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Flea control failure? Myths and realities

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Why is it that, despite the proliferation of research on their biology and control, fleas remain such a burden for companion animals and their owners? This review highlights a range of reasons for persistence and apparent treatment failures. It argues that a sustainable approach will require integrated pest management based upon a detailed understanding of the flea life cycle, targeting not only adult fleas but also the immature stages in the environment, combining several modes of control and limiting the risk of chemoresistance. Individual characteristics of the pet and its environment need to be considered. Control of fleas can be achieved, over a timescale of several months, if basic rules are respected.

Flea burdens: a never-ending story

Fleas are the most important insect ectoparasites of dogs and cats worldwide [1,2] and may readily infest humans. Beside direct pathogenic effects resulting from their obligate blood-feeding and the immuno-allergic skin response, fleas are also competent vectors for numerous pathogens, some of them being zoonotic – such as *Yersinia pestis* (plague), *Rickettsia typhi* (murine typhus), *Bartonella henselae* ('cat scratch disease' in humans), *Rickettsia felis* (flea spotted fever), and the tapeworm species *Dipylidium caninum* [3].

Recent studies have highlighted the high rate of flea infestation that is common in companion animals, varying between 12% and 47% in some European countries [4–6]. In most temperate areas, large variations in abundance occur during the year, with lower populations in winter, but usually without complete disappearance. Flea populations then increase from spring to fall. This has been reported in Spain, Italy, Hungary, and Germany [4–6] with peak infestation usually between June and August and lowest abundances between January and April [4,6]. In some countries, including Austria, Italy, Germany, and Spain, peak infestation rates of more than 70% have been reported [5]. Infestation rates may be highly variable from one year to another but also depend on location – rural or urban – and whether the pet has access to the outdoors.

Given the high prevalence of fleas with pathogenic and vector potential, effective control represents a major objective in small-animal veterinary medicine. The recent decade has seen the development of an increased number of insecticides dedicated to the control of flea infestation. These include topical and oral adulticides and insect growth regulators (IGRs). Nevertheless, flea infestations often persist or reoccur, even after the application of ostensibly potent flea-control products [7,8]. The reason why fleas remain a significant burden for companion animals and their owners, despite the proliferation of research on fleas and their control, is therefore an important question. The aim of the present Opinion article is to discuss possible reasons for the persistence of flea infestations, with a focus on the European situation where recent similar reviews are lacking. Most of the discussion presented here relates specifically to fleas of the genus *Ctenocephalides*.

Many factors influence the efficacy of a flea treatment strategy, and most of the time these factors are poorly understood by the main stakeholder, that is, the pet-owner. This is one of the main reasons for what appears to be treatment failure. Hence, a control strategy based on integrated management principles must include educating and promoting realistic expectations.

The flea life cycle and persistent reinfestation from an environmental reservoir

The life-history strategies of parasites allow them to exploit their hosts effectively. Understanding both these strategies and the impact of parasites on their hosts is fundamental for developing appropriate control. Fleas are adapted to coexist with hosts that occupy discrete nest or bedding sites and which are usually only intermittently available; this is often compounded by long seasonal host absences and adverse environmental conditions in which they must be able to survive.

When hosts are present, a flea infestation is characterized by a long-lasting (up to 21 days) association between the adult flea and the host, during which multiple bloodmeals are taken, often several times per day [1,2,9,10].

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When dropping off its host, the adult flea may only survive for 3–5 days. Only a relatively small proportion of fleas on pet animals probably move from one host to infest other animals, and the risk of one pet animal infesting another, in a waiting room or show for example, remains low; a recent study on cats indicated that only approximately 4% of infestations are acquired in this way [11]. Subsequent to host infestation and the first blood-meal, females begin egg-laying 36 h later, on average, depositing 20–30 eggs per day. The eggs fall from the fur of the host within a few hours, with approximately 70% being dislodged within 8 h [9,10]. Hatching and larval development occur in the nest or bedding material. This protected microhabitat combines moderate temperatures, high relative humidity, and a source of dried adult flea fecal blood [9,10]. In a domestic environment, appropriate conditions for larval survival may be found in a wide variety of locations where the pets are living, and the role of wooden floors and car upholstery is often underestimated. Having passed through three larval stages, the third-stage larva spins a silk cocoon in which it molts into a flea pupa and undergoes metamorphosis into a pre-emergence, pharate (cloaked) adult. The latter stage is highly resistant and is mechanically protected from the effects of insecticides [2]. Adults may then emerge from the cocoon immediately or, in the absence of appropriate stimuli, after several months. Once emerged, adult fleas must find a host and blood-feed to maintain the continuous infestation [9].

Hence, as a result of this life cycle, adult fleas on pets represent only the 'visible part of the iceberg'; indeed, only 1–5% of the flea population is represented by the adults on a host. The remaining 95% is hidden and is composed of difficult-to-find immature stages present in the environment. Furthermore, the presence of a highly resistant pupal stage and the pharate adult together provide considerable flexibility that allows persistence for extended periods during the absence of the host or rapid activity on the return of a host. Moreover, the rate of population growth may be high [9,12]. These factors together provide the most significant features explaining the majority of apparent control failures.

Optimal flea control needs to take into account these life-cycle characteristics. Adult fleas infesting the host must be eliminated, and further infestations by latent environmental stages should be prevented. As a result, with continuous treatment of a host, elimination of a flea population is likely to take an extended period of time. In field trials, on average 2–4 months are required to control flea populations, including environmental stages, from infested areas [5,13–15]. Modeling studies have shown that populations may even persist for up to 6 months in the absence of regular emergence stimuli, that is, the maximum lifespan of the pre-emerged fleas in cocoons [9,12]. These simulations demonstrate that the direct treatment of adult populations on the animal host using persistent insecticide prevents egg-laying and population growth, but continuous reinfestation by fleas from the environment is expected for as long as the environmental reservoir persists. The fleas observed on the animal during this period are not usually individuals that survived the treatment, but are newly emerged young adults that will be killed by the insecticide soon after they jump onto the host (Figure 1).

External flea source as reservoir of reinfestation

Usually, the regular treatment of an infested host will be successful at controlling the fleas on the animal and in the immediate domestic environment. However, for animals that live in an open environment the role of external flea sources may be crucial in explaining further reinfestation [16]. This may be because the pet enters a contaminated area outside the household, or an untreated, contaminated host may visit the household. In the first case, although the presence of antiparasitic protection will decrease the probability of acquiring fleas, effective control will depend on the treatment cycle. Any failure in the continuity of the treatment will lead to reinfestation. External flea sources may include cars, other households, and parks where many owners are walking with their pets. The identification of these external contaminated areas is often difficult. In the second case, contamination of areas of the household suitable to support the flea life cycle may be due to the sporadic presence of infested animals (e.g., neighbor's cat, feral pets, or wild animals) contributing to the repletion of the environmental reservoir and limiting the clearance of the flea infestation [5,13–15].

Persistent infestation by different flea species

Many flea species can infest companion animals – the cat flea, *Ctenocephalides felis felis*; the dog flea, *Ctenocephalides canis*; the human flea, *Pulex irritans*; and the hedgehog flea, *Archeopsylla erinacei* – are the most commonly identified. In Europe *C. felis felis* is the dominant species and is often recovered in more than 90% of cases on cats and dogs [2,7]. In some European countries *C. canis* may represent more than 50% of the fleas found on dogs [6]. Nevertheless, occasionally rodent fleas, flea species of small carnivores/insectivores, or birds fleas are observed, such as *Spilopsyllus cuniculi, Xenopsylla cheopis, Ceratophyllus gallinae*, and *Leptosylla segnis* [2,4,6]. Unless owners obtain appropriate expert identification of the flea, they are likely to attribute the presence of these 'exotic' species on their animal to domestic control failure.

Persistent infestation due to owner-related behavior

One of the main reasons for pet owner-related flea-control failure is lack of compliance [7]. The most common causes include: (i) infrequent product application or a treatment interval extended to 8–9 weeks, noting that most flea products licensed today have a duration of activity of 4–6 weeks; (ii) treatment conducted only when fleas are seen on the animal; (iii) failure to treat all of the animals present in the same house; and (iv) suspension of treatment in winter even though fleas are still active. Additional causes may include the application of an incorrect dosage, linked to the use of an inappropriate size-related dosage, especially on growing puppies or large cats, or incorrect administration technique, such as application of a topical product on the hair rather than onto the skin. Some oral products need to be given along with food to permit optimal absorption. Excessive washing or frequent water immersion (bathing or swimming), as well as application to a wet