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Control of fleas on naturally infested dogs and cats and in private residences with topical spot applications of fipronil or imidacloprid

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Abstract

Thirty-four flea-infested dogs and cats residing in 20 homes in Tampa, FL were randomly placed into 1 of 2 treatment groups during the summer of 1997. Pets were treated topically with either 10.0% w/v imidacloprid or 10% w/v fipronil spot-on on day 0, then once for every 28–30 days for 90 days. Flea populations were assessed in the environment using an intermittent-light trap, while pet flea burdens were assessed using visual area counts. A single application of imidacloprid was 95.3 and 97.4% effective in reducing flea populations on pets at 7 and 28 days, respectively. A single application of fipronil was 97.5 and 97.0% effective in reducing flea populations on pets at the same time points. Following 3 monthly applications of either imidacloprid or fipronil, flea burdens on pets were reduced by 99.5 and 96.5%, respectively. In addition, flea numbers in the in-home environment were reduced by 99.0 and 98.6% in homes, where pets were treated with imidacloprid or fipronil, respectively.

Keywords: Fipronil; Imidacloprid; Cat flea; *Ctenocephalides felis felis*; Treatment; Control

1. Introduction

Failure to control fleas on pets often resides in the inability of pet owners to adequately apply an insecticide formulation to their pets. Therefore, owner compliance should be enhanced with the use of effective insecticides that are easy to apply.

Several topical insecticide formulations designed for spot application have demonstrated considerable adulticidal activity. In one laboratory study a spot-on formulation of permethrin provided greater than 95% efficacy through 22 days on dogs (Fisher et al., 1994). Fenthion

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applied in a single spot to dogs in laboratory studies at 8 and 20 mg/kg, provided 100 and 93.5% control for 17 and 21 days, respectively (Arther and Cox, 1985; Hopkins and Baldock, 1984). While the permethrin and fenthion formulations cited above are only approved for dogs in the USA, two other residual insecticides, imidacloprid and fipronil, are approved for both dogs and cats. In three different laboratory studies a 10% w/v imidacloprid spot-on killed 95.1–97.8% of the fleas infesting dogs and cats for at least 4 weeks (Cruthers and Bock, 1997; Hopkins et al., 1997; Jacobs et al., 1997). Fipronil marketed in both spot-on and spray formulations has also demonstrated residual activity exceeding 4 weeks. In a simulated home environment study, a 10% w/v fipronil spot-on applied for every 28 days provided 100% control of fleas for 168 days (Hutchinson et al., 1998).

The objective of this study was to evaluate and compare the effectiveness of topically applied imidacloprid and fipronil spot formulations to control flea infestations on pets and in the environment in naturally infested homes in Tampa, FL.

2. Materials and methods

2.1. Homes

Through referrals from The Sunshine Animal Hospital, 20 flea-infested homes in the Tampa, FL area were selected for the study during the summer of 1997. Homes were selected based on the following criteria: (1) a minimum of 5 adult fleas collected in a 16–24 h period in two lighted flea traps and a minimum of 5 adult fleas observed in total area counts on at least one dog or cat in the household; (2) one to three healthy, non-fractious dogs or cats lived at the residence; (3) home owners willing to start the study between 20 May and 20 June 1997 and (4) home owners willing to participate in the study for 90 days.

2.2. Treatment groups

Homes and pets meeting all the above criteria were randomly placed into 1 of 2 treatment groups. Pets in treatment Group 1 were weighed to ensure proper dosing (Table 1) and then treated topically with 10.0% w/v imidacloprid (Advantage™ Flea Adulticide; Bayer, Shawnee Mission, KS) according to label directions. Cats were treated with a single spot application on the back of the neck. Dogs weighing less than 24.9 kg, were treated with a single spot applied between the shoulder blades; dogs weighing over 24.9 kg were treated by applying a spot of imidacloprid on the dorsal midline between the shoulder blades and another spot just anterior to the dorsal tailhead. All pets were treated on day 0 then once for every 28–30 days for a total of three treatments.

Pets in treatment Group 2 were also weighed to ensure proper dosing (Table 1) and were then treated topically with 10.0% w/v fipronil (Frontline® Top Spot™; Merial Animal Health, Athens, GA) according to label directions. Dogs and cats were treated with a single spot application applied between the shoulder blades. All pets were treated on day 0 and then once for every 28–30 days for a total of three treatments.

No other topical or premises flea treatments were used during the study. There were no restrictions on the animals regarding exposure to rain, swimming or movement outdoors.

Table 1
Chart used to dose dogs and cats with either imidacloprid or fipronil spot-on formulations

Imidacloprid[a]			Fipronil[b]		
Weight (kg)	Volume (ml)	Dose (mg)	Weight (kg)	Volume (ml)	Dose (mg)
Dogs					
≤4.54	0.4	40.0	≤10.0	0.67	67.0
4.54–9.07	1.0	100.0	10.0–20.0	1.34	134.0
9.07–24.9	2.5	250.0	20.0–40.0	2.68	268.0
>24.9	2×2.5	500.0	>40.0	2×2.6	536.0
Cats					
≤4.08	0.4	40.0	All weights	0.5	50.0
>4.08	0.8	80.0			

[a] Imidacloprid: 9.1% w/w; 10% w/v (Advantage™ Flea Adulticide; Bayer, Shawnee Mission, KS).
[b] Fipronil: 9.7% w/w; 10% w/v (Frontline® Top Spot™; Merial, Athens, GA).

2.3. Flea population assessment techniques

The numbers of adult fleas emerging in the home were assessed using intermittent-light traps (Dryden and Broce, 1993). One trap was placed in each of two rooms for 16–24 h. Rooms selected were based on where the pet(s) spent most of their time or where owners had observed fleas. Once rooms were selected, the traps were returned to those rooms in the same location at every counting period. Fleas collected on the adhesive pads of the traps were enumerated and identified to species.

The flea population on each pet was assessed using a visual area count methodology (Dryden et al., 1994). Area counts were performed at five locations on each animal: dorsal midline, tail head, left lateral, right lateral, and inguinal region. Area counts were limited to 1 min per location and conducted by parting the hair against the lay using both hands until the area was covered. Area and environment flea counts were conducted on days 0, 7, 14, 21, 28, 40–45, 54–60, 69–75 and 84–90.

Percent control achieved by the flea products was calculated by the following formula: {(day 0 geometric mean flea counts (area or trap)−day x geometric mean flea counts (area or trap))/day 0 geometric mean flea counts (area or trap)}×100. The pet and trap counts were analyzed separately at each time point, using both the two-sample t-test and the Wilcoxon rank sum test (also known as the Mann–Whitney test) to test for differences in the two groups.

3. Results

On day 0, the flea traps collected an average of 13.8 (S.D. = 11.0; range 5–33) and 42.1 (S.D. = 65.3 range 5–189) fleas from the homes in Groups 1 and 2, respectively (Table 2). Due to the wide range in day 0 trap counts, percent control values were calculated using geometric means. In all homes in both treatment groups, emerging flea populations declined minimally during the first 2–3 weeks. However, reductions in emerging flea populations of 95.1 and 89.6% occurred by day 28 for homes in Groups 1 and 2, respectively (Table 2).

Table 2
Reduction in premises flea counts when naturally flea-infested dogs and cats were treated monthly with spot-on formulations of imidacloprid or fipronil

Treatment group	No. of households		Days post-treatment							
			0	7	14	21	28	40–45	54–60	84–90
Imidacloprid[a]	10	Mean number of fleas[c]	13.8	18.0	12.7	12.3	1.0	1.0	0.0	0.1
		Standard deviation	11.0	25.6	14.0	26.3	1.7	2.8	0.0	0.3
		Geometric mean number of fleas	10.1	6.2	6.6	2.4	0.5	0.5	0.0	0.1
		Percent control[d]	0.0	38.3	34.1	75.8	94.7	97.1	100.0	99.1
Fipronil[b]	10	Mean number of fleas	42.1	40.2	21.2	12.5	3.2	1.9	0.8	0.3
		Standard deviation	65.3	80.7	29.9	14.0	3.9	3.0	1.2	0.7
		Geometric mean number of fleas	14.4	6.6	6.0	5.3	1.5	0.7	0.5	0.2
		Percent control	0.0	53.9	58.0	63.3	89.4	94.9	96.7	98.8

[a] Advantage™ Flea Adulticide (Bayer Animal Health) 0.5 ml; 9.1% w/w (10% w/v).
[b] Frontline® Top Spot™ (Merial Animal Health) 9.7% w/w (1.030 sp. gr. 10% w/v).
[c] Mean number of fleas recovered in two intermittent-light flea traps.
[d] {(Day 0 geometric mean flea counts (area or trap)−day x geometric mean flea counts (area or trap))/day 0 geometric mean flea counts (area or trap)}×100.

During the entire 90 day study, 1747 fleas were trapped in the 20 residences and all were identified as *Ctenocephalides felis felis* (Bouché), the cat flea.

Pets in Group 1 (11 dogs and 6 cats) had an average of 41.3 (S.D. = 58.8; range 5–196) fleas observed in area counts on day 0 (Table 3). Dogs and cats in Group 1 weighed an

Table 3
Reduction in on-animal flea counts when naturally flea-infested dogs and cats were treated monthly with spot-on formulations of imidacloprid or fipronil

Treatment group	No. of dogs/cats		Days post-treatment							
			0	7	14	21	28	40–45	54–60	84–90
Imidacloprid[a]	11/6	Mean number of fleas[c]	41.3	1.5	1.4	6.8	1.7	0.0	0.2	0.1
		Standard deviation	58.8	2.2	2.5	18.4	4.7	0.0	0.6	0.3
		Geometric mean number of fleas	19.0	0.9	0.8	0.9	0.5	0.0	0.1	0.1
		Percent control[d]	0.0	95.5	96.0	95.2	97.5	100.0	99.3	99.5
Fipronil[b]	12/3	Mean number of fleas	27.6	0.8	1.4	1.2	1.4	0.3	0.3	1.3
		Standard deviation	21.3	1.5	2.1	2.7	3.0	0.7	0.9	2.1
		Geometric mean number of fleas	19.8	0.5	0.8	0.4	0.6	0.2	0.2	0.7
		Percent control	0.0	97.6	95.9	97.7	97.1	99.0	99.2	96.4

[a] Advantage™ Flea Adulticide (Bayer Animal Health) 0.5 ml; 9.1% w/w (10% w/v).
[b] Frontline® Top Spot™ (Merial Animal Health) 9.7% w/w (1.030 sp. gr. 10% w/v).
[c] Mean number of fleas counted in visual area counts.
[d] {(Day 0 geometric mean flea counts (area or trap)−day x geometric mean flea counts (area or trap))/day 0 geometric mean flea counts (area or trap)}×100.

average of 14.14 kg (S.D. = 10.54; range 1–35.4) and 4.84 kg (S.D. = 3.2; range 2.3–5.9), respectively. The average age of the pets was 3.92 years (S.D. = 3.25; range 0.5–11).

Pets in Group 2 (12 dogs and 3 cats) had an average of 27.6 (S.D. = 21.3; range 5–72) fleas observed in area counts. Dogs and cats in Group 2 weighed an average of 19.36 kg (S.D. = 13.7; range 5.45–68.18) and 4.69 kg (S.D. = 0.94; range 3.6–5.5), respectively. The average age of the pets was 4.08 years (S.D. = 3.25; range 0.83–11).

A mean application rate of imidacloprid on day 0 of 17.37 mg/kg (S.D. = 8.76) provided 95.3% control of fleas within 7 days and provided 95.3–97.5% control for days 14–28 (Table 3). Control of fleas on the pets treated with fipronil at a mean rate of 12.26 mg/kg (S.D. = 1.36) was 97.5 and 97.0% on days 7 and 28, respectively. Following three monthly applications of either imidacloprid or fipronil the flea counts were reduced by 99.5 and 96.5%, respectively. At no time point were the trap or area count means of the two treatment groups significantly different ($P > 0.05$) using either the two-sample *t*-test or the Wilcoxon rank sum test.

4. Discussion

A high level of flea control was observed on pets for 28 days following a single application of either imidacloprid or fipronil. The residual adulticidal activity of these two formulations is remarkable, particularly considering the original flea burden and the reinfestation pressure observed in this study.

The intermittent-light flea traps used in this study have been shown to collect >86% of the live fleas released into a carpeted room (3.1 m×3.3 m) during 20 h test periods (Dryden and Broce, 1993). The ability of this trap to collect such a high percentage of newly emerged fleas in a room provides for an accurate determination of flea development and emergence in a home. Monitoring of flea emergence over time allows for the assessment of when the flea life cycle was interrupted.

C. felis felis is capable of completing development and emerging in as little as 13 days, or emergence may be delayed up to 174 days depending on temperature and emergence stimuli (Rust and Dryden, 1997). However under most household conditions, the cat flea will complete its development and emerge within 3–5 weeks (Rust and Dryden, 1997). In the current study, there was a dramatic reduction in emerging fleas observed in these homes 3 weeks after treatments were initiated. Therefore it appears that the topical application of these insecticides interrupted flea development in these households. The level of adult flea kill was potentially large enough to have drastically reduced reproduction in most homes shortly after animals were treated. From this data it was estimated that in Tampa, FL during the summer of 1997 the majority of fleas completed development and emerged within 21–28 days. Therefore, the continued emergence of fleas in some homes after day 28 indicates that inhibition of flea reproduction and subsequent development was not 100%.

The area count methodology used in this study has been shown to detect an average of 23.5% of the pet flea burden (Dryden et al., 1994). Therefore, average initial flea burdens based on geometric means were estimated to be 80.8 and 84.3 for pets in Groups 1 and 2, respectively.

This study demonstrated that flea control could be achieved by effective topical therapies without the use of environmental treatments. Although a high level of flea control was achieved in this study by day 90, a substantial number of fleas did emerge in these homes for the first 21 days. Therefore, when veterinarians are presented with a pet with flea allergy dermatitis or a home with a massive infestation, it may be prudent to recommend the application of both insecticides and insect growth regulators to the environment to provide for more rapid reductions in flea burdens.

The heavy reliance on insecticides to control fleas is believed to have expedited the development of resistant populations of cat fleas (Dryden and Rust, 1994). Of the species of fleas tested, the cat flea is resistant to the greatest number of different categories of insecticides (Rust and Dryden, 1997). Cat flea isolates have been found to be resistant to DDT, dieldrin, malathion, permethrin, chlorpyrifos, diazinon, propetamphos, bendiocarb, cyfluthrin, cypermethrin, fluvalinate and carbaryl (Rust and Dryden, 1997). Unfortunately, the extent or prevalence of insecticide resistance in cat flea populations has not been determined. While it may be difficult or impossible to determine if a particular product failed because of resistance, it is inescapable that significant differences in flea strain susceptibility to insecticides do exist and at least some failures are due to resistance. If we continue to rely on single compounds or single classes of insecticides to control fleas, selection for resistance may be inevitable.

No matter what the environment, flea control in and around man-made structures lends itself well to the concept of Integrated Pest Management. Educating the homeowner on the biology and habitat of fleas infesting their home and pet(s) is essential. Constructing an integrated flea control program necessitates the understanding of flea biology, population assessment techniques, mechanical control systems, biological control, insect growth regulators and traditional neurotoxic insecticides.

It has been previously documented that reproduction can be prevented by topical or systemic insect growth regulators. Topical applications of methoprene, fenoxycarb, pyriproxyfen and systemically active lufenuron, an insect development inhibitor, are effective ovicidal and larvicidal compounds (Rust and Dryden, 1997).

Based upon this information, the use of these effective adulticides in combination with juvenile hormone analogs and/or insect development inhibitors should provide effective flea control and prevent subsequent flea generations. The topical or systemic insect growth regulator provides for prolonged residual ovicidal activity, interrupting future flea development, even after the residual activity of the insecticide has diminished. Relying solely on one flea product to control fleas invites the rapid development of resistance. The use of compounds, with completely different modes of action (adulticidal insecticides and insect growth regulators), combined with mechanical and biological control systems should delay the onset of resistance and ensure client satisfaction.

This field study was conducted without the inclusion of a placebo group. It is recognized that the use of a non-placebo group might have provided a better comparison and evaluation of the efficacy of the two treatment regimens. However, it is the opinion of these authors that the large flea infestations commonly encountered in Florida prohibit the use of a placebo group. Withholding treatment is potentially detrimental to the health and welfare of the dogs and cats.

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