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## Ectoparasites of the Swift Fox in Northwestern Texas

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**ABSTRACT:** Ectoparasites were collected from chemically immobilized swift foxes (*Vulpes velox*) in the Texas Panhandle (USA). Three species of fleas (*Pulex irritans*, *Dactylopsylla percernis*, and *Euhoplopsyllus affinis*) and one species of tick (*Ixodes sculptus*) were found. *Pulex irritans* was the only abundant ectoparasite; it occurred on all 23 foxes brushed in 1999–2000 and all but one of 34 hosts examined in 2000–01. Otherwise, this swift fox population had a depauperate ectoparasite fauna; the remainder of the ectoparasites only occurred on a few ( $\leq 5\%$ ) of the hosts. Because of previous taxonomic confusion between *P. irritans* and the closely related *P. simulans*, the zoogeographic distribution of these two species in many areas of western North America needs to be verified. Apparently, only the human flea *P. irritans* occurs on wild canids in the Texas Panhandle. However, there are previous records of *P. simulans* on other carnivores in western and central Texas. Some of these specimens were re-examined, and their identifications were reconfirmed. Also, the recent literature on the controversial taxonomic status of these two flea species is reviewed. The male terminal aedeagal sexual apparatus is the only means currently available to separate *P. irritans* and *P. simulans*.

**Key words:** Ectoparasites, *Ixodes sculptus*, *Pulex irritans*, survey, swift fox, *Vulpes velox*.

From 1995 to 2001, the swift fox (*Vulpes velox*) was classified as warranted but precluded as a threatened species by the US Fish and Wildlife Service (Washington, DC, USA; Kamler, 2002). Research on swift foxes greatly increased throughout their range during the 1990s because of this classification. Also during this time, they were translocated into Canada. Collections made from live-trapped swift foxes in the grasslands of the northern Texas Panhandle (USA) allowed us to compare the ectoparasite fauna of this fox population with those reported in other studies from adjacent fox populations in Oklahoma and Colorado (USA) by Kilgore (1969) and Miller et al. (1998), respectively. In the

Texas Panhandle, swift foxes seem to locate their dens invariably near black-tailed prairie dog (*Cynomys ludovicianus*) colonies (J. F. Kamler, pers. obs.). Therefore, we were concerned especially with the distribution and occurrence of those species of fleas that could serve as potential vectors of plague (*Yersinia pestis*).

We had two study sites in northwest Texas: a private cattle ranch on the border of Dallam and Sherman counties (36°24'N, 102°19'W) and the Rita Blanca National Grasslands in west-central Dallam County (36°31'N, 102°64'W). Both study sites consisted of shortgrass prairies dominated by buffalograss (*Buchloe dactyloides*) and blue grama (*Bouteloua gracilis*) and were adjacent to agriculture and Conservation Reserve Program (US Department of Agriculture, Washington D.C., USA) fields. Ectoparasites were collected during all seasons except summer, when pups were active at the den sites—from August to January 1999–2000 and 2000–01, respectively.

Ectoparasites were found on all of 23 and 34 swift foxes examined in 1999–2000 and 2000–01, respectively. Foxes were live-trapped with Havahart® cage traps (Woodstream Corp., Lititz, Pennsylvania, USA) on both study sites for another research project (Kamler, 2002). Captured swift foxes were anesthetized with ketamine hydrochloride (Fort Dodge Laboratories, Inc., Fort Dodge, Iowa, USA) and removed from the trap (Kamler, 2002). For the collection of ectoparasites, anesthetized foxes were liberally sprayed with Hartz® 2 in 1 flea and tick killer (Hartz Mountain Corp., Secaucus, New Jersey, USA) and thoroughly combed for 5–10 min using a stainless steel mini flea comb with 12.2 teeth/cm (International Pet Sup-

TABLE 1. Estimates of prevalence, intensity, and abundance of ectoparasites on the swift fox from northwestern Texas.

Year, species	Prevalence		Abundance	Intensity		Total <sup>c</sup>
	NE/NI <sup>a</sup>	%	$\bar{x} \pm SE^b$	$\bar{x} \pm SE$	Range	
1999–2000						
<i>Pulex irritans</i>	23/23	100	13.70±1.88	13.70±1.88	1–32	290
<i>Dactylopsylla percernis</i>	2/23	9	0.09±0.06	1.00±0	0	2
<i>Euhoplopsyllus affinis</i>	1/23	5	0.04±0.04	1.00±0	0	1
2000–2001						
<i>Pulex irritans</i>	33/34	97	18.97±2.03	19.55±2.00	0–50	683
<i>Dactylopsylla percernis</i>	2/34	3	0.06±0.04	1.00±0	0	2
<i>Ixodes sculptus</i>	3/34	9	0.09±0.05	1.00±0	0	3

<sup>a</sup> No. of hosts examined/no. of hosts infected.

<sup>b</sup> Mean  $\pm$  standard error.

<sup>c</sup> Total no. of specimens collected.

plies and Distribution, Inc., San Diego, California, USA). Ectoparasites were not observed leaving the anesthetized hosts or after the application of the insecticide. The entire body of each animal was thoroughly combed once, following a consistent pattern for each fox. Ear canals also were inspected for ectoparasites. For each fox, ectoparasites were combed into a metal tray and were then placed in a labeled vial that contained 70% ethanol. Fleas were infrequently observed around the den site of foxes during the trapping periods for either year. Our estimates for ectoparasite prevalence, intensity, and abundance are detailed in Table 1. Samples were transported to a laboratory at Texas Tech University Health Sciences Center (Lubbock, Texas, USA), where they were prepared for identification. Ticks were examined in 70% ethanol at 60 $\times$  magnification with a Leica GZ6 stereo microscope (Leica, Inc., Buffalo, New York, USA). They were identified using the original species description in Cooley and Kohls (1945). Fleas were soaked over night in 10% potassium hydroxide, washed in 70% ethanol that contained 1% hydrochloric acid by volume, dehydrated in a graded alcohol series, cleared in oil of wintergreen, and mounted in Canada balsam (Fox, 1968). Fleas were identified using keys and descriptions in Hubbard (1968),

Smit (1958), and Hopla (1980). Voucher specimens of ectoparasites collected from the swift foxes in the present study are deposited in the US National Parasite Collection (Beltsville, Maryland, USA; accession numbers 115A-4 to 115A-7/8, M1642-C). The terminology used herein to describe ecological relationships of parasites follows that outlined in Bush et al. (1997). The research protocol for the study was approved by the Texas Tech University Animal Care and Use Committee. Swift foxes were captured under permits issued by the Texas Department of Parks and Wildlife (Austin, Texas, USA) and the US Fish and Wildlife Service Endangered Species Program (Albuquerque, New Mexico, USA).

Three species of fleas (*Pulex irritans*, *Euhoplopsyllus affinis* [Pulicidae], and *Dactylopsylla percernis* [Ceratomyzidae]) and one species of tick (*Ixodes sculptus* [Ixodidae]) were found (Table 1). *Pulex irritans* was the only common ectoparasite. It occurred on all of the 23 foxes examined in 1999–2000 and on all but one of the 34 hosts examined in 2000–01; likewise, intensity and abundance values for this flea were high during both years (Table 1). Although *P. irritans* was extraordinarily abundant in this swift fox population, the remainder of the ectoparasites occurred on only a few ( $\leq 5\%$ ) of the hosts. We believe that ectoparasites other than *P. irri-*

*tans* represent incidental infestations that are infrequently acquired from their prey species. *Ixodes sculptus* is a parasite mostly of rodents, especially ground squirrels *Citellus* spp. (Cooley and Kohls, 1945). The normal hosts of *D. percernis* and *E. affinis* are pocket gophers (*Thomomys* spp.) and lagomorphs (*Lepus* spp. and *Sylvilagus* spp.), respectively (Hubbard, 1968). *Pulex irritans* was reported previously from swift foxes by both Kilgore (1969) and Miller (1998), and *I. sculptus* was found by Miller (1998). As far as we can determine, our collections of *D. percernis* and *E. affinis* from the swift fox represent new host records for these fleas.

Before the latter half of the last century, *P. irritans*, also known as the “human flea,” was the only commonly reported pulicid flea on a variety of wild carnivores, including foxes and coyotes (*Canis latrans*) in the western United States (Hubbard, 1968). Then, Smit (1958) resurrected *Pulex simulans*, a species originally described by Baker (1895). This flea appeared to be a more zoophilic species distinct from, but closely related to, *P. irritans*. Smit (1958) believed that *P. irritans* has a predilection for humans and large carnivores, whereas *P. simulans* occurs mostly on colonial rodents. This would make the latter species potentially a better vector for plague in the western United States, where the disease is firmly entrenched in prairie dog (*Cynomys* spp.) colonies. Lewis (1993) indicated that *P. irritans* was a cosmopolitan species that is usually found on various large, coarse-coated mammals such as pigs, canids, mustelids, deer, tapirs, and peccaries, but that it also occurred on humans. *Pulex irritans* was listed as a vector for plague in the United States, but it was conjectured to be of lesser importance in maintaining the sylvatic cycle than *P. simulans* (Lewis, 1993). Additionally, both fleas have been implicated in the transmission of flea-borne rickettsioses, specifically *Rickettsia typhi* and *R. felis*, as well as for the bacterium that causes “cat-

scratch fever” (*Bartonella henselae*) in North America (Azad et al., 1997).

The resurrection of *P. simulans* by Smit (1958) made all previous records of *P. irritans* from wild animal hosts questionable, at least throughout the known range of the two often-overlapping species in North and South America. However, this led to the incorrect assumption that all pulicids previously reported on wild carnivores were *P. simulans* rather than *P. irritans*. For example, Gier and Ameel (1959) after, finding only *P. simulans* on coyotes from the central great plains of Kansas, erroneously concluded that “. . . it is probable that most if not all of the fleas identified from wild animals as *P. irritans* are actually *P. simulans*.” Smit (1958) and Gier and Ameel (1959) doubted the validity of the *P. irritans* identified by Eads (1948) from a series of coyotes collected in Texas. However, the records of only *P. irritans* on swift foxes from the southern High Plains of Texas (this study) and southeastern Colorado (Miller et al., 1998), as well as the mixed infections of *P. irritans* and *P. simulans* on foxes from the Oklahoma Panhandle (Kilgore, 1969), confirms that *P. irritans* is a common flea species on some canid populations in the southwestern great plains (Fig. 1a,b,c). Although only *P. simulans* was found in coyotes in Kansas (Gier and Ameel, 1959) (Fig. 1d), *P. irritans* has been identified on coyotes in Andrews County at the southern edge of the High Plains of western Texas (D. B. Pence, unpubl. data; Fig. 1e). In contrast, only *P. simulans* was found by Stone and Pence (1977) on the bobcat (*Lynx rufus*) from the rolling plains of Knox County, Texas, approximately 250 km southeast of the swift fox study areas (Fig. 1f). Likewise, only *P. simulans* occurred on the ringtail (*Bassariscus astutus*) from Brewster and Jeff Davis counties in the Chihuahuan Desert of southwestern Texas (Fig. 1g) and from Burnett and Kimble counties in the hill country of central Texas (Custer and Pence, 1979) (Fig. 1h). We have reexamined the males from all

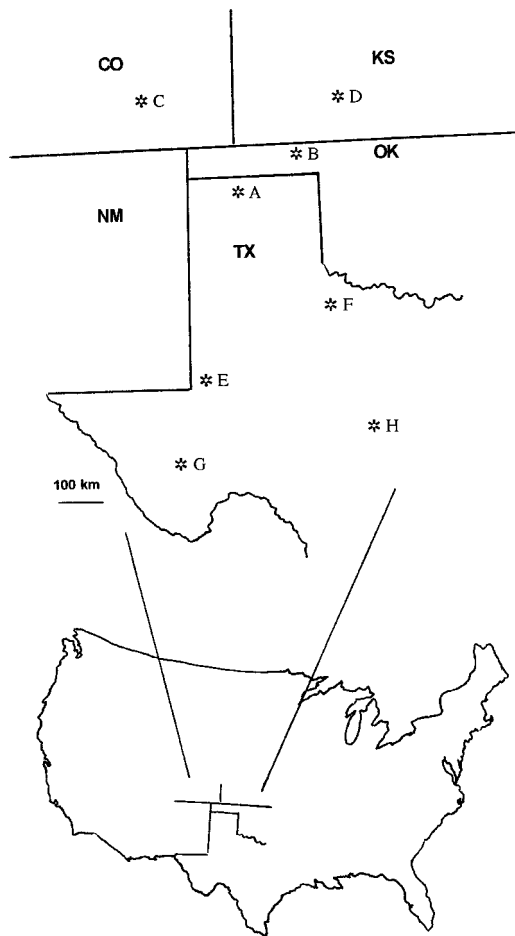


FIGURE 1. Confirmed records of *Pulex* spp. in carnivores in western Texas and adjacent areas. A. Only *P. irritans* was reported on swift foxes in the High Plains of northwestern Texas (this study). B. Both *P. irritans* and *P. simulans* have been documented on swift foxes from the High Plains of western Oklahoma (Kilgore, 1969). C. Only *P. irritans* was found on swift foxes at the western edge of the High Plains in southeastern Colorado (Miller et al., 1998). D. Numerous records of *P. simulans* have been reported on coyotes across the state of Kansas (Gier and Ameel, 1959). E. Only *P. irritans* was collected on coyotes from the southern edge of the high plains of western Texas (D. B. Pence, unpubl. data). F. Only *P. simulans* was found on bobcats examined in the rolling plains of western Texas (Stone and Pence, 1977). G, H. Only *P. simulans* was found on ringtails from the Chihuahuan Desert of southwestern Texas (G) and the hill country in central Texas (H) (Custer and Pence, 1979).

these series of specimens from both hosts and reconfirmed their identifications as *P. simulans*.

Smit (1958) found that *P. irritans* and *P. simulans* could be separated morphologically on the basis of only on slight, but apparently consistent, differences in the structure of the crochets and aedeagal sclerites in the male genitalia. Hopla (1980) refigured the male genital structures and noted considerable morphometric variation in these structures across specimens from both species. This also was especially evident in the large series of specimens of *P. irritans* that we collected from swift foxes. Still, as was emphasized by Hopla (1980), the dorsal movable sclerite of the aedeagus of *P. simulans* is always much broader throughout its length than the corresponding structure, which narrows considerably toward the distal extremity, in *P. irritans*, and this remains the only reliable characteristic that can be used to separate the species. Like Smit (1958) and Hopla (1980), we found no reliable characteristics that can be used to separate females of these species. Thus, females are usually listed as the same species as the male pulcids with which they are associated on a particular host.

Dittmar et al. (2003) emphasized that the identical females, overlapping geographic ranges in both New World hemispheres, very minor differences in male genitalia, records of cross-mating on certain hosts, and likely gene flow between populations or taxa raised serious doubts about the species validity of *P. simulans* and *P. irritans*. And, although their initial rDNA studies on contemporary North American *P. simulans* and *P. irritans* and pre-Hispanic archaeological specimens of South American *P. simulans* indicated that substitutions had occurred at the three positions, they failed to completely resolve the taxonomic dilemma of whether these two taxa should continue as separate species or be combined as a single cosmopolitan species. Zoogeographically, they did suggest that subsequent further prelimi-

nary studies on nuclear and mitochondrial genes pointed toward an existing metapopulation of *Pulex* sp. where *P. simulans* and *P. irritans* form several subpopulations in association to their hosts (Dittmar et al., 2003). Until these issues are fully resolved, we believe that it is of importance to continue to document the occurrence and distribution of *Pulex* spp., especially in areas such as western Texas, where the two presently defined taxa interface or overlap. To this end, we have initiated a study to examine the occurrence and distribution of the flea population in the prairie dog colonies that are closely associated with swift fox den sites in the northern Texas Panhandle.

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