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0.4% Dimeticone spray, a novel physically acting household treatment for control of cat fleas

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ABSTRACT

The cat flea, *Ctenocephalides felis*, is the most important ectoparasite of cats and dogs worldwide as a cause of irritation and health problems. Most products to control these pests in the household environment rely upon a combination of neurotoxic insecticides and insect growth regulators to inhibit development of flea eggs and larvae into adults. However, some of these are affected by problems of insecticide resistance as well as public concerns about their potential for toxicity in domestic use. Heavy synthetic oils, like the siloxane dimeticone, are currently widely used to treat human ectoparasite infestations, acting by a physical mode of action, and have been used in a variety of presentations for killing all life stages of fleas. We have investigated the activity of low concentrations of high molecular weight dimeticone in a volatile silicone base for ability to immobilise flea life stages without asphyxiating them. We found that cat flea adults and larvae were immobilised by a surface film of dimeticone that inhibited movement of cuticular joints, apparently forming an effective sticky trap. When cocoons were treated the fleas continued to develop within the pupae but failed to emerge. An aerosol spray incorporating 0.4% concentration of dimeticone, for use as a residual household treatment, showed no significant difference in knock down capability compared with that of a widely used pyriproxifen/permethrin spray in a repeat challenge test, with effects persisting to inhibit adult flea emergence in the test arena area for more than 3 weeks after application.

1. Introduction

The cat flea, *Ctenocephalides felis* (Bouché), is the most abundant ectoparasite of cats and dogs worldwide and the most common domestic biting nuisance (Rust and Dryden, 1997). The domestic nature of the hosts means that all stages of fleas are often found in households, particularly in pet bedding, soft furnishings, and on carpets, with the result that control of the insects is of primary concern for any pet owner.

Due to the significant nuisance value of cat fleas, billions of dollars have been spent on their control every year for some considerable time (Krämer and Mencke, 2001), but with limited success. Historically this has involved extensive application of insecticides, and more recently insect growth regulatory chemicals, both to the pets and to affected areas within the house. Over time, the effectiveness of these compounds has been compromised by selection of insecticide resistance in the fleas (Bossard et al., 1998, 2002). In addition there are also worries amongst some consumers about the potential for toxicity of such chemicals that might come into contact with children playing on the treated surfaces or in relation to the exposure of the pets themselves (Dudley, 2002; Falconer, 2013; PeTA, 2013), although there is no evidence of safety concern on the part of any regulatory agencies.

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In recent years there has been considerable interest in development of methods to control ectoparasites using chemical entities that have a physical mode of action. This has been most notable in the category of human head louse control in which synthetic oils such as polydimethylsiloxane (dimeticone) have been shown to immobilise and kill the insects (Burgess, 2009; Burgess et al., 2005). A similar activity can be observed against a variety of arthropod species (Itoh and Nishimura, 1987). However, the process of spiracle occlusion leading to asphyxiation or water disruption, which is considered a physical mode of action by medical regulatory authorities, is not recognised as being a physical mode of action by the authorities enforcing regulation of environmental biocides under the terms of the Biocidal Products Directive (Directive 98.8. EC) in the European Union, whereas the general concept of "sticky traps", which can include any non-setting, viscous, physically tacky or adhesive, immobilising, non-physiologically acting surface or surface film, is currently considered to fall within the classification of a physically acting approach and is thereby exempted from regulation under the Directive.

This report describes an investigation to evaluate the potential for use of high molecular weight, high viscosity, dimeticone as a "sticky trap" for domestic use against various life stages of cat fleas in comparison with a widely used insecticide and growth regulator based preparation. Some of these observations and results were previously presented as a poster and supporting audio visual presentation at the World Association for the Advancement of Veterinary Parasitology (WAAVP) (Burgess et al., 2007)

2. Materials and methods

2.1. Fleas

We obtained the various flea life stages from a laboratory reared flea colony, which had been in culture in our laboratory for approximately 12 years. This was maintained using an "Artificial dog" apparatus (Flea Data, Inc., Freeville, NY, USA) in which adult fleas were fed on citrated cow blood through an artificial membrane (Meola et al.,1993; Pullen and Meola, 1995). We collected flea eggs from the feeding chambers at 2–3 day intervals, i.e. at or just before the point of hatching, and incubated the emerging larvae in a standard larval rearing medium at 25 °± 2 °C and 70% ± 5% relative humidity (RH) until they had reached the third larval instar, normally around 12 days after emergence from their eggs. If adult fleas were required they were separated using the vacuum collection system supplied with the "Artificial dog".

2.2. Petri dish tests

We used Whatman No 1 filter paper as the substrate for initial evaluations of the activity of test materials. These were based on an existing silicone preparation containing 4% high molecular weight dimeticone in a decamethylcyclopentasiloxane (cyclomethicone) solvent (Hedrin 4% lotion, Thornton & Ross Ltd., UK), diluted using additional quantities of cyclomethicone. The original mixture was diluted two-fold, 4, 10, 20, and 40-fold. Aliquots of 500 μL of the different concentrations of the diluted fluid were applied evenly by pipette over the surface of 90 mm filter discs to give dimeticone application rates ranging from 0.152 mg/cm^2 to 0.0076 mg/cm^2. When the surface of the disc appeared dry by evaporation, and no detectable fluid could be picked up by dabbing the surface with a gloved finger tip, the test paper was considered ready for use. Each treated disc was fitted into a glass Petri dish and 10 fleas added. Separate tests were performed using adult fleas and third stage larvae. Three repetitions were performed at each dilution.

After selection of an appropriate mixture, which was then hand filled into a pressurised aerosol dispenser by a contract supplier, further tests were conducted using fabric substrates selected from types used in pet bedding. Discs of two types of fabric, a velvet-like surface and a ribbed cordwain, were cut to fit flea rearing containers with a diameter of 55 mm and then sprayed with the aerosol silicone mixture. Within 10 min of spraying, and again after drying for 7 days, adult or larval fleas were added and observed at intervals to determine whether their activity had changed in any way, for example by exhibiting signs of distress, through uncoordinated or erratic movements, or whether they were moving about or resting normally.

An additional test was conducted to find out whether the dimeticone mixture had any effect on pupae within their cocoons. For this test, mature larvae were placed on the fabric, provided with a dusting of culture medium to encourage pupation and left for 72 h, during which time the majority of larvae had spun cocoons. The newly formed cocoons were then sprayed using the same dose rate as the simulated use tests described below. This spray exposure occurred approximately 24–48 h after completion of spinning of the cocoons, which time allowed the enclosed larva to complete its moult to the pupa stage. A second group of cocoons was treated 5 days after formation to determine whether the time of application of the spray, relative to the state of maturation of the pupa, resulted in any difference of effectiveness. Treated cocoons were dissected at intervals and compared with untreated cocoons, until fleas began to emerge from the untreated cocoons approximately 14 days after the initial formation of the cocoons.

2.3. Simulated use tests

We subsequently set up simulated use tests for evaluation of a commercial finished product aerosol containing 0.4% dimeticone in cyclomethicone (Household Flea Spray, Ceva Animal Health Ltd., UK), developed from this investigation.[2] The aerosol can was found to deliver approximately 1 g spray per second of atomisation, equivalent to 4 mg high molecular weight dimeticone. This spray was compared with an industry standard product containing the insecticide permethrin (5 g/L), an insect growth regulator (IGR) pyriproxifen (50 mg/L), and piperonyl butoxide (10 g/L)(Indorex®, Virbac, France). For this product the aerosol delivered approximately 1.25 g spray

[2] The brand name and new owner of the rights to the product is: Flee, Bimeda Inc., Ireland.