir with stirring, a 50 m flexible tube with a double jet system, and jet size of 0.08 mm. The concentrations used were 2g/L in the first house and 4 g/L

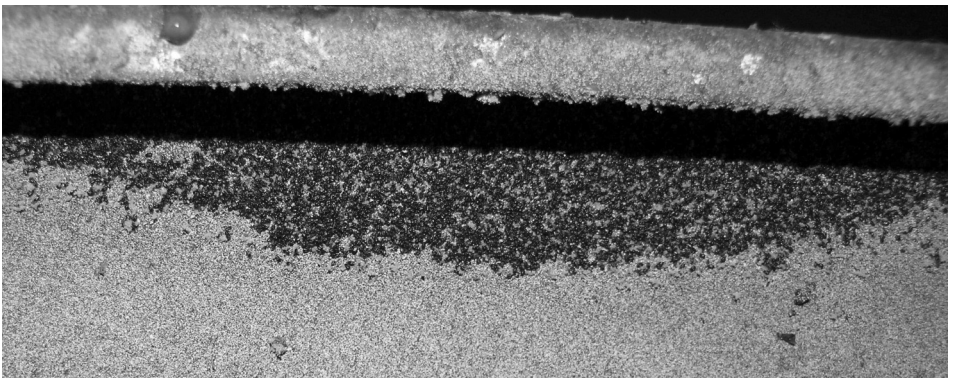

FIGURE 1. Lower surface of feeding racks with aggregations of *Dermanyssus gallinae*.

in the second house. The pressure used was 6–10 bar. A total of 140 liters of solution was sprayed in each house.

Efficacy evaluations were done weekly over a period of 56 days after treatment in the first house and 93 days after treatment in the second. For such, a sample of substrate was randomly taken from each of ten points from throughout each of the three houses immediately before the application of spinosad and every seven days afterwards. Each sample consisted of mites and debris collected from an area of approximately 10 x 10 cm at three locations (conveyer belt that carries the eggs, connecting sites and the lower surface of the feeding racks) (Fig. 1), with the help of a 2 cm wide paint brush. Each sample was transferred into a container which was then sealed and immediately taken to the lab. Mites of each sample were then separated from the debris under stereomicroscope. All mites from samples with apparently up to 1,000 mites were slide mounted in polyvinyl-lactophenol. In the case of samples containing more than 1,000 mites after a rough estimate, all mites were placed in a container with 100 mL of 70% alcohol and then an aliquot of 10 mL was taken to filter out all mites, which were mounted as previously indicated. All mites were counted and all mounted mites were identified. The efficacy of the treatments was calculated by Abbott´s formula (Abbott, 1925).

Results

Laboratory trials

The laboratory trials showed the efficacy of spinosad against nymphs and adults of *D. gallinae* at both concentrations. Average nymph mortalities, including dead and moribund mites, were very similar, namely 91.6 and 97.4% for concentrations of 2 and 4 g/L, respectively (Table 1).

TABLE 1. Response to spinosad in engorged nymphs (6-day exposure period) and adults (5-day exposure period) of *Dermanyssus gallinae* under laboratory conditions.

Treatment	Nymphs			Adults		
	Total number of mites	% dead	% (dead + moribund)	Total number of mites	% dead	% (dead + moribund)
Spinosad 2 g/L	202	89.6	91.6	327	62.1	65.7
Spinosad 4 g/L	196	95.4	97.4	321	90.3	93.1
Control	194	3.1	3.1	335	2.4	2.4

TABLE 2. Descriptive data analysis with ANOVA for trials with adults of *Dermanyssus gallinae* to spinosad.

	N	Mean	Standard Deviation	Min	Max
Untreated	3	0.83865	0.48419	1.50	3.00
2 g/L	3	11.47519	6.62520	53.00	73.80
4 g/L	3	9.70000	5.60030	81.40	98.30
total	9	40.82870	13.60957	1.50	98.30

TABLE 3. Efficacy of spinosad against *Dermanyssus gallinae* (all mobile stages) after treatments of two poultry layer houses in farm Hattenbach (house 1 at 2 g of spinosad/L, house 2 at 4 g of spinosad/L) and farm Brunkhorst (untreated control).

Days after treatment	Total number of mites (all mobile stages)			Efficacy (%)	
	house 1 (2 g/L)	house 2 (4 g/L)	control	house 1 (2 g/L)	house2 (4 g/L)
0	12010	10260	12300	-	-
7	241	71	15720	98.5	99.5
14	38	0	14980	99.7	100
21	263	1	8750	97.0	99.9
28	81	1	18749	99.6	99.9
35	1117	16	16880	93.4	99.9
42	2248	7	10800	79.2	99.9
49	3110	1	12090	74.3	99.9
56	10310	196	14080	26.8	98.6
63	n.c.	280	13870	n.c.	98.0
70	n.c.	444	6410	n.c.	93.1
77	n.c.	565	9450	n.c.	94.0
84	n.c.	3066	7090	n.c.	56.8
93	n.c.	11510	7560	n.c.	0

n.c. not counted

Average adult mortality, also including dead and moribund mites, was 65.7 and 90.3% for concentrations of 2 and 4 g/L, respectively; in this case, statistical differences were observed between treatments (p= 0.0001), with no overlapping between ranges of mortality rates (Table 2).

Field trials

In the house sprayed with 2 g/L, almost 100% mite mortality was observed until 28 days post treatment; on day 49, reduction was 74.3% (Table 3). Mortality dropped to only 26.8% at this concentration on day 56, when monitoring was discontinued. In the house sprayed with 4 g/L, mortality was at least 93.1% up to day 77 post treatment, dropping to 56.8% on day 84 and no mortality on day 93, when monitoring was discontinued (Table 3). The untreated control house maintained high red mite infestations throughout the experimental period.

Discussion

The results showed that spinosad is effective against all mobile stages of the poultry red mite. The 4 g/L dose provided a greater reduction in mite numbers and for longer duration than the 2 g/L dose. Present issues in controlling *D. gallinae* are that there are no approved acaricide that can be used because of residues in meat and eggs. Carbamate, organophosphate and pyrethroid acaricides can only be used in the service period between flocks, when hens are absent from the houses. Another major issue is the high resistance against available acaricides. Therefore, it is important to find new substances to control this parasite.

Elector (spinosad) is registered in the Germany, UK, France and Italy for the control of the poultry red mite, darkling beetles (*Alphitobius diaperinus*) and house flies (*Musca domestica*). Registration is pending in other countries of Western Europe. Field evaluations have been conducted in all countries where it is registered as well as in the countries pending approvals, always with good results.

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