An Update on Fleas, Flea-Borne Diseases, and Flea Control

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Abstract

Fleas are blood-feeding arthropods that can infest a wide variety of hosts. *Ctenocephalides felis*, the cat flea, is the most common flea species found on dogs and cats worldwide, as well as the most medically important in the veterinary setting. This article focuses on *C felis*, the diseases associated with flea feeding, and available products that both eliminate flea infestations on pets and break the flea life cycle in the environment.

Take-Home Points

- Flea allergy dermatitis remains one of the most common dermatologic issues in dogs and cats.
- Fleas transmit a variety of bacterial and parasitic pathogens, and proper flea control is key to eliminating these infections.
- Flea control products with a rapid residual speed of kill are necessary to eliminate fleas throughout the dosing period of a product.
- Due to the environmental burden of flea life stages, continuous flea control of 3-plus months is often needed to eliminate home infestation.
- Year-round flea control is recommended for dogs and cats in most of North America due to the extended seasonal occurrence of fleas.

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The most common flea of domestic dogs and cats worldwide is *Ctenocephalides felis*, the cat flea (**FIGURE 1**).[1] In some countries, *Ctenocephalides canis* is more commonly found on dogs, but this species is rare in the United States.[2,3] Other flea species that have been recovered from dogs and cats include *Pulex* species, *Xenopsylla cheopis,* and *Echidnophaga gallinacea*; however, this review primarily describes the veterinary importance of the cat flea and the effectiveness of current parasiticides in treating and/or preventing infestation.

Life Cycle

All fleas of veterinary importance have a similar life cycle that comprises 4 stages: egg, larva, pupa, and adult (go.navc.com/49D0ftK). The eggs, larvae, and pupae develop in the environment and rely on multiple environmental and host cues to continue development. Once in the pupal stage, adult fleas wait for the right combination of stimuli, including physical pressure, heat, and carbon dioxide, to emerge and seek a new host.[4]

After finding a host, adult cat fleas live, feed, and mate on their host, becoming permanent ectoparasites after feeding for approximately 24 hours.[5] While fleas can be found feeding anywhere on the host, they are most likely to be recovered from the area covering the middle of the back to the base of the tail and extending laterally down the rear legs ("the flea triangle") on dogs; on cats, they are more likely to be recovered from the head and neck region due to fastidious grooming.[6]

Many mammals can serve as the host for adult fleas, including several species of periurban wildlife, such as cats, dogs, skunks, opossums, raccoons, several rodent species, coyotes, and foxes. Therefore, infestation—and reinfestation—can be common in pets that have access to the outdoors. This risk underscores why effective flea control requires targeting adults on the host using products with a rapid residual speed of kill to prevent reproduction and environmental contamination while also breaking the life cycle in the environment.

Diseases Associated With Flea Feeding

The cat flea is the most medically important ectoparasite of cats and dogs, responsible for anemia, flea allergy dermatitis (FAD), and the transmission of several pathogens of veterinary and human importance. On average, each female cat flea ingests ~14 µL of blood each day; therefore, infestation with high numbers of fleas can result in a significant regenerative anemia.[4]

While flea feeding is associated with several dermatologic conditions, the most significant is FAD, an allergic condition caused by antigens in flea saliva.[6] FAD is among the most common dermatologic conditions in dogs; therefore, effective flea prevention is key to the dermatologic workup of pruritic dogs. Some animals are highly sensitive and can have severe reactions to low numbers of fleas (< 5 fleas); therefore, FAD should not be ruled out solely on the basis of finding few or no fleas on the animal during examination. In fact, animals that are reactive to fleas, especially cats, may have fewer fleas due to the intense grooming behaviors they exhibit.

Both FAD and flea feeding can induce a variety of dermatologic lesions such as alopecia, excoriations, erythema, papules, and crusts.[6] These lesions can lead to secondary bacterial infections that exacerbate the condition of the animal. While addressing the entirety of the clinical case is important, highly effective flea control is the key to reducing dermatologic lesions caused by the presence of fleas (**FIGURE 2**).[7,8]

FIGURE 1. Adult female *Ctenocephalides felis* flea. Note the distinct genal comb by the mouthparts **(black arrow)** and pronotal comb at the base of the head **(yellow arrow)**, which help identify *C felis* from other fleas commonly found in North America.

Flea-Borne Pathogens

Bacterial Pathogens

C felis has been implicated in the transmission of a variety of bacterial pathogens (**TABLE 1**). The most common bacterial species associated with the cat flea are *Rickettsia*, *Bartonella*, and *Mycoplasma*.[9] *Yersinia pestis,* the causative agent of bubonic plague, and *Rickettsia typhi*, the causative agent of murine typhus, are primarily associated with *X cheopis* (the Oriental rat flea) and rodents.

The cat flea maintains and transmits different pathogens in different ways. For *Rickettsia felis* and *Mycoplasma* species, the cat flea is a direct mechanical vector, transmitting the pathogen during feeding, while for *Bartonella* species, it passes infectious bacteria in its feces (stercorarian transmission), contaminating the environment.[9-13]

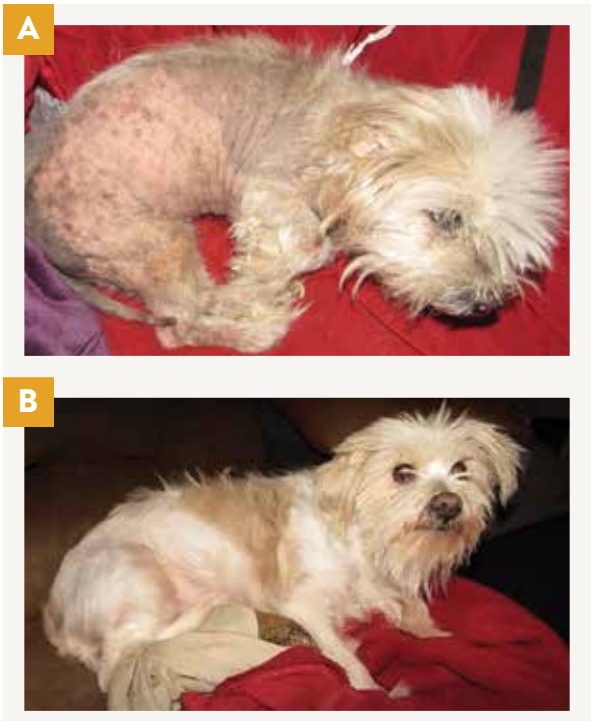

FIGURE 2. (A) Severe dermatologic lesions in a dog experiencing flea infestation. **(B)** The same dog 83 days post-treatment with an isoxazoline product. The photo was taken during a research study evaluating the ability of a selamectin-sarolaner product for cats and sarolaner product for dogs to eliminate home flea infestations and reduce dermatologic lesions associated with flea feeding.[8]

Bartonella Species

Bartonella species are the most commonly reported bacterial pathogens transmitted by the cat flea, with up to 85% of cats and 50% of dogs in the United States testing positive for antibodies.[11] These numbers reflect overall exposure; PCR testing of whole blood in the same study detected *Bartonella* species in 62.5% of the cats and 9.2% of the dogs.[11] The species identified included *Bartonella henselae, Bartonella koehlerae, Bartonella vinsonii,* and *Bartonella clarridgeiae*, each of which causes different diseases in dogs and cats.[11]

The most notable of the *Bartonella* diseases is cat scratch fever, in which *B henselae* residing on a cat's claws is introduced into human skin, leading to symptoms such as fever, enlarged lymph nodes, and even bacterial endocarditis.[9-11]

Rickettsia Species

Domestic dogs are the likely reservoir host for *R felis*, and the cat flea can both acquire the pathogen and transmit it to naïve hosts during feeding.[9,12] The cat flea can also pass *R felis* vertically to progeny for up to 12 generations without an infectious blood meal in that period. Thus, while the percentage of infected fleas can vary greatly depending on region (1% to 96%), the risk of infection from *C felis* is ever present, even in laboratory-reared fleas.[14]

Mycoplasma Species

Canine and feline hemoplasmas are relatively common, with up to 52.4% of dogs and 66.7% of cats reported as PCR positive in various studies.[13] *Mycoplasma haemocanis* and *Candidatus* Mycoplasma haemominutum are the most common hemoplasmas in dogs and cats, respectively, although several other species also affect both cats and dogs.[13] While several hemoplasmas have been found in *C felis*, flea feeding is not considered to be the primary transmission route, which is likely direct contact via fighting and biting.[13]

Treatment

Treatment of flea-borne bacterial infections often requires prolonged courses of antibiotics, especially for *Bartonella* infections, which may require combination therapy, including fluoroquinolone and doxycycline antibiotics.[10]

The use of flea control may be helpful in reducing the risk of infection or reinfection with flea-borne

pathogens; however, there is strong evidence supporting this for only *Bartonella* infections in cats. In laboratory studies, cats treated with a 10% imidacloprid–1% moxidectin topical solution were 100% protected from *B henselae* infection compared to controls.[15] In another study, privately owned cats maintained on a 10% imidacloprid–4.5% flumethrin collar were significantly less likely to test positive for *Bartonella* species by PCR testing of whole blood than cats that were on no flea prevention.[16] Despite the limited studies, year-round flea control is key to reducing flea exposure, thereby reducing pathogen exposure for pets and people.

Other Flea-Borne Pathogens

C felis is also the known vector for 2 other parasitic pathogens, *Dipylidium caninum* and *Acanthocheilonema reconditum*. *D caninum*, the flea tapeworm, infects dogs and cats via ingestion of a flea containing the infectious intermediate stage. Although diagnosis of *D caninum* infection was historically challenging, new antigen and PCR techniques have suggested that roughly 0.65% of dogs and 2.5% of cats are positive for this tapeworm.[17] Fortunately, the intermediate stage (cysticercoid) within the flea requires the flea to feed for approximately 24 hours before becoming infectious. Therefore, animals on highly effective flea control have been shown to be protected from infection.[18] Given the recent reports of praziquantel resistance in *D caninum*, rapid and effective flea control is key to preventing infection or reinfection with this tapeworm.[19]

A reconditum is a filarial nematode that is transmitted by the cat flea and lives within the skin of dogs. Overall, *A reconditum* does not cause clinical disease in dogs, but it does produce microfilariae that enter peripheral circulation and must be differentiated from those of *Dirofilaria immitis*, the canine heartworm.[20] Veterinarians are encouraged to have any microfilariae seen in whole blood definitively identified by morphologic or molecular characteristics, especially in the face of a negative canine heartworm antigen test.

Treatment of Flea Infestations and Flea Control

Infestations with adult fleas can be treated using a variety of active ingredients and formulations for use on dogs and cats. These can be separated into 3 broad categories:

- Topical adulticide products that are approved by the U.S. Environmental Protection Agency
- Systemically acting adulticide products, which are predominantly approved by the U.S. FDA

TABLE 1 Common Bacterial Species Transmitted by *Ctenocephalides felis*

	PRIMARY RESERVOIRS	HOST EXPERIENCING DISEASE	CELL TYPE INFECTED	CLINICAL SIGN/DISEASE
***Rickettsia* species**				
Rickettsia felis	Dogs, cats, other mammals	Humans	▪ Endothelial cells	▪ Fever ▪ Myalgia ▪ Rash ▪ Eschar at the bite site
R felis–like organisms[9,10]				
***Bartonella* species**				
Bartonella henselae[9,11]	Cats	Humans, dogs, cats	▪ Endothelial cells ▪ Erythrocytes ▪ Macrophages	▪ Fever ▪ Swollen lymph nodes ▪ Endocarditis ▪ Neuroretinitis ▪ Encephalopathy ▪ Bacillary angiomatosis
Bartonella clarridgeiae	Cats			
Bartonella koehlerae	Cats			
Bartonella quintana	Humans			
***Mycoplasma* species**				
Mycoplasma haemofelis	Cat	Cat	▪ Erythrocytes	▪ Fever ▪ Jaundice ▪ Hemolytic anemia ▪ Splenomegaly
Mycoplasma haemocanis[9,12]	Dog	Dog		

TABLE 2 Common Active Ingredients in Topical Flea Control Products[5]

ACTIVE INGREDIENTS	DRUG CLASS	MECHANISM OF ACTION	EXAMPLE PRODUCTS[a] (MANUFACTURER; SPECIES)
Imidacloprid	Neonicotinoid	Nicotinic acetylcholine receptor antagonist	Advantage II (Elanco; cats and dogs)[b], Advantix (Elanco; dogs), Seresto (Elanco; cats and dogs)[b]
Dinotefuran			Vectra (Ceva; cats and dogs), Vectra 3D (Ceva; dogs)
Fipronil	Phenylpyrazole	Glutamate- and GABA-gated chloride-channel antagonist	Frontline (Boehringer Ingelheim; cats and dogs)
Permethrin	Synthetic pyrethroids	Axonal sodium-channel depolarization	Vectra 3D (dogs), Advantix (dogs)
Flumethrin			Seresto (cats and dogs)

GABA = γ-aminobutyric acid.
[a]Most of these compounds are available as generic products, and this list is not comprehensive.
[b]Formulations for both cats and dogs exist, but the final product may be species-specific depending on dose and the safety of other active ingredients.

TABLE 3 Common Active Ingredients in Systemic Flea Control Products[5,19]

ACTIVE INGREDIENTS	DRUG CLASS	MECHANISM OF ACTION	EXAMPLE PRODUCTS[a] (MANUFACTURER; SPECIES)
Nitenpyram	Neonicotinoid	Nicotinic acetylcholine receptor antagonist	Capstar (Elanco; cats and dogs)[b]
Selamectin	Macrocyclic lactones	Glutamate-gated chloride-channel antagonist	Revolution (Zoetis; cats and dogs)[b]
Spinosad	Spinosyns	Nicotinic acetylcholine receptor antagonist	Comfortis (Elanco; dogs)
Spinetoram			Cheristin (Elanco; cats)
Sarolaner	Isoxazolines	Glutamate- and GABA-gated chloride-channel antagonist	Revolution Plus (Zoetis; cats), Simparica (Zoetis; dogs)
Lotilaner			Credelio (Elanco; dogs), Credelio Cat (Elanco; cats)
Afoxolaner			Nexgard (Boehringer Ingelheim; dogs)
Esafoxolaner			Nexgard Combo (Boehringer Ingelheim; cats)
Fluralaner			Bravecto (Merck; dogs), Bravecto Plus (Merck; cats)

GABA = γ-aminobutyric acid.
[a]Most of these compounds are available as generic products, and this list is not comprehensive.
[b]Formulations for both cats and dogs exist, but the products may be species-specific depending on dose and the safety of other active ingredients within the final product.

- Insect growth regulators (IGRs) that vary in approval depending on formulation and use

Adulticidal Topical Products

Topically applied products are designed to be delivered via a spot-on, spray, or collar and have little to no systemic absorption or efficacy. These products, once applied, disperse across the body from the site of application; therefore, some time is needed to ensure full coverage, and some studies suggest they are not evenly dispersed to distal sites such as the lower leg extremities.[21] While fleas are exposed to the active ingredients immediately upon contact with the hair coat, these products should not necessarily be considered repellent in driving away fleas prior to feeding, especially given the rapid attachment and feeding seen in fleas.[22]

Additionally, topical products are susceptible to degradation or dilution over time from exposure to sunlight, swimming, bathing, and shampooing, which

may affect drug efficacy, specifically at the end of the dosing period.[21] **TABLE 2** highlights several of the most common topical active ingredients and products.

Adulticidal Systemic Products

Several drug classes can also be utilized as systemically acting flea control products, the newest of which are the isoxazolines (**TABLE 3**). Aside from nitenpyram, systemically acting products are all FDA labeled and require a veterinary prescription, in contrast to topical products. Systemic products, regardless of route of administration (oral, transdermal, injectable), are all systemically absorbed and are effective when fleas ingest the blood meal.[21,23]

Despite requiring fleas to feed, many of the systemic products are highly effective and maintain a rapid speed of kill throughout the dosing period. This high speed of kill allows the systemic products to even control FAD in allergic dogs.[7,8] The isoxazoline products have become the most commonly prescribed options for labeled flea and tick control and are now found in combination formulas that also have labeled efficacy against heartworms and some intestinal helminths, depending on formulation.

Insect Growth Regulators

IGRs (also known as insect development inhibitors) such as methoprene, pyriproxyfen, and lufenuron are commonly added to products to disrupt the flea life cycle and reduce environmental burdens more rapidly.[5] They work either as juvenile hormone mimics (methoprene and pyriproxyfen) or as chitin inhibitors (lufenuron) that disrupt successful molting or egg development. Historically, these were helpful in combination with products that did not have a rapid speed of kill and allowed some eggs to be produced prior to adult flea death. The IGRs work by disrupting the development of immature stages and preventing eggs and larvae from maturing into reproducing adults, thus providing a secondary point to break the life cycle.[5] In the future, IGRs will likely still play a key role in flea control, as combining an IGR with an adulticidal compound decreases the likelihood of developing resistance.

Summary

Despite decades of effective ectoparasite control for cats and dogs, the cat flea continues to be a major issue in veterinary medicine. Year-round compliance with highly effective flea control is key to preventing home infestations, reducing FAD, and decreasing the risk of flea-borne diseases to people and pets. **TVP**

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