Swift Fox, *Vulpes velox*, Den Use Patterns in Northwestern Texas

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Predator avoidance may be a reason why Swift Foxes (*Vulpes velox*) are one of the most burrow-dependent canids in North America. Typically Swift Foxes have multiple dens, which they frequently move among. As part of a larger study to reduce Coyote (*Canis latrans*) related mortalities on Swift Foxes, we installed artificial escape dens in areas occupied by Swift Foxes on Rita Blanca National Grassland, Dallam County, Texas. For this paper, our objective was to determine the effects of artificial escape dens on Swift Fox den use patterns. From January 2002 to August 2004 we captured, radio-collared, and monitored 55 Swift Foxes. We documented annual number of dens used, rate of den use (fidelity), distance between dens, den area, and den sharing. We compared treated (artificial dens installed) and untreated (no artificial dens) areas but found no differences in annual number of dens ($P = 0.64$; $\bar{\chi} = 8$), rate of den use ($P = 0.96$; $\bar{\chi} = 35\%$), mean distance between dens ($P = 0.99$; $\bar{\chi} = 2{,}311$ m), den area ($P = 0.55$; $\bar{\chi} = 5.72$ km^2), or den sharing ($P = 0.46$; $\bar{\chi} = 42\%$ of time). We did not observe an effect of artificial escape dens on Swift Fox den use patterns probably because artificial escape dens were designed for temporary escape cover rather than diurnal den use.

Key Words: Swift fox, *Vulpes velox,* den range, den sharing, den use, fidelity, Texas.

Swift Foxes (*Vulpes velox*) were once abundant throughout the short and mid-grass prairies of North America but have rapidly declined with expansion of human settlement (Egoscue 1979). Studies have shown that the Swift Fox primarily inhabits areas of native rangeland (Allardyce and Sovada 2003). Much of the historical Swift Fox range has been fragmented into patches of native rangeland, Conservation Reserve Program, and agricultural fields (Allardyce and Sovada 2003). Habitat loss has been one of the reasons Swift Foxes were temporarily a candidate for endangered species listing with the United States Fish and Wildlife Service (USFWS) from 1992 to 2001 (USFWS 1995; USFWS 2001; Allardyce and Sovada 2003).

Predation has been another limiting factor on Swift Fox populations (Kamler et al. 2003a). Many studies have shown that Coyotes (*Canis latrans*) are the primary source of Swift Fox mortality, with annual survival rates ranging from 43 to 53% (Sovada et al. 1998; Kitchen et al. 1999; Matlack et al. 2000; Anderson et al. 2003; Allardyce and Sovada 2003). Because Coyotes rarely consume Swift Foxes they kill (Sovada et al. 1998; Kitchen et al. 1999; Allardyce and Sovada 2003), Coyote predation seems to be the result of both interference and exploitative competition (Kamler et al. 2003b).

Predator avoidance may be one reason why Swift Foxes are one of the most burrow-dependent canids in North America (Moehrenschlager et al. 2004). Dens are an integral part of Swift Fox ecology. Swift Foxes use dens year-round not only for protection from predators, but also for reproduction, resting, and avoidance of extreme climatic conditions (Egoscue 1979). In sparsely vegetated habitats occupied by Swift Foxes, dens may constitute crucial escape cover. Arjo et al. (2003) found the number of dens used by Kit Foxes (*Vulpes macrotis*) was positively correlated with Coyote numbers. In addition, White et al. (1994) suggested that Kit Foxes established a number of dens (≥20) to facilitate escape.

It has also been suggested that Swift Foxes move frequently among different den sites (Kilgore 1969; Hines and Case 1991), but little detail on den use patterns has been reported. Understanding Swift Fox den behavior may be an important factor in sustaining viable populations throughout their range.

Because Swift Foxes use dens year-round (Egoscue 1979), we installed artificial escape dens as part of a larger study to determine if lack of den sites limited Swift Fox populations in northwest Texas, USA (McGee 2005). The objective of this paper was to document the effects of artificial escape dens on Swift Fox den use patterns. We determined annual number of dens used, rate of den use (fidelity), distances between dens, den area, and den sharing. We predicted that with more dens available in treated areas Swift Foxes would use more dens, have less fidelity for certain dens, have greater distances between dens, and be less likely to share a den. We made comparisons between treated (artificial escape dens installed) and untreated (no artificial dens installed) areas.

Study Area

We collected data from a contiguous 100-km^2 area on the Rita Blanca National Grassland (NG) in Dallam County, Texas, approximately 43 km northwest of Dalhart, Texas (Figure 1). The NG consisted of native rangelands with short-grass prairie dominated by Blue Grama (*Bouteloua gracilis*), Side-oats Grama (*Bouteloua curtipendula*), Burrograss (*Haplopappus tenui-*

sectus), and Buffalograss (*Buchlöe dactyoides*) that were moderately to intensively grazed by cattle (*Bos taurus*; Kamler et al. 2003a,b; Nicholson 2004; McGee 2005).

Methods

We captured, handled, and radio-collared Swift Fox using methods described by McGee (2005). We tracked Swift Fox to their diurnal resting sites (dens) using a hand-held antenna 1–2 times per week. We recorded each den location with a Garmin global positioning system receiver (Garmin International Inc., Olathe, Kansas, USA). We only used Swift Fox that were monitored ≥8 months of the year in data analysis. We calculated annual estimates from September to August of each year for all analyses. This was to allow Swift Foxes an adjustment period after installation of artificial dens and to perform two full years of data analysis.

During April 2002, we placed 108 artificial escape dens in three spatially separated areas (Figure 1). We considered Swift Foxes belonging to a treated area if their home ranges overlapped an artificial escape den area by ≥50%. We considered untreated Swift Foxes as those whose home ranges did not overlap artificial escape den areas (McGee 2005). No Swift Foxes in untreated groups were ever located within an artificial escape den treated area. Also, we considered foxes to belong to the same family group if they used the same area and dens concurrently (Kitchen et al. 1999; Kamler et al. 2003a,b).

Escape dens consisted of corrugated plastic sewer pipes 4.04 m long, 20.32 cm diameter with 20.32 cm holes cut in the middle to allow foxes to modify and expand subterranean dens ($6.41/m U.S.; Amarillo Plumbing Supply, Inc., Amarillo, Texas, USA). The diameter size of our artificial escape dens was based on previous studies that reported a mean den opening height of 20.0 cm for Swift Fox dens (Cutter 1958; Hillman and Sharps 1978; Pruss 1999; Jackson and Choate 2000). Coyote dens were reported to be 30–37 cm in diameter (Bekoff 1977; Althoff 1980; Bekoff 1982; Harrison and Gilbert 1985). We assumed that artificial escape den entrances, being the same diameter as natural Swift Fox dens, were too narrow for Coyotes. A John Deere 260 skid loader (Deere and Company World Headquarters, Moline, Illinois, USA) was used to install and cover the sewer pipe with only the two open ends exposed. Escape cover was randomly oriented and spaced approximately 322 m apart in a 2.59 km^2 grid pattern for a density of 36/2.59 km^2 (McGee 2005).

We calculated rate of den use (fidelity) by dividing number of dens by the number of times the fox was located in dens (× 100%). Lower values represented higher den fidelity. We calculated distances between dens using Bearing and Distance Extension for ArcView 3.2 (Environmental Systems Research Institute, Redlands, California, USA). We used den locations to estimate annual den areas for Swift Foxes using 100% minimum convex polygon (MCP) method (Mohr 1947) as calculated by Home Range extension (Rodgers and Carr 1998) for ArcView 3.2 (Environmental Systems Research Institute, Redlands, California, USA). We calculated den sharing as percentage of time a radio-collared Swift Fox was found in a den with another radio-collared fox.

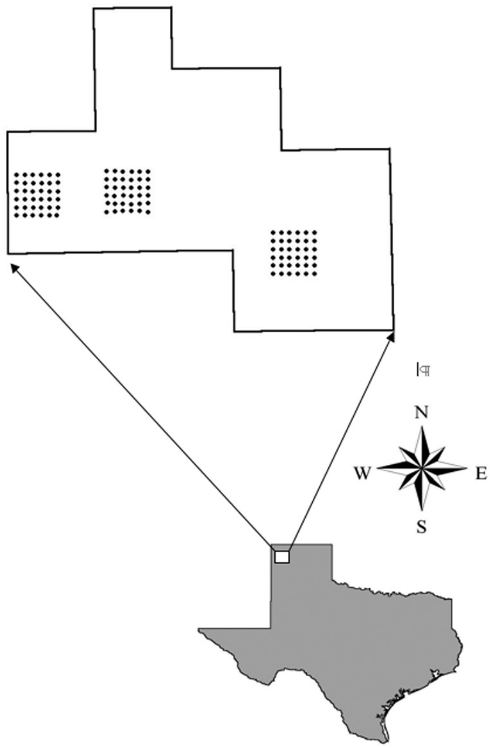

FIGURE 1. Map of the 100-km^2 study area located on the Rita Blanca National Grassland in northwest Dallam County, Texas, USA. One hundred and eight artificial escape dens (black dots) where installed in three separate grid locations.

We found no statistical differences among years so we pooled data to increase power. We used 1-way ANOVAs in SPSS 12.0 (SPSS 2003) to determine differences between treated and untreated areas for annual number of dens used, mean distances between dens, and mean den areas. We compared average rate of den use and sharing between treated and untreated areas using Yates' corrected chi-square tests (Zar 1999). Differences were deemed significant when $P < 0.05$.

Results

From January 2002 to August 2004, we captured and radio-collared 55 Swift Foxes (31 males, 24 females). We documented a total of 104 Swift Fox dens

TABLE 1. Average annual number of dens and den area of Swift Foxes on Rita Blanca National Grassland (NG) in northwest Texas, 2002–2004.

		Annual number of dens		Den range (km^2)	
Study area	n	$\bar{\chi} \pm$ SE	range	$\bar{\chi} \pm$ SE	range
treated	8	7.88 ± 0.48	6–10	6.34 ± 1.86	0.52–13.21
untreated	4	7.50 ± 0.50	7–9	4.50 ± 1.91	0.81–9.20

during our study including four separate occasions when we radio-tracked and observed Swift Foxes within artificial escape dens during the day. Due to the high turnover rate in our Swift Fox population, only 12 Swift Foxes (n = 8 treated, n = 4 untreated) were monitored for ≥8 months a year from September 2002 to August 2004.

There was no difference (P = 0.64) in annual number of dens used (mean ± SE) by Swift Foxes between treated (7.88 ± 0.48, n = 8) and untreated (7.50 ± 0.50, n = 4) areas (Table 1). Average rate of den use (fidelity) was similar (Yates' χ^2 = 0.003, P = 0.96) between treated (35.9%) and untreated (35.4%) areas. Mean distance between dens (± SE) was not different (F < 0.001, P = 0.99, 1-β = 0.05) between treated (2308 ± 442 m, n = 8) and untreated (2317 ± 654 m, n = 4) areas. There was no difference in den area (F = 0.38, P = 0.55, 1 – β = 0.09) between treated (6.34 ± 1.86 km^2, n = 8) and untreated areas (3.81 ± 1.91 km^2, n = 4). Den sharing only occurred between mated pairs. Average rate of den sharing was similar (Yates' χ^2 = 0.56, P = 0.46) between treated (44.9%) and untreated (39.0%) areas.

Discussion

We have shown that average number of dens used by Swift Fox each year was eight in northwest Texas (Table 1). Schauster et al. (2002) documented number of Swift Fox dens used was 2–8 for breeding and gestation season, 5–10 for pup-rearing season, and 3–8 for the dispersal season. Similar multiple den use has been documented with other small canids that share a dependence on dens, such as Artic Fox (*Alopex lagopus*; Eberhardt et al. 1983) and Kit Fox (Tannerfeldt et al. 2003; Moehrenschlager et al. 2004). Koopman et al. (1998) reported an average of 11.8 dens per year for Kit Foxes in California. Arjo et al. (2003) suggested to an increase in the number of dens used by Kit Foxes in western Utah could have been related to the increase in Coyote presence.

We found that Swift Foxes had relatively high fidelity to particular dens for both treated and untreated areas. Koopman et al. (1998) found that Kit Foxes exhibited a strong affinity for particular dens because Kit Foxes were located in their most frequently used den 32% of the time. Artic Foxes also preferred certain dens while others were used infrequently (Eberhardt et al. 1983). We suspect that den fidelity may be the result of den quality. Distinctions have been made between good and bad dens for Artic Foxes (Tannerfeldt et al. 2003). On the other hand, Swift Foxes frequently switch between dens (Egoscue 1979; Hines and Case 1991), suggesting poor den quality. One of the reasons for frequent changes between dens has been attributed to the large numbers of fleas found in Swift Foxes' dens (Kilgore 1969). Other factors like human disturbance, leaking, shifting towards food resources, and predator avoidance may play a role in Swift Foxes den switching and fidelity (Kilgore 1969; Tannerfeldt et al. 2003).

In addition, we documented a mean distance between dens of 2311 m (range 729–3998 m). Similarly, Moehrenschlager (2000) found that Swift Foxes in Canada moved to dens up to 1900 m away. In contrast, Cutter (1958) noted that Swift Fox dens in overgrazed pastures of northern Texas were concentrated but did not state the distance between dens. Cutter (1958) noted that up to six dens were frequently observed within 65 hectares of pastureland. Greater distances between dens would allow Swift Foxes access to more resources within their environment if dens were used to escape predators.

It has been suggested that carnivore home-range size can be affected by habitat composition and food distribution (Macdonald 1983). White and Ralls (1993) observed that larger Kit Fox home ranges were associated with low prey availability. We suspect that these effects can be applied to den area of Swift Foxes as well. Our results indicated a mean den area of 5.72 km^2. It is possible that Swift Foxes with larger den areas may have had greater access to food resources while avoiding predators. Ables (1969) recognized that Red Fox (*Vulpes vulpes*) home range size was affected by food abundance and availability. In addition, Hines and Case (1991) speculated that carrion availability and prey distribution probably affected Swift Fox home range size and shape. Likewise, Olson and Lindzey (2002) suggested that intensive hunting by Swift Foxes near natal dens may have reduced prey availability and consequently forced adults to expand the areas in which they hunted. Thus, larger den areas may be the result of fewer resources (Hines and Case 1991).

Although additional adult foxes have been observed with mated pairs at Swift Fox (Egoscue 1979; Covell 1992; Kitchen et al. 1999; Lemons et al. 2003), Arctic Fox (Eberhardt et al. 1983), and Kit Fox (Ralls et al. 2001; Tannerfeldt et al. 2003) den sites, we did not document this occurrence. Of the Swift Foxes that we monitored, only mated pairs were ever found occupying the same den. Adult radio-collared Swift Foxes in our study denned with their mate 39–44% of the time. Similarly, Koopman et al. (1998) found that mated adult Kit Foxes denned together about 45% of the time. Also, Ralls and White (2003) found that Kit Fox pair members shared the same den 51% of the time. It is possible that we underestimated the rate of den sharing. We believe that on occasion a radio-collared fox denned with adult foxes that were not radio-collared.

In conclusion, we were able to describe Swift Fox den use patterns in northwest Texas even though we did not observe an effect of artificial dens. One possible reason for not observing an effect may be the low sample sizes. Even though we captured 55 Swift Foxes during our study, residents were not abundant as data analysis was only performed on eight Swift Foxes in treated and four Swift Foxes in untreated areas that were monitored ≥8 months per year. Also, no observed effect of artificial dens may be due to the fact that artificial dens were designed for temporary escape from predators, specifically Coyotes, while Swift Foxes were away from their natural dens. As part of the larger study mentioned before (McGee 2005), we found higher annual Swift Fox survival ($P = 0.07$) in artificial den treated areas (0.81) than in untreated areas (0.52) on the same study site. Higher survival in treated areas suggests that Swift Foxes were using artificial dens for escape during their normal nocturnal activities. Diurnal use of artificial dens was limited. We only tracked Swift Foxes to artificial escape dens on four occasions during the day. Therefore, alternative artificial den designs need further study to find a more suitable diurnal artificial den for Swift Foxes.

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