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PREY INDICES AND BEHAVIORS AT A GRAY FOX DEN IN SAN MATEO COUNTY, CALIFORNIA

L. Mark Elbroch[1] and Maximilian L. Allen[2]

ABSTRACT.—The gray fox (*Urocyon cinereoargenteus*) is an under-studied species in North America. Here we provide data gathered through observations over 17 d at a gray fox den in San Mateo County, California. We recorded prey indices through direct observation, as well as through indirect observation with photos recorded by motion-triggered cameras. The largest prey was a mule deer fawn, which we determined was killed by a gray fox. This finding is the first record of gray fox predation on mule deer. Lagomorphs and rodents formed the majority of prey items. We also recorded behavior that both contradicted and corroborated previous literature. We observed the male bringing food items to the den, a behavior that previous researchers have disagreed about. We also observed allogrooming between the adult pair, as well as one instance among pups where leg-lifting accompanied by presentation of the genitalia was clearly used as an aggressive dominant behavior rather than a submissive behavior, as reported in previous literature.

RESUMEN.—El zorro gris (*Urocyon cinereoargenteus*) es una especie poco estudiada en Norteamérica. Aquí brindamos información que se obtuvo al observar la guarida de un zorro gris en el condado de San Mateo, California, durante más de 17 días. Registramos la presencia de presas a través de la observación directa, y de manera indirecta por medio de fotografías tomadas con cámaras automáticas activadas a través de movimiento. La presa más grande fue un cervatillo de venado bura, el cual determinamos que fue cazado por un zorro gris, y es el primer registro de que el zorro gris depreda al venado bura. La mayor parte de las presas fueron lagomorfos y roedores. Además, registramos conductas que contradicen o confirman la literatura publicada sobre el tema. Observamos el macho mientras traía alimentos a la guarida, con lo cual otros investigadores no estaban de acuerdo. También observamos a la pareja de adultos en conducta de aseo mutuo, y realizamos una nueva interpretación de una conducta registrada por otros investigadores. Si bien algunos observadores previos hicieron hincapié en que el levantar la pata y mostrar los genitales representa una conducta de sumisión entre los cachorros de zorro, registramos un evento en el que esta conducta se utilizó también de manera dominante y agresiva.

Understanding the ecology of individual species is an important component to understanding ecological systems, and such understanding is becoming increasingly important to conservation biology (Caro 1999). Despite a century of scientific studies and publications in North America, there remain species whose ecology continues to be poorly understood. These species include common mammals that have little economic value (Fuller and Cypher 2004) and species that are either uncommon across much of their range or difficult to observe. One such species is the common gray fox (*Urocyon cinereoargenteus*), which is uncommon, as well as nocturnal and difficult to observe. Due to these factors, there is a lack of research on some aspects of the most basic ecology of gray foxes.

Much of the limited research on the ecology of gray foxes to date has been anecdotal, based on red foxes (*Vulpes vulpes*), or based on observations of captive-raised animals (Taylor 1943, Fox 1971). The seasonal diets of gray foxes have been studied in varied locations across North America (Errington 1935, Scott 1955, Hockman and Chapman 1983), but more studies of regional significance could be used. In California, the primary means of gathering data on the diets of gray foxes has been indirect, either through stomach analysis of trapped animals (Grinnell et al. 1937) or scat analysis (Kuenzi et al. 1998, Neale and Sacks 2001). Observations of reproduction are also limited; for example, the exact gestation period of the gray fox is currently unknown (Fritzell and Haroldson 1982). Here we present the diet and behavior of gray foxes recorded during 17 days at a den site in San Mateo County, California. We provide data on prey items and indices, as well as notes on behaviors that both corroborate and contradict previous reports on the species.

Our observations occurred at a single den site in San Gregorio, California (37.357318° N,

[1]Panthera, 8 West 40th Street, 18th Floor, New York, NY 10018.
[2]Corresponding author. Victoria University of Wellington, School of Biological Sciences, Box 600, Wellington 6140, New Zealand. E-mail: maximilian.allen@vuw.ac.nz

TABLE 1. Prey indices recorded at a gray fox (*Urocyon cinereoargenteus*) den.

Prey item	Live weight (g)	Number of records	Total weight collected (g)	% of total number of prey	% of total weight killed
Black rat, *Rattus rattus*	182.5	8	1460	28.6	11.1
Big-eared woodrat, *Neotoma macrotis*	271	5	1355	17.9	10.3
Brush rabbit, *Sylvilagus bachmani*	700	5	3500	17.9	26.7
California vole, *Microtus californicus*	53.5	3	160.5	10.7	1.2
Botta's pocket gopher, *Thomomys bottae*	155.5	3	466.5	10.7	3.6
Trowbridge's shrew, *Sorex trowbridgii*	4.8	1	4.8	3.6	0.0
Mule deer fawn, *Odocoileus hemionus*	6110	1	6110	3.6	46.5
California red-sided garter snake, *Thamnophis sirtalis*	72	1	72	3.6	0.6
Banana slug, *Ariolimax columbianus*	3	1	3	3.6	0.0

–122.334891° W, 127 m asl). The den was located 2 m from the nearest building, within the drainage pipes beneath the driveway of a remote private residence. The entrance to the den was a PVC pipe 27.9 cm in diameter, and the aspect of the den entrance was 196°. The dominant habitat surrounding the den was Valley Oak Woodland, with a secondary habitat of Redwood (Mayer and Laundenslayer 1988). The den was located within 60 m of a perennial stream.

Observation of the den site occurred over 17 days (10–27 May 2005) and included direct observations and indirect observations recorded by motion-triggered cameras. Two types of cameras were used: initially, we employed a Trailmaster passive-sensor, 35-mm film camera with a maximum capacity of recording 36 events, but we quickly switched to a Digital Camtrakker, which had a memory card capable of recording 88 events. Prey items at the den site were recorded in 3 ways: (1) direct observation of adult foxes carrying in prey items; (2) photographs of adults carrying prey to the den recorded by motion-triggered cameras; and (3) morning sweeps of 10 m^2 surrounding the den entrance for prey items discarded, partially eaten, or cached. The live weights for all prey items were obtained by taking the midpoint of the weight range published in Jameson and Peeters (2004), with 3 exceptions: (1) for the mule deer fawn (*Odocoileus hemionus*), we used the mean weight at 10 days for hand-raised fawns (Halford and Alldredge 1978); (2) for a banana slug (*Ariolimax columbianus*) prey item, we used the weight of a banana slug of equivalent size; and (3) for the California red-sided garter snake (*Thamnophis sirtalis*), we used weights published by Heckrotte (1967). We used the live weights to determine the energetic gains of a particular prey species, as well as that prey species' relative importance as a percentage of the total prey recorded (Table 1).

Behavioral observations of 5 pups and the adult pair were made whenever possible at all times of day, from early morning until several hours after dark. Camera traps recorded behaviors beyond the hours of direct observation until film or memory ran out, which it did every night. Adults in the images and observations were classified as male or female when possible. These classifications were based on the visible signs of lactation, indicative of the adult female, and the presence of a torn ear, indicative of the adult male.

As noted in Table 1, the largest food item brought to the den was a mule deer fawn, while brush rabbits (*Sylvilagus bachmani*), black rats (*Rattus rattus*), and big-eared woodrats (*Neotoma macrotis*) were also significant food sources. Predation on mule deer by gray foxes has not been recorded previously, while lagomorphs and rodents are a staple of gray fox diets (Errington 1935, Scott 1955, Hockman and Chapman 1983). Other interesting prey items were a California red-sided garter snake and a banana slug, as reptiles and mollusks are uncommon items in gray fox diets.

The record of the mule deer fawn is of particular interest. In California, Grinnell et al.

(1937) assumed any ungulate prey found in the stomachs of gray foxes constituted incidental feeding at available carcasses, and Allen et al. (unpublished data) found gray foxes to be the second most common scavenger at deer carcasses in a study in Mendocino County, California. However, Neale and Sacks (2001) noted that ungulate remains peaked in fox scats from late winter into spring, suggesting the possibility that they were also killing lambs (*Ovis aries*) and fawns. Forensic investigation of the fawn's carcass revealed tooth marks on the neck and bruising, yet no punctures through the skin, as is diagnostic in bobcat (*Lynx rufus*) and coyote (*Canis latrans*) kills (Wade and Bowns 1982, Acorn and Dorrance 1990, Elbroch 2003). Further investigation included skinning the fawn to assess signs of muscle trauma visible on the inside of the skin. We did not detect trauma to the body or the back of the neck, characteristic of larger predators, or damage wrought by striking vehicles. In addition, the remoteness of the den site made it unlikely the carcass was a fresh roadkill. Light trauma was evident on the throat where short lines of fur were removed, we believe, by the teeth of a gray fox. Hoof wear indicated that the fawn had walked and had not been stillborn. Images from the Digital Camtrakker revealed that the adult male dragged the fawn carcass to the den entrance at 1:00 AM; subsequent images showed the pups feeding on the fawn. Based on the internal and external analysis, all evidence supported the hypothesis that a gray fox had killed the fawn, most likely through strangulation. This mention is the first report of gray fox predation of a mule deer.

Caching is a well-known behavior of red foxes; however, Parkinson (*in* Grinnell et al. 1937) reported that gray foxes have "little or no instinct to hide away or store food up." On one occasion during the den observations, an entire black rat was discovered cached in the shade 3 m from the den entrance. The cache site was poorly constructed, and the black rat was removed by the following morning.

Grinnell et al. (1937) reported that both the male and female participate in the feeding of the pups. This report was also corroborated by Fritzell and Haroldson (1982). Most recently, Fuller and Cypher (2004) reported that there is only "some evidence" that males may contribute to feeding the pups. Camera images and direct observations corroborated the earlier publications that report participation by both males and females in the feeding of pups.

Fox (1971) believed gray foxes to be more social than either arctic foxes (*Vulpes lagopus*) or red foxes. This observation was based on captive foxes, of which only the gray foxes exhibited allogrooming. On 3 occasions, allogrooming between the adult male and adult female was observed near the den site while the foxes rested during daylight hours, corroborating the observation of captive gray fox behavior in wild foxes.

Fox (1971) reported that leg-lifting and presentation of the genitalia in gray fox pups is a passive-submissive or appeasement behavior. Taylor (1943) also reported leg-lifting in what appeared a mutual greeting, as paired pups were observed in mutual leg-lifting and smelling of each other's genitalia after approaching one another. Corroborating observations for both of the above interpretations were made numerous times at this den. In addition, we observed a different interaction that provides further insight into presentation of the genitalia by fox pups to conspecifics. On one occasion, we observed the largest and most dominant pup approach the runt of the litter outside the den and attempt to present its genitalia to the smaller animal. In response, the runt changed course to avoid the encounter. The dominant animal repositioned itself and presented again, but the runt continued to ignore the presentation and changed course. After a third failed attempt to present its genitalia, the dominant animal leaped atop the runt, biting the neck, growling, and bearing the smaller animal to the ground. The dominant animal shook the runt violently, and then stood, raised a hind leg and presented its genitalia. The runt rose and sniffed the dominant animal's genitalia, after which they quickly went separate ways and the runt returned to exploring and playing. During this encounter, the presentation of genitalia appeared to be an aggressive-dominant behavior, rather than the assumed passive-submissive behavior reported in previous publications.

Here, we have provided new data on prey indices and behaviors of common gray foxes. The conservation of any species needs to be based on a thorough understanding of its basic ecology, as well as sound science. We encourage others to add observations lacking in our

communal knowledge of wild mammals, especially observations of mammals that are understudied due to their low economic value.

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LITERATURE CITED

ACORN, R., AND M. DORRANCE. 1990. Methods of investigating predation of livestock. Alberta Agriculture, Food and Rural Development, Edmonton, Alberta, Canada.

CARO, T.M. 1999. The behaviour-conservation interface. Trends in Ecology and Evolution 14:366–369.

ELBROCH, M. 2003. Mammal tracks and sign: a guide to North American species. Stackpole Books, Mechanicsburg, PA.

ERRINGTON, P. 1935. Food habits of mid-west foxes. Journal of Mammalogy 16:192–200.

FOX, M.W. 1971. Socio-infantile and socio-sexual signals in canids: a comparative and ontogenetic study. Zeitschrift für Tierpsychology 28:185–210.

FRITZELL, E.K., AND K.J. HAROLDSON. 1982. *Urocyon cinereoargenteus.* Mammalian Species 189:1–8.

FULLER, T.K., AND B. CYPHER. 2004. Gray fox (*Urocyon cinereoargenteus*). Pages 92–97 *in* C. Sillero-Zubiri, M. Hoffmann, and D.W. Macdonald, editors, Canids: foxes, wolves, jackals, and dogs—status survey and conservation action plan. IUCN/SSP Canid Specialist Group, Gland, Switzerland; and Cambridge, United Kingdom.

GRINNELL, J., J.S. DIXON, AND J.M. LINSDALE. 1937. Furbearing mammals of California. Volume 2, pages 421–451. University of California Press, Berkeley, CA.

HALFORD, D.K., AND A.W. ALLDREDGE. 1978. A method for artificially raising mule deer fawns. American Midland Naturalist 100:493–498.

HECKROTTE, C. 1967. Relations of body temperature, size and crawling speed of the common garter snake *Thamnophis s. sirtalis.* Copeia 4:759–763.

HOCKMAN, J.G., AND J.A. CHAPMAN. 1983. Comparative feeding habits of red foxes (*Vulpes vulpes*) and gray foxes (*Urocyon cinereoargenteus*) in Maryland. American Midland Naturalist 110:276–285.

JAMESON, E.W., AND H.J. PEETERS. 2004. California natural history guides: mammals of California. 2nd edition. University of California Press, Berkeley, CA.

KUENZI, A.J., M. LYNCH, D. VAN VUREN, I. LOREDO, AND M.L. MORRISON. 1998. Diets of three predators at Concord Naval Weapons Station, Contra Costa County, California. Northwestern Naturalist 79: 64–67.

MAYER, K.E., AND W.F. LAUNDENSLAYER, EDITORS. 1988. A guide to wildlife habitats in California. State of California, The Resources Agency, Department of Forestry and Fire Protection, Sacramento, CA.

NEALE, J.C., AND B.N. SACKS. 2001. Food habits and space use of gray foxes in relation to sympatric coyotes and bobcats. Canadian Journal of Zoology 79:1794–1800.

SCOTT, T. 1955. Dietary patterns of red and gray foxes. Ecology 36:366–367.

TAYLOR, W.P. 1943. The gray fox in captivity. Journal of Texas Game and Fish 1:12–13, 19.

WADE, D., AND J. BOWNS. 1982. Procedures for evaluating predation on livestock and wildlife. Texas Agricultural Extension Service, Texas Agricultural Experiment Station and U.S. Fish and Wildlife Service, Publication B-1429.

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