SHORT COMMUNICATION

Distribution of Cat Fleas (Siphonaptera: Pulicidae) on the Cat

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ABSTRACT A total of 3,382 cat fleas, *Ctenocephalides felis* (Bouché), was taken from 164 of the 200 stray cats examined. It was observed that cat fleas preferred specific areas on the cat. A significantly higher mean number of fleas was found on the area of head plus neck than on the ventral part of the body. More specifically, the mean number of fleas was highest on both of the neck and dorsal areas. However, in terms of the density of fleas, the neck had more fleas than the dorsal area did. The fewest fleas were found infesting the legs and tail. Distribution of fleas on the cat may well be explained by the various grooming patterns of the cat, and the knowledge of flea distribution may be valuable for application of on-animal flea control procedures.

KEY WORDS *Ctenocephalides felis*, on-host distribution, on-animal control, grooming behavior, cat flea

VETERINARIANS HAVE FOUND that fleas may prefer specific areas on live cats and dogs. *Echidnophaga gallinacea* (Westwood) has a preference for the facial area of the dog, whereas *Spilopsyllus cuniculi* Dale prefers the pinna and periauricular areas of the cat (Scott et al. 2001). Amin (1976) reported that the hindquarters and neck of ether-anesthetized dogs were more commonly infested than other parts of the body. Although there were several surveys of flea abundance and prevalence on cats (Beresford-Jones 1981, Coman et al. 1981, Wilson-Hanson and Prescott 1982, Harman et al. 1987, Shyu et al. 1993), the distribution of cat fleas, *Ctenocephalides felis* (Bouché), on a cat's body has seldom been addressed. Osbrink and Rust (1985) reported that there was no significant difference in the mean number of fleas collected from any particular area of the cat. However, they counted fleas on the cats after euthanasia. Hinkle et al. (1991) indicated that the male cat flea, unlike many other holometabolous, hematophagous arthropods, is exclusively a blood-feeder. It might display a form of parental care by the adult fleas to contribute to the feeding of the young. Thus, both sexes of adult fleas remained on the host constantly, except when dislodged by grooming, to continually produce flea feces as larval food. Although cat fleas display little tendency to leave their live cat host, even when flea population exceeded 300 fleas per cat (Hinkle et al. 1998), it may quickly abandon a dying host. The results of Osbrink and Rust (1985) differed from the anecdotal observations of some pet owners and veterinarians. Some veterinarians in Taipei, in a questionnaire survey conducted by Shyu (1992), considered the head and neck area the most flea-burdened area.

Hinkle et al. (1998) pointed out that host grooming was the most significant mortality factor acting on adult fleas once they achieved a host. The animal itself and the infestation level affected the grooming efficiency. Flea exposure can increase grooming rate in cats (Eckstein and Hart 2000b). According to Rust (1992), cats spent >77% of their time resting and sleeping. However, 27.6% of the remaining time was spent grooming. Hart (1976) indicated that mature cats spent 30–50% of their awake time in grooming. Beaver (1992) described various grooming patterns of cats in detail.

The aim of the current study was to more precisely describe the distribution of cat fleas on the cat. In addition, we discuss the flea distribution in relation to grooming behavior of the host animal and for consideration in the future research on the control aspects.

Materials and Methods

Stray cats were live trapped in cat traps (60 by 30 by 30 cm) that had a single door and that were baited with fried chicken. Traps were placed at night in the streets of Taipei from January to December 1991. Each captured animal was brought to the laboratory within 30 min, and anesthetized with ketamine (≈1 ml) by mus-

Protocol for the use and treatment of cats in this research is on file and was approved by the Laboratory Animal Care Committee, Department of Entomology, National Taiwan University. Releasing cats at the site where they were trapped was conducted in accordance with "Final disposition of animals" in "Guidelines for treatment of animals in behavioral research and teaching" published on the cover page of journal "Animal Behavior." These guidelines were promulgated by Ethical and Animal Care Committees formed by the Association for the Study of Animal Behavior and the Animal Behavior Society.

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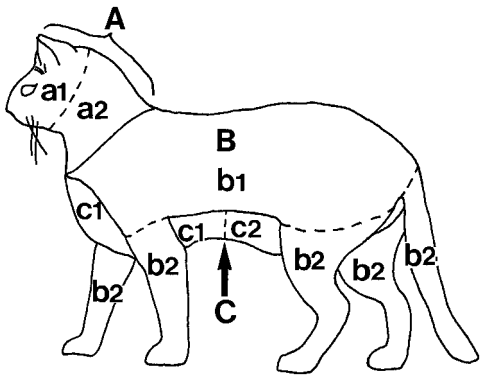

Fig. 1. Arbitrarily determined regions of the cat's body for flea examination. Three major areas of the cat: (A) Head and neck. (B) Dorsal and extremities. (C) Ventral. Six minor areas: (a1) Head. (a2) Neck. (b1) Dorsal. (b2) Extremities. (c1) Anterior ventral. (c2) Posterior ventral.

cular injection. Fleas were removed (with bare hands) from six randomly chosen minor areas (belonging to three major areas, see Fig. 1) of the animal surface pelage by quickly parting the cat's fur. Fleas were preserved in vials containing 70% alcohol, labeled separately for each cat, and later identified to species using a stereomicroscope. All animals were examined by the same researcher and each one was examined for a minimum of 20 min. However, if the cat still had fleas, examination time was extended until no flea was found within the last 2 min. Three major areas, including the head and neck, dorsal and extremities, and ventral areas (Fig. 1), were sampled in random order decided by casting a die. The neck is an area connecting the head to the shoulders and includes the lower surface of the lower jaw. Two minor areas within each major one were examined in alternating order, and each minor area was examined for 200 s. This was done to minimize the effect that the examination itself could have on the natural distribution of the fleas on the cat. The number of fleas in each area was recorded as well. After examination, the captured cat was temporarily placed in a cage for about half an hour of recovery. The cat was then released at the site where it was trapped. Cat traps were set up beside garbage-gathering sites, and several cats could be caught in the same location (with several trapping sites) in one night. However, to avoid capturing the same cat again we move other trapping locations on different trapping dates. We also memorized each cat's identity by recording the trapping location and date as well as the information of each cat.

Results and Discussion

Overall, 3,382 fleas were taken from 164 of the 200 stray cats examined, with 36 cats yielding no fleas. All fleas were *Ctenocephalides felis* (Bouché). The maximum number of fleas on a cat was 161. There were significant differences in the mean number of fleas not only among the three major areas (*F*-test; $F = 3.9$; df = 2, 198; $P < 0.01$) (Table 1) but also among six minor areas of the cat body ($F = 12.53$; df = 5, 198; $P < 0.01$) (Table 2). In major areas, the highest percentage of fleas was found on the smallest surface of the head and neck area (45.89%), and the lowest one was on the ventral area (22.80%) (see Table 1 and Fig. 1). In minor areas, the highest percentage of fleas was found on the neck area (29.4%), and the second highest was on the dorsal area (26.6%). The mean numbers of fleas on the above two minor areas did not differ significantly. However, the size of the dorsal area apparently exceeds that of the neck area. Thus, the density of fleas on the neck should surpass that on the dorsal area. The lowest percentage of fleas was found on the extremities (legs and tail) area (6.72%) (see Table 2 and Fig. 1). Our results were similar to the information obtained from the questionnaire to veterinarians conducted by Shyu (1992). The veterinarians also considered that the head and neck was the most flea-burdened area, followed by the dorsal and ventral areas, respectively. None of them reported that legs were common places to find fleas. However, Osbrink and Rust (1985) found no apparent preference for any particular areas of the cat's body after euthanasia, and the flea number generally corresponded to the surface size of various areas.

According to Beaver (1992), the cat grooms much of its body with its tongue and teeth through licking and biting (Fig. 2). The caudally directed, well-developed lingual papillae are particularly suitable for licking. Because the head and neck are so difficult to care for by oral grooming, problems are more numer-

Table 1. The mean number and percentage of cat fleas collected from the three major areas of the cat's body ($n = 200$)

Major area	Description	No. fleas collected		% collected
		Mean	SE	
A	Head/neck	7.46a	0.97	45.89
B	Dorsal/extremities	5.42ab	0.75	33.33
C	Ventral	3.38b	0.52	20.80

Means with different letters were significantly different ($P < 0.01$) using the Fisher's least significant difference (LSD) multiple range tests.

Table 2. The mean number and percentage of cat fleas collected from the six minor areas of the cat's body ($n = 200$)

Minor area	Description	No. fleas collected		% collected
		Mean	SE	
a1	Head	2.61b	0.44	16.30
a2	Neck	4.69a	0.57	29.40
b1	Dorsal	4.25a	0.56	26.60
b2	Extremities	1.07c	0.28	6.72
c1	Anterior ventral	1.81bc	0.32	11.30
c2	Posterior ventral	1.54bc	0.24	9.64

Means with different letters were significantly different ($P < 0.01$) using the Fisher's least significant difference (LSD) multiple range tests.

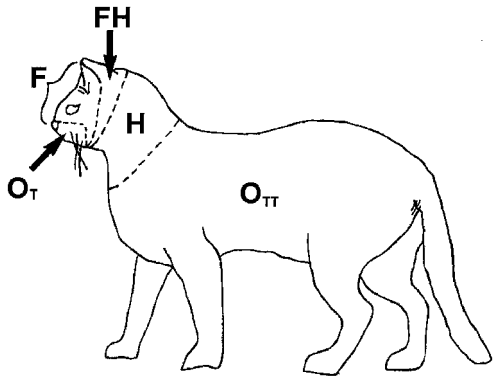

Fig. 2. Areas groomed in various manners by the cat. (F) Forepaw grooming. (FH) Fore- and hindpaw grooming. (H) Hindpaw grooming. (O_T) Oral grooming (tongue). (O_{TT}) Oral grooming (tongue and teeth) (modified after Beaver 1992).

ous in these areas. Scratch grooming with the hind claws may be useful in dislodging fleas from the head and neck; however, its duration took only 1/50 of the time of oral grooming (Eckstein and Hart 2000a).

We found the ventral area had the lowest number of fleas among three major areas. Eckstein and Hart (2000a) reported that cats spend 30% of their oral grooming time budget in their chest and anogenital area as well as abdomen licking, and spend only 13% of oral grooming time licking their sides and back.

The cat can clean their legs with tongue and teeth, and frequently licks its forepaws and then employs them as a washing tool to groom facial areas. Eckstein and Hart (2000a) reported that combined hindleg licking, tail licking, and face washing occupied 57% of the oral grooming time budget. Thus, this may explain why we observed the fewest fleas on the extremities among minor areas.

Grooming behavior of host animal plays a key role to the mortality of fleas on hosts (Hinkle et al. 1998, Eckstein and Hart 2000b), and may be an important factor on the on-host distribution of fleas. However, the cat flea is a species that has extensive spination and is very successful in remaining on a cat throughout coevolution. The cat flea may be very adapted to the cat's body and also successful in avoiding grooming, the most intensive selection pressure. Thus, it is worthwhile exploring other possible factors, such as flea pheromone or the skin temperature of various areas on the cat, involved in the movement of fleas on the host animal.

The results of Tränkle (1989) and our ongoing laboratory experiments (unpublished data) also indicated that cat fleas aggregate close to the neck. Tränkle (1989) suggested that fleas aggregate on the head for mating and females move to other parts of the body for egg laying. However, her hypothesis still needs to be demonstrated. Regardless of why fleas aggregate to the neck of the cat the final distribution of fleas may affect the efficacy of on-animal control procedures. Spot-on treatments and insecticide collars may be good choices for flea control based on our results of flea distribution. However, a successful on-animal flea control program depends not only on the measure applied on the infested animal but also on the spreading and residual effects of the chemicals. Thus, research on how chemicals spread through the cat via its fur, skin, or blood to kill fleas is worthwhile (Krämer and Mencke 2001).

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