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Grooming and control of fleas in cats

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Abstract

Oral grooming is common in cats, as in rodent and bovid species where grooming has been shown to be effective in removing lice and ticks. In Experiment 1, we examined the effectiveness of oral grooming in removing fleas which are the main ectoparasite of cats. Elizabethan collars (E-collars) which prevented grooming were fitted on nine cats in a flea-infested household and 3 weeks later, flea numbers on these cats were compared with nine control cats in the same household. Flea numbers dropped in the control cats reflecting an apparent drop in adult fleas in the environment, but in the E-collar cats, flea numbers did not drop, and were about twice as numerous as in control cats. The significantly greater number of fleas on the E-collar cats was attributed to their inability to groom off fleas. In Experiment 2, videotaping of nine different cats from the flea-infested household revealed that these cats groomed at about twice the rate of 10 similarly videotaped control cats from a flea-free colony. These results reveal that flea exposure can increase grooming rate in cats and that grooming is effective in removing fleas.

Keywords: Grooming behavior; Fleas; Ectoparasites; Cats

1. Introduction

Oral grooming is a frequently performed behavioral pattern of cats as it is in bovids (Hart, 1990; Hart et al., 1992) and rodents (Bolles, 1960) as well. Recent observations on domestic cats (*Felis domestica*) indicate that they spend about 8% of non-sleeping/resting time in self oral grooming (Eckstein and Hart, 2000). Grooming serves

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a number of functions, of which ectoparasite control is particularly important (Hart, 1990). In experiments on mice, prevention of oral grooming by Elizabethan collars (E-collars) led to a 60-fold increase in total louse infestation over baseline levels (Murray, 1961). In impala (*Aepyceros melampus*) restrained from grooming with neck harnesses, the number of ticks reaching the adult stage was 20-fold that of impala wearing control harnesses and that could groom normally (Mooring et al., 1996).

Fleas appear to be the most common ectoparasite of cats and some studies allude to indirect evidence that grooming in cats is effective in removing fleas (Hudson and Prince, 1958; Osbrink and Rust, 1984; Dryden, 1989). One study reports that 50% of fleas placed on cats were recovered in feces (Wade and Georgi, 1988), indicating that fleas were removed by oral grooming. There does not exist, however, any work providing quantitative documentation that cats in which grooming is prevented carry a higher flea load than control cats exposed to the same environment.

Cats groom with their tongues, and the tongue is covered with cornified spines, rough to the touch, which would logically play a role in the removal of ectoparasites. Scratch grooming may also be useful in dislodging fleas from the head and neck. Apparently, once fleas leave or are dislodged from a cat, they live only a day or two off the host (Rust, 1994). Thus, efficient grooming behavior should reduce flea prevalence in the environment.

Experiment 1 was designed to investigate the effectiveness of grooming by preventing grooming with E-collars while cats were exposed to fleas and comparing their flea load with that of control cats in the same environment. The study was intended to reveal the role of grooming in ectoparasite control in cats in a naturalistic environment. The E-collar not only prevents oral grooming but also scratch grooming of the head. If grooming is effective in controlling fleas in cats, then it would be adaptive for grooming to increase when cats are exposed to increased numbers of fleas. Experiment 2 was designed to determine if flea infestation increases grooming in the cat. The study site for both experiments took advantage of the opportunity to perform observational experiments on cats in a large colony living in a flea-infested household (prior to the cats being treated to eliminate the flea infestation).

2. Experiment 1: prevention of grooming and flea load

In addition to examining the effects of prevention of grooming on flea load in cats continuously exposed to fleas in the environment, this experiment included an assessment of flea prevalence in the environment where cats frequently rested and slept.

2.1. Methods

2.1.1. Study site and subjects

The study was conducted during the months of May and June in a flea-infested private home housing over 30 free-ranging adult cats in Sacramento, California. The cats were divided into two groups with an equal number of long-haired cats in each group and a comparable distribution of baseline flea counts (E-collar group, $x = 15.6$ fleas;

control group, $x = 15.1$ fleas; see below for procedure) The adult cats selected from those available and meeting these criteria comprised four females and 14 neutered males. Following completion of this experiment and Experiment 2, the household was treated for fleas and the individual cats were treated as well with standard flea control procedures.

2.1.2. Flea collection and quantification

Flea (*Ctenocephalides felis*) numbers on the cats were estimated using a modification of patch sampling described for beagle dogs (Dryden, 1993) while the cat was gently restrained. Six strokes with a flea comb were applied over each of the seven body regions where fleas had most often been seen in preliminary observations (ventral neck, dorsal neck, back, left and right sides of the chest, abdomen and middle inguinal region). Fleas captured from each region in the comb were trapped in soapy water and counted. After the start of the experiment, all cats were wearing either the E-collar or a control collar (described below). Just before sampling for fleas, these collars were removed out of view of the investigators by the owner of the cats in order to keep the investigators blind to the subject's group assignment while conducting flea counts.

The number of fleas collected from individual cats would be expected to vary as fleas were groomed off, jumped on, jumped off or died. Given the potential for variation in flea numbers, frequent sampling of each subject would be best to estimate individual flea numbers. However, the sampling technique itself removed fleas which would not only affect subsequent flea counts, but would tend to mask potential differences between cats that were restrained from grooming and those unrestrained. Thus, sampling was limited to once a week. A flea count for each cat was obtained once prior to the application of grooming restraint (baseline) and subsequently, once a week for the next 3 weeks. Because environmental fluctuations in flea exposure can affect flea counts on cats, cats restrained from grooming were compared with control cats during the same time period. So as to have two end-point counts on each cat, the mean of the counts at weeks 2 and 3 was used to compare treatment differences.

2.1.3. Grooming restraint

Cats in the experimental group were fitted with a plastic E-collar of the type used in veterinary practice to prevent cats from excessively licking (E-collar group). The conical E-collar extended 10 cm from the neck forward to an outer diameter of 14 cm. The control group wore a nylon neck collar, 1.0 cm wide, which did not inhibit grooming. Cats in both groups ranged freely in the house and mingled with each other and with cats not included in the study. In the cats wearing E-collars, no major alterations in normal behavior (feeding, drinking, sleeping) were noticed upon repeated (unrecorded) observations. However, cats wearing the E-collars often behaved as though they were attempting grooming. Allogrooming was still free to occur among the E-collar subjects and was not recorded.

2.1.4. Environmental flea sampling

To monitor the exposure of cats to fleas in the environment, the room where the cats most frequently rested and slept was sampled for the presence of flea eggs and larvae on

weeks 1 and 3. A moistened white cotton cloth was placed inside the tube of a vacuum cleaner such that a small pocket was formed. An area 60 cm by 30 cm was vacuumed on bare floor adjacent to the wall in two separate locations. The areas sampled on week 3 were adjacent to the areas sampled on week 1. The cloth from each sampling was immersed in 750 ml of 70% isopropyl alcohol to suspend (and preserve) flea eggs, larvae, and debris. The alcohol-suspended material collected from the cloth was filtered using a Buchner filter apparatus with Watman #2 filter paper. The particulate material, collected on the filter paper, was examined under a dissecting microscope. Eggs were counted on 10 non-overlapping microscopic fields. Eggs' counts greater than 30 were noted as ''too numerous to count''. Larvae were counted by examining the entire filter paper disk. Following termination of the experiment, the house and cats were treated for fleas.

2.1.5. Statistical analysis

The non-parametric Mann–Whitney *U*-test was used to test for differences between the two groups in flea counts. Because the difference was predicted to be in one direction, the test was one-tailed with the level of significance set at 0.05.

2.2. Results

Over the course of the experiment, the mean flea count of the control group decreased from a mean of 15.1 in baseline to a mean of 8.9 in weeks 2–3. In contrast to the decline in flea counts of the control group, the E-collar group showed a slight increase from a baseline mean of 15.6 to a mean of 17.7 fleas in weeks 2–3. Thus, at end point, the flea count of the E-collar group was approximately double that of the control group; this was a significant difference ($p < 0.05$). A comparison between the two groups in change in flea counts from baseline to the end point at weeks 2–3, shown in Fig. 1, also revealed a significant difference ($p < 0.01$).

The reduction in adult flea numbers on the control cats was paralleled by an apparent reduction in flea eggs in the environment. The number of flea eggs per field recovered by environmental sampling dropped in week 1 from > 30 in all fields to a mean of 1.8

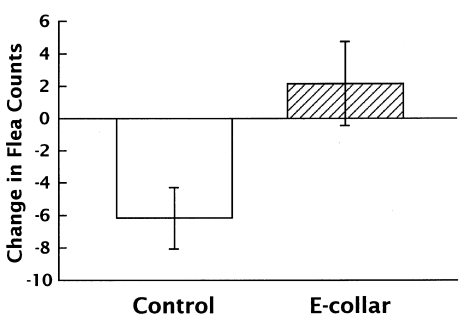

Fig. 1. Mean ($\pm$SEM) change in flea counts after 3 weeks for the control and E-collar groups. The difference was statistically significant.

per field (range 0–5) in week 3. Larvae, on the other hand, were absent in the sample from week 1 and increased to 14 in week 3.

3. Experiment 2: effects of fleas on grooming

Since the cats restrained from grooming in Experiment 1 had more fleas at weeks 2–3 than control cats, it would appear as though grooming was indeed effective in reducing flea numbers. Experiment 2 explored the concept that stimuli from the presence of fleas increase grooming.

3.1. Methods

3.1.1. Study sites and subjects

To compare cats that have been free of fleas for an indefinite period of time with those that were flea-exposed, it was necessary to use cats from two different locations. For the flea-exposed group, nine adult cats (three neutered males and six spayed females) were selected from the flea-infested, multi-cat household of Experiment 1; excluding those used in Experiment 1. These subjects were initially screened for fleas by combing the seven anatomical regions outlined in Experiment 1, and were only included if a total of six or more fleas were recovered. The 10 control group cats came from an ectoparasite-free breeding colony (four females, six neutered males, over 1 year of age) maintained at the University of California, Davis.

To maximize behavioral sampling of time spent on grooming, data on grooming for both groups were obtained by time-lapse videotaping over an entire 12-h period. However, videotaping required the use of an observation cage to keep the freely moving cat within viewing range. Accordingly, individual cats from both groups were placed sequentially in a cage ($61 \times 96 \times 127$ cm high) equipped with a shelf, food, water and litter. The subjects remained in visual, auditory, and olfactory contact with the other cats of the household or colony. Cats were placed in the cage in the evening and allowed 12 h to habituate prior to the daylight 12-h videotaping.

3.1.2. Videotape recording and analysis

The videotapes representing 12 h of observation on each cat were reviewed for the number and duration of each oral and scratch grooming bout. Oral grooming in cats occurs in bouts of licking episodes that are usually directed to different body areas in sequence (multiple area grooming); single-region grooming generally accounts for less than 10% of oral grooming bouts (Eckstein and Hart, 2000). Grooming bouts, which were noted as being directed to multiple or single regions, were considered to be terminated when either a non-grooming activity occurred (e.g. eating, eliminating, resting), or more than 60 s elapsed without a grooming episode. Separate start and stop times were entered if more than 5 s of non-grooming followed a grooming episode within a grooming bout. A description of the anatomical regions used is available in Table 1. Scratch grooming bouts consisted of scratching episodes and were always directed to a single region.

Table 1
Anatomical areas of grooming

Region	Anatomical details
Oral grooming	
Face wash	Front paws, legs, and head
Neck/chest	The frontal plane including the chest and shoulders
Sides/back	The lateral and dorsal torso, caudal to the shoulders, cranial to the tail, groomed by lateral neck flexion
Abdomen	The ventral torso, caudal to the shoulders and cranial to the tail, groomed by ventral neck flexion
Hindleg	Hindlegs and feet
Anogenital	The genitals and proximal third of the ventral tail
Scratch grooming	
Chin	The head cranial to the ears, including the chin
Ear	The head caudal to and including the ears
Neck	Caudal to the head and cranial to the shoulders
Tail	Distal 2/3 of the tail

3.1.3. Statistical analysis

The non-parametric Mann–Whitney *U*-test was used to draw comparisons between the two groups with the level of significance set at 0.05. Where the direction of the results was predicted (greater overall grooming in cats from flea-infested environment), the one-tailed test was used.

3.2. Results

Cats in the flea-exposed group spent about twice as much time oral grooming and eight times as much time scratch grooming as control cats (Fig. 2). With both oral and

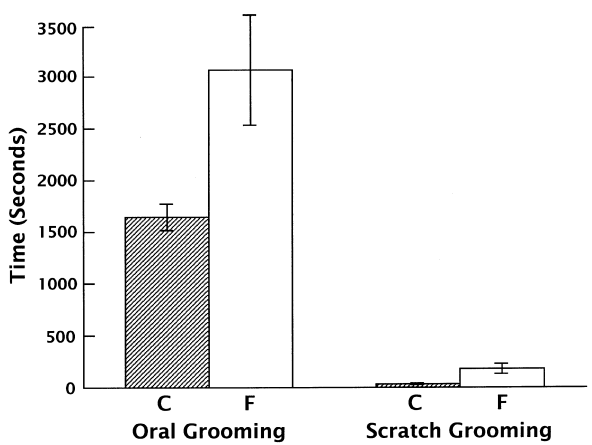

Fig. 2. Mean (±SEM) time spent in oral and scratch grooming by control (C) and flea-exposed cats (F). The difference between the C and F groups was significant for both oral and scratch grooming.

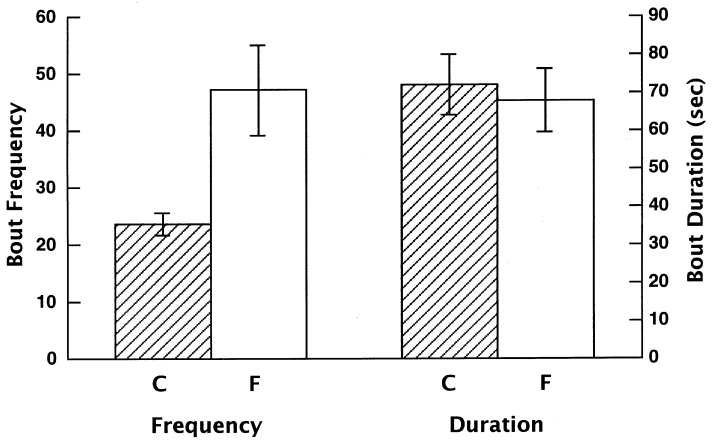

Fig. 3. Mean (+SEM) frequency (left axis) and duration (right axis) of oral grooming bouts by control (C) and flea-exposed cats (F). The mean difference in bout frequency between the two groups was significant ($p < 0.01$, two-tailed).

scratch grooming, the difference was significant ($p < 0.05$, one-tailed). The enhancement of oral grooming in the flea-exposed group, compared with the control group was due to a greater bout frequency ($p < 0.01$, two-tailed) and not longer bout duration (Fig. 3). The increase in scratch grooming in the flea-exposed group was also accounted for by an increase in bout frequency ($p < 0.01$, two-tailed) and not bout duration. The enhancement of oral grooming was due to an increase in multiple region ($p < 0.05$, two-tailed) and not single-region grooming. In fact, cats in the flea-exposed group devoted a mean of 79 s to single-region grooming compared with 113 s of single-region grooming for the control group ($p < 0.05$, two-tailed).

4. Discussion

Cats in a flea-infested environment are continuously being attacked by new fleas who then seed the environment with eggs once they have successfully fed. Flea numbers on animals are affected by fluctuations in developmental forms of fleas in the environment and behavioral defenses of cats against the fleas (assuming no application of artificial flea control). The results of Experiment 1 revealed that the behavioral defense of grooming seems to effectively reduce flea numbers on cats. This was shown by the approximate two-fold higher flea counts in the group of cats prevented from grooming with E-collars compared with cats of the control group living in the same environment. The magnitude of the potential difference between the E-collar group and the control group was undoubtedly reduced by the weekly removal of fleas as part of the necessary sampling procedure.

The reduction in flea counts in the control group over the course of the experiment was apparently a reflection of an overall decline in adult fleas in the household environment. This assumption was supported by the environmental sampling for flea

eggs and larvae. The number of flea eggs picked up by the vacuuming procedure declined from >30 per field to a mean of 1.8 per field by week 3. Repeated flea sampling of cats in both the E-collar and control groups may have helped reduce the adult fleas and flea eggs in the household. The increase in flea larvae counts in the environment from week 1 to week 3 represented the hatching of flea eggs which were numerous at the start of the experiment. Eventually, the larvae would have re-populated the household with adult fleas, but this would have been beyond the duration of this experiment.

Despite the changes in environmental flea exposure, the statistically significant difference between the flea counts of the E-collar group and the control group confirms the implications by others that grooming in cats is an important variable in the natural control of fleas (Hudson and Prince, 1958; Osbrink and Rust, 1984; Wade and Georgi, 1988; Dryden, 1989; Rust and Dryden, 1997). In addition to preventing oral grooming, the E collars also prevented scratch grooming of the head; thus, a reduction of both types of grooming could account for the increase in fleas on the cats with E-collars.

The difference in flea counts between the E-collar and the control groups was not as great as that seen in studies involving the prevention of grooming on lice in mice (Murray, 1961) and ticks in impala (Mooring et al., 1996). Given the greater mobility of fleas and re-infestation from fleas in the resting areas, this lower degree of grooming effectiveness for fleas is not surprising. Nonetheless, the effectiveness of oral grooming in removing fleas has been exploited by a parasite common to both fleas and cats, *Dipylidium caninum*, a tapeworm for which the cat is the definitive host. Tapeworm eggs, passed out in feces are eaten by flea larvae and develop into an infective stage within the maturing flea. When fleas are consumed by a cat after being groomed off, the tapeworm develops into the adult stage in the cat's intestinal tract (Soulsby, 1982).

In Experiment 2, cats from the flea-infested environment spent almost twice as much time oral grooming and eight times longer scratch grooming as cats living in the flea-free colony. This statistically significant effect is one of the few studies on any species showing that ectoparasite exposure evokes increased grooming activity. This effect has been shown previously only for oral grooming in impala exposed to ticks (Mooring, 1995; Mooring et al., 1996) and for preening in chickens exposed to lice (Brown, 1974). Data from videotape analysis revealed that this flea-induced increase in grooming was totally accounted for by an increased frequency of bouts directed to multiple regions.

The increase in grooming evoked by the presence of fleas brings up the issue of the physiological control of grooming bouts. Two models for the control of oral grooming in non-primate species are: (1) peripherally-driven or stimulus-driven grooming and (2) programmed or centrally-driven grooming (Hart et al., 1992). In stimulus-driven grooming, the animal delivers grooming bouts to a part of the body as a function of cutaneous or peripheral stimulation, such as might be expected from a flea bite. In programmed grooming, the animal delivers bouts according to a loosely-running endogenous or central generator that evokes a bout of grooming after an elapsed time. With programmed grooming, ectoparasites would be removed before they bite or cause any cutaneous stimulation. Such grooming would also result in care of the pelage by removal of dirt and stale oil.

Findings from our study on the organization and control of grooming in cats (Eckstein and Hart, 2000), are consistent with the physiological study of Swenson and Randall (1977) in supporting the programmed grooming model as opposed to the stimulus-driven model as the main physiological basis of grooming in cats. With regard to the present study, when fleas are present, the stimulus-driven model would logically predict an increase in grooming, particularly of longer bouts, directed to single regions (corresponding to flea bites). The programmed grooming model, on the other hand, would predict that a systemically absorbed substance from flea bites (e.g. flea saliva, Hart 1997) would accelerate the central timing mechanism producing an increase in number of grooming bouts (not necessarily longer bouts) directed to multiple regions. Since the increase in grooming in cats with flea exposure was accounted for by an increase in bout frequency directed to multiple body regions, the results from Experiment 2 are most consistent with the programmed grooming model.

In conclusion, the findings support the concept that flea exposure in cats systematically increases the grooming rate of both oral and scratch grooming and that such grooming is effective in reducing the number of fleas harbored by cats in a flea-infected environment.

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