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OBSERVATIONS OF ANTAGONISTIC AND NONANTAGONISTIC INTERACTIONS BETWEEN THE SAN JOAQUIN KIT FOX (*VULPES MACROTIS MUTICA*) AND THE AMERICAN BADGER (*TAXIDEA TAXUS*)

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Abstract—Interactions between the American badger (*Taxidea taxus*) and members of the Canidae have been reported in detail previously in the literature, including the coyote (*Canis latrans*), swift fox (*Vulpes velox*), and red fox (*Vulpes vulpes*). Most of these interactions were cooperative or nonantagonistic; however, a few were exploitative or otherwise antagonistic. Here we report for the first time antagonistic and nonantagonistic interactions between the San Joaquin kit fox (*Vulpes macrotis mutica*) and the American badger.

Resumen—Las interacciones entre el tejón norteamericano (*Taxidea taxus*) y miembros de la familia Canidae se han registrado detalladamente antes en la literatura, incluso el coyote (*Canis latrans*), zorro rápido (*Vulpes velox*) y zorro rojo (*Vulpes vulpes*). La mayor parte de estas interacciones fueron cooperativas o no antagónicas, sin embargo unas cuantas fueron explotadoras o por otra parte antagónicas. Aquí registramos por primera vez interacciones antagónicas y no antagónicas entre el zorro de San Joaquín (*Vulpes macrotis mutica*) y el tejón norteamericano.

The American badger (*Taxidea taxus*) is a generally solitary animal, usually hunting without the assistance of other badgers or other species (Long, 1973). On occasion, however, the badger will tolerate co-occurring canids, in what could be described as commensal or sometimes mutualistic relationships (Lehner, 1981). Though these behaviors are not fully understood and are somewhat counterintuitive, various observations by researchers and naturalists have revealed some insight into this rare instance of interspecific tolerance not commonly observed in the wild.

Reports of badger and coyote (*Canis latrans*) interactions in the scientific literature date as far back as 1883. Aughey (1884) and Hawkins (1907) describe badgers and coyotes traveling together, and Aughey additionally noted playful behaviors between the two species. Descriptions of badgers and coyotes hunting together have further documented cooperative behaviors between the two species (Robinson and Cummings, 1947; Cook, 2000). A cooperative hunting strategy observed by Cahalane (1950) was described as a "double rush" behavior in which case both the coyote and badger charge prairie dog (*Cynomys* species) colonies, increasing the potential for confused and disoriented prairie dogs to become prey for at least one of the predators. Coyotes have also been observed checking adjacent burrow openings while the badger excavates a burrow, apparently to catch rodents as they attempt to escape (Lehner, 1981; Kiliaan et al., 1991).

Minta et al. (1992) described badger–coyote associations as likely neither cooperation nor reciprocal altruism but more likely a nonevolved mutualistic behavior. They state that "[b]oth species probably drew upon a behav-

ioral repertoire evolved in the context of intraspecific interactions to establish a functional, if limited, two-species social system." An alternative explanation is that coyotes simply take advantage of badgers because, in some instances, it is unknown if the badgers were able to obtain prey during the interactions; or it may be a form of mutualistic behavior if they are able to each benefit from the relationship. Clark (2007) proposed that the coyote uses the badger as a "tool" to extract prey from the ground. In this scenario, the benefit to the badger is not clear; however, if a rodent detects a coyote at a burrow exit and subsequently remains underground, the badger may eventually excavate and catch the prey.

Although cooperative interactions between badgers and coyotes are the most frequently reported associations, interactions between the swift fox (*Vulpes velox*) and the badger have also been described. Ausband and Ausband (2006) reported a swift fox and a badger in proximity of one another, with the swift fox watching the badger forage within a rodent burrow complex. The authors surmised that the two species may have been foraging together, despite reports of American badgers preying on swift foxes (Carbyn et al., 1994).

Not all interactions, however, are cooperative or otherwise nonantagonistic. Hibbard (1963) reported an interaction between a red fox (*Vulpes vulpes*) and a badger in which the fox repeatedly lured the badger away from a sheep carcass. The red fox moved close enough to the carcass to incite the badger into a chase, then returned to the carcass and secured a few bites before the badger returned. The sequence was repeated five or six times in a 5-min period of time. Rathbun et al. (1980) reported predation events on badgers by coyotes. In one instance a lone coyote attacked an adult badger; however, the badger was able to defend itself. In another instance three coyotes were observed collectively harassing a badger that they eventually killed.

Here we report observations between San Joaquin kit foxes (*Vulpes macrotis mutica*) and American badgers that provide further insight into the interactions between badgers and canids. These interactions were observed on the Carrizo Plain National Monument (San Luis Obispo County, California), an area with habitat characteristic of *Atriplex* scrub and California grassland. On 4 September through 6 September 2013, while conducting nighttime spotlight surveys of private conservation inholdings within the study area, we observed an American badger and San Joaquin kit fox in proximity to one another on three occasions at two locations separated by approximately 24 km. On one occasion these interactions were observed contemporaneously at these two locations, which clearly represented two different sets of interactants.

The interactions during the spotlight sessions appeared to be nonantagonistic and on at least one occasion clearly involved foraging behaviors. The first interaction involved a single badger and a kit fox traveling in a common direction, with the kit fox remaining a few meters behind the badger. The slow travel speed and periodic checking of rodent burrow entrances indicated that the badger was likely foraging. At a second location a single badger was observed again traveling across the landscape in a manner that indicated it was hunting, and again in this instance a single kit fox remained within a few meters behind the badger. At this same location the following night (6 September) a single badger was again observed in proximity to a single adult San Joaquin kit fox. The pair was then briefly joined by a second adult kit fox, and all three animals traveled across an open area where we observed them with spotlights and binoculars to a distance of about 150 m. The trio then moved out of sight. Shortly thereafter, the badger and one of the kit foxes reappeared at the edge of the clear area, remaining within approximately 1 to 2 m of each other. The badger was then clearly observed excavating the burrow of a giant kangaroo rat (*Dipodomys ingens*), during which time the fox darted back and forth around the badger, and appeared to be examining other openings of the kangaroo rat burrow. At one of these openings, while the badger's head was below the ground surface, the kit fox lunged at the ground and then ran to a group of shrubs. The badger backed out of the excavated hole and quickly followed the kit fox into the denser vegetation where we were no longer able to observe them.

In addition to these direct observations, we obtained photographic evidence of both antagonistic and nonantagonistic behaviors between the San Joaquin kit fox and the American badger within another private conservation inholding in the northern portion of the Carrizo Plain, approximately 20 and 44 km northwest of the locations where the interactions described above occurred. Habitat at this location was California grassland. Infrared motion-activated cameras, set with a burst rate of three photos with a 10-s delay between bursts on the Bushnell cameras (model 119636C, Alliant Techsystems Inc., Arlington, Virginia) and no delay between bursts on the Reconyx camera (UltraFire XR6 model, RECONYX, Inc., Holmen, Wisconsin), were deployed at subterranean dens to monitor use by kit foxes and other species and on three occasions interactions between San Joaquin kit foxes and American badgers were recorded.

On 29 April 2012 an aggressive interaction between a kit fox and a badger was recorded with an infrared camera. At 2011h, a camera station captured a series of three photographs of a badger with its head facing into a den opening with an adult kit fox, ears flattened, apparently lunging toward the badger within about 30 cm. In the third photograph of the sequence the badger's head is below ground and the kit fox appears to make contact with the badger. The next photograph in the sequence occurred about 80 s later and shows the badger

FIG. 1—A 40-min photo span showing an interaction between two juvenile San Joaquin kit foxes (*Vulpes macrotis mutica*) and an American badger (*Taxidea taxus*) near a single subterranean den, Carrizo Plain, San Luis Obispo County, California.

approximately 2 m from the den, followed by a sequence of the badger walking around the den opening. Approximately an hour and a half later a kit fox was recorded at the very edge of a photograph, near the den opening, and then 50 min later a kit fox was photographed several times standing squarely at the den opening, after which it was observed walking away from the den. Before this interaction, on 28 April 2012, the kit fox was photographed throughout the day sleeping and grooming near the entrance of the den, indicating that the fox had taken residence. The kit fox continued to be detected at the den regularly for 2 days after the interaction.

On 26 July 2012, a series of photos were taken of a nonantagonistic interaction between two juvenile kit foxes and one badger. At 2250h, a lone badger moved toward a den (Fig. 1a) and appeared to enter it. Two minutes later, two kit foxes appeared to be exploring the den entrance (Fig. 1b), but they did not enter (Fig. 1c). The badger emerged from the den at 2253h, with one kit fox sitting approximately 2 m from the den entrance (Fig. 1d), and remained outside the den for 8 min (Fig. 1e).

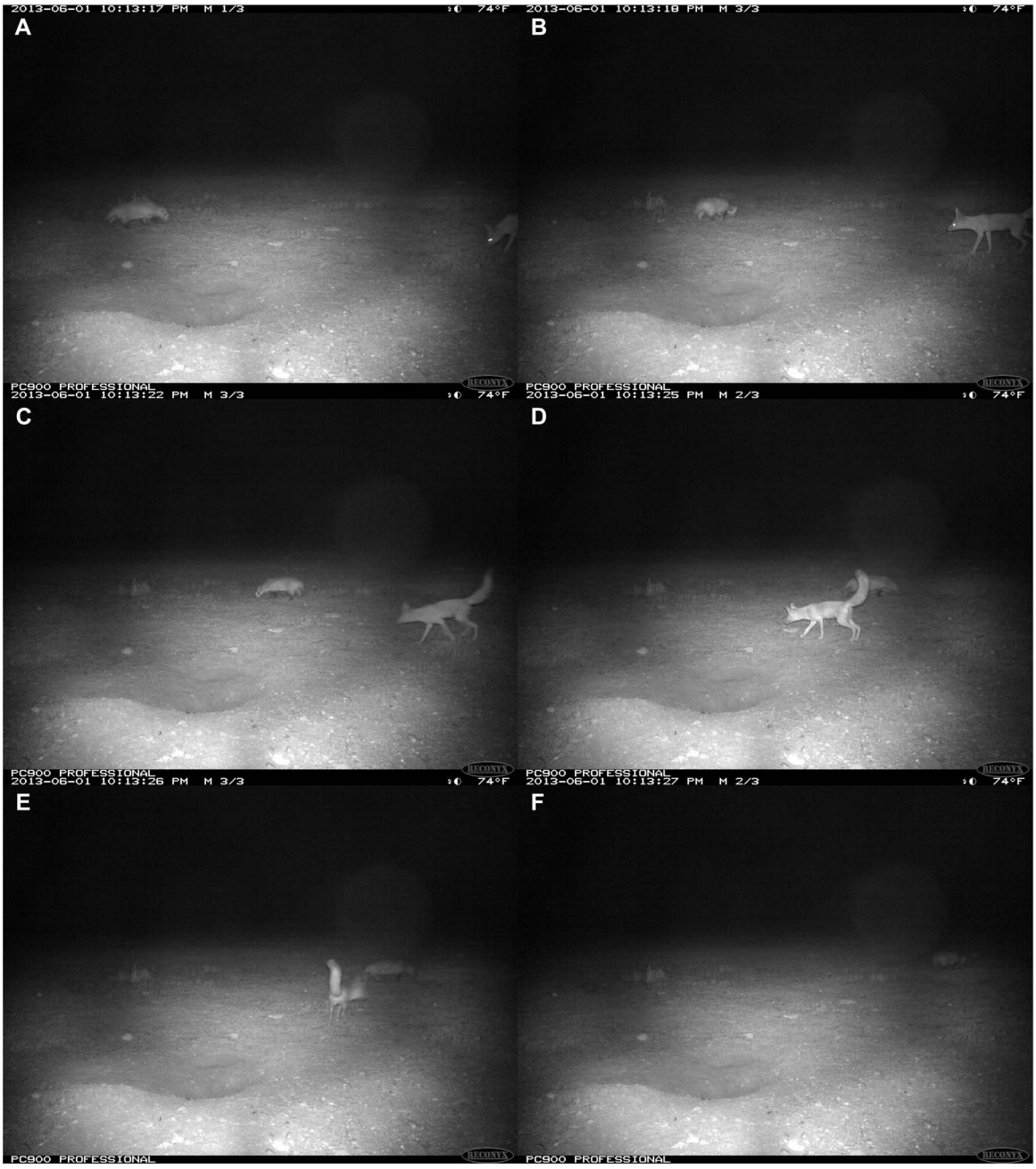

FIG. 2—A 10-s photo span showing apparent independent foraging of a San Joaquin kit fox (*Vulpes macrotis mutica*) and an American badger (*Taxidea taxus*), Carrizo Plain, San Luis Obispo County, California.

Nearly 30 min later, a kit fox returned with ears perked and examined the den (Fig. 1f). The two species both seemed interested in the den. The following day (27 July 2012), a kit fox was photographed using the den all day. On 28 July 2012, a badger investigated the same den in the morning and a kit fox visited the den that night. The den was then unoccupied for the following 2 weeks, after which a one-way door was installed to prevent occupation of the den during upcoming construction activities.

On 1 June 2013 (Fig. 2), a 10-s nonantagonistic event was recorded with a motion-sensing camera. A badger and a kit fox appear to be independently foraging within just a few meters of each other. Neither species displayed interest in a nearby den.

Our observations of interactions between San Joaquin kit foxes and American badgers show that both antagonistic and nonantagonistic interactions occur between the species. It appeared that the kit fox benefited from the interactions, whereas the badger was tolerant of the kit fox during hunting events. In addition, in some situations it may simply be energetically costly or risky for kit foxes and badgers to interact in an antagonistic manner, and

therefore tolerance represents a least-cost pathway (see Johnson, 2010; Broekhuis et al., 2013; Vanak et al., 2013). Kit foxes also benefit from badgers by using badger prey excavations as denning shelters (Cypher 2003), although on our study sites availability of dens does not seem to be a limiting factor on the landscape. In two of the photographic series described above, both species exhibited interest in a common denning complex, with one interaction appearing antagonistic, which might have been the result of the kit fox protecting the den as a resource. Further research is needed to accurately classify the interactions between San Joaquin kit foxes and American badgers in the context of animal behavior theory. Our observations described here provide limited insight into this question.

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SPRING ASSOCIATION AND MICROHABITAT PREFERENCES OF THE COMAL SPRINGS RIFFLE BEETLE (*HETERELMIS COMALENSIS*)

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Abstract—The Comal Springs riffle beetle (*Heterelmis comalensis*) is an endangered species inhabiting springs of the Edwards Aquifer. It is known to exist only in Comal spring in Guadalupe and Comal Counties,