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THE *Journal of Wildlife Rehabilitation* is designed to provide useful information to wildlife rehabilitators and others involved in the care and treatment of native wild species with the ultimate purpose of returning them to the wild. The journal is published by the International Wildlife Rehabilitation Council (IWRC), which invites your comments on this issue. Through this publication, rehabilitation courses offered online and on-site in numerous locations, and its outreach to those in the profession, the IWRC works to disseminate information and improve the quality of the care provided to wildlife.

ON THE COVER:

Eastern cottontail (*Sylvilagus floridanus*) seen in the wild, apparently considering its options.

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LEFT:

Juvenile California condor (*Gymnogyps californianus*), the largest North American land bird, near the South Rim of Grand Canyon National Park.

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DEPARTMENTS

Fostering orphaned pups of endangered San Joaquin kit foxes (*Vulpes macrotis mutica*): three case studies

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ABSTRACT
San Joaquin kit foxes (*Vulpes macrotis mutica*) occur in central California and are endangered due to habitat loss. We describe three case studies in which orphaned pups were fostered in captivity and returned to or provisioned entirely in the wild. In February 1992, six three-week-old pups whose mother had died were recovered and fostered by caregivers until about ten wks of age. Four of these pups were placed in the den of their father and a new female (Case 1). The remaining two pups were placed with a foster kit fox family (Case 2). In April 2019, a mother of five pups was found dead and no other adults were present (Case 3). The pups were left in their natal den and provisioned and monitored. In all cases, rescuers chose courses of action based on the life stage of the pups and resources available for fostering. Among the 11 orphaned pups, at least four survived until the fall, at least two survived until the following breeding season, and at least one successfully reproduced.

KEYWORDS: California, captive rearing, fostering, orphans, San Joaquin kit fox, Vulpes macrotis mutica

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Introduction

Wildlife rehabilitation is the process of caring for orphaned, injured, or sick wildlife with the intention of releasing them back to their natural habitat. There are frequently ethical dilemmas when making the decision to rehabilitate wildlife such as whether or not human intervention is required, whether the animal is treatable and will survive treatment, and if the animal will function normally when released back to its natural habitat.[1] At times, the situation may require euthanasia if the animal cannot be returned to its natural habitat or placed in an accredited facility.[1] This decision becomes more complicated when dealing with endangered species.

The San Joaquin kit fox (*Vulpes macrotis mutica)* is a small canid endemic to the San Joaquin Desert in Central California. San Joaquin kit foxes are Federally listed as Endangered and California listed as Threatened due to habitat loss.[2] Based on habitat modeling within the kit fox's range, there may be as few as 3,000 San Joaquin kit foxes left.[3] It is important to protect remaining individuals as much as possible, so when an orphaned, injured, or sick San Joaquin kit fox is reported, biologists do everything feasible to ensure the animals' successful rehabilitation.

Canids have a period of prolonged dependence on their parents after birth.[4] The mother of a litter is critical for pup survival until they are fully weaned at around eight wks of age.[5] If something happens to the mother after the pups are weaned, it is possible for the father or other family members to provide food for the pups and successfully raise them to dispersal age.[6] If pups do not have adult family members, they likely will perish in the absence of human intervention. Such intervention frequently involves capture and care at a facility. However, often times wildlife raised in captivity are not releasable due to habituation to people or inadequate preparation that prevents them from properly caring for themselves after release.[7] Translocations and reintroductions of wildlife species have varying post-release survival rates between 11–53%.[7]

Furthermore, permanent captivity may not be an optimal option for orphaned San Joaquin kit foxes or other endangered species. A zoo or other facility must have the proper permits to house an endangered species. Also, space may not be available for the animal(s). Thus, keeping individuals in their natural environment or returning them there as soon as possible is preferable to bringing them into long-term captivity.

We describe three case studies involving orphaned San Joaquin kit fox pups. Two cases involved raising pre-weaned pups in captivity and then returning them to the wild and the third case involved providing assistance to post-weaned pups in the wild.

General Methods

The case studies described below were opportunistic efforts that involved rapid decisions and adaptive measures as events unfolded. Thus, these were not formal studies with methods defined a priori. However, there were some methods that were common among the efforts. We trapped foxes with wire-mesh box traps (38 × 38 × 107 cm; Tomahawk Live Trap, Hazelhurst, Wisconsin) that were covered with oiled cloth tarps to guard against the elements. We opened traps at sunset, baited them with various meat-based products, and checked them at sunrise. Captured foxes were coaxed from traps into a cloth bag and manually restrained during handling.

Foxes received VHF radio collars for tracking. The collars used were made by Advanced Telemetry Systems (Isanti, MN) or AVM Instrument Company (Livermore, CA), or were handmade using small mammal transmitters (Lotek Wireless Inc, Newmarket, Canada) glued to belting material. The latter were placed on young pups and the ends of the belting were sewn together with cotton thread to provide a break-away capacity in the event the pups were not recaptured. All collars weighed <3% of fox body weight. All fox trapping, handling, and collaring was consistent with guidelines for the use of wild animals in research established by the American Society of Mammalogists[8] and conducted in accordance with conditions and protocols established in several permits from the U.S. Fish and Wildlife Service and Memoranda of Understanding from the California Department of Fish and Wildlife. Collared foxes were tracked using 2 or 3-element Yagi antennas (Telonics, Mesa, AZ or Advanced Telemetry Systems, Isanti, MN).

Background for Case Studies 1 and 2

In 1992, two ecological studies on San Joaquin kit foxes were in progress in the Elk Hills-Lokern area of western Kern County, California, U.S.A. One study was being conducted by EG&G Energy Measurements (EG&G)[9] and the other was being conducted by the California Energy Commission (CEC).[10] Both studies entailed monitoring radio-collared kit foxes.

On 18 February 1992, an adult female kit fox was found dead, likely killed by a coyote (*Canis latrans*), by EG&G staff. The female was lactating, and a quick necropsy revealed that she had six placental scars on her uterus. The location of the den the female was using was known, and after consulting with the U.S. Fish and Wildlife Service (USFWS) and the California Department of Fish and Game (now the California Department of Fish and Wildlife [CDFW]), the decision was made to excavate the den to determine if pups were present. Later that day, EG&G staff began excavating the den and after approximately an hour of careful digging, they reached a chamber with four small pups.

The pups were immediately transported to Dr. Ted Murphy in Bakersfield, California, U.S.A. Dr. Murphy ran a wildlife rehabilitation facility at the California State University-Bakersfield and had experience working with kit foxes. The pups were approximately 3 wks old (eyes were open, teeth just beginning to emerge) and clearly would not have survived as they were still nursing and dependent upon their now-deceased mother.

The next day, the den was revisited, and additional digging was conducted prior to filling in the excavation. In a deeper chamber at the bottom of the den, two additional pups were found and recovered. These also were immediately transported to Dr. Murphy. The weights of the six pups (three females, three males) ranged from 240–265 g.

Dr. Murphy constructed an artificial den within his home to raise the pups. The den initially consisted of a cardboard box, and as the pups grew, additional interconnected boxes were added. Initially, the pups were fed a milk replacement formula for puppies (Esbilac, PetAg, Hampshire, Illinois, U.S.A.). After a couple of weeks, the pups transitioned to commercial puppy food, and then raw chicken pieces soon followed by dead house mice, and finally live mice. Direct contact with the pups was minimized and dirt and other natural items were added to the den to simulate conditions in a natural den. By the last week of March 1992, the pups all weighed almost 700 g and a plan was formulated for releasing them into the wild.

Prior to release, all of the pups were ear-tagged and fitted with small radio-collars. The collars were small nylon cat collars on which the metal buckle had been replaced with a button. Also, two elastic inserts were incorporated into the collars to allow expansion as the pups grew.

In five locations, the collars were cut and then stitched back together with cotton thread. This thread would deteriorate over

time thereby creating breakaway opportunities if the collars became too tight. Finally, a small VHF transmitter was attached to each collar with dental acrylic. The final weight of the collars was 10–12 g, which was approximately 1.5% of the pups' weight at the time of release. The collars were placed on the pups one week prior to their release to ensure a proper fit and to allow the pups to acclimate to the collars.

Case Study #1: Ex-situ human fostering and reintroduction with a related adult fox

Whereas EG&G staff had been monitoring the mother of the pups before she died, CEC staff had been monitoring an adult male fox that was presumed to be the father of the pups. This male had frequently been tracked to the same den as the mother prior to the birth of the pups. Since the death of the mother and the recovery of the pups, this male had been observed denning with a smaller, uncollared fox that was presumed to be a female and potentially an offspring from a previous litter that had not yet dispersed. Some female young of the year will delay dispersal and remain in their natal range, and these foxes will occasionally inherit that range if their mother dies, as may have happened in this situation.[11] These young foxes also can act as "helpers" and assist the parents in raising the current litter of pups.[12]

Thus, the decision was made to introduce four of the pups (two females, two males) into the den of their biological father and the unknown adult because she was likely a related helper. Only four of the pups were introduced to this den because (1) we were concerned about overwhelming the adult pair, and (2) success was uncertain and we did not want to risk potentially losing all six pups if the adults rejected, abandoned, or mistreated the pups. Therefore, the remaining two pups were introduced into the den of a foster kit fox family (see Case Study #2).

For two consecutive nights prior to release, a male and a female pup were placed in a cage near the den of the father at sunset and observed for approximately two h. On both nights, the father and the uncollared female emerged from the den and investigated the pups in the cage. The pups exhibited excitement at the visits, and the adults exhibited curiosity without any sign of aggression. On the morning of 24 March, the two pups were placed in the den of the adults. A tarp was placed over the opening for 30 minutes to ensure the pups did not immediately run out of the den and become lost. Later that day, pieces of chicken were left outside of the den to ensure that food was available for the pups. The den was observed that evening. The uncollared female was observed eating some of the chicken and then later was observed bringing food items to the den.

The next evening, another male and female pup were placed in a cage outside the den. The female pup released that morning emerged from the den and very excitedly interacted with her litter mates. More chicken was left at the den, and the next morning the two pups that had been caged the night before were released into the den.

During visits to the den in the days following the introduction of the pups, three of the pups were occasionally observed just inside the den entrances. The first of the male pups released was never observed, and the signal from his collar never moved. Although not confirmed, the evidence indicates that this pup likely did not survive and probably died down in the den. Supplemental food continued to be left outside of the den each day. However, by the fourth day (28 March), dead kangaroo rats and kangaroo rat parts (*Dipodomys* sp.) were observed outside of the den indicating that one or both adults were bringing prey items that the pups were consuming. Supplementation was discontinued after 10 April.

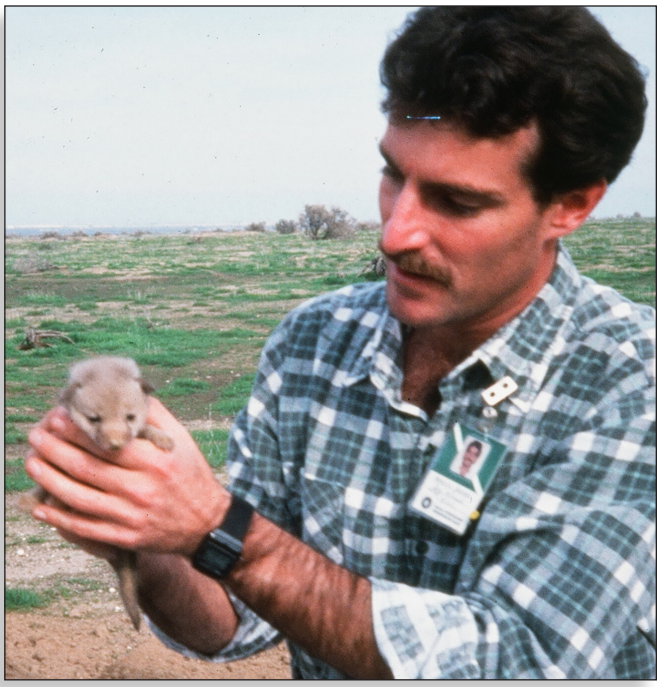

FIGURE 1. Greg Warrick of EG&G with one of the orphaned pups recovered during excavation of a natal den in the Lokern area, California, U.S.A. 18 February 1992 (photo by B. Cypher).

The second male pup was recaptured on 12 May and fitted with an adult-sized radio-collar with room for growth. This pup continued to den with the adult foxes although it occasionally denned alone, which is common for young of the year as they increasingly become more independent. This fox was found dead on 2 October and appeared to have been killed by a coyote. He was found 3.5 km from his reintroduction site and may have been in the process of dispersing when he died. Mortality rates are high among dispersing individuals because they are unfamiliar with den locations outside of their natal home range.[11]

The two female pups continued to be monitored for approximately 35 days until their transmitter batteries expired (end of May). Despite attempts, the pups were not recaptured to recollar them, and therefore their final fate was unknown.

Case Study #2: Ex-situ human fostering and release with unrelated adult foxes

CEC staff had been subsequently monitoring another adult female kit fox who was mated with an uncollared male. This pair had produced a litter of two pups (average litter size for kit foxes is

approximately four).[13] The decision was made to introduce the remaining two orphaned pups (one female, one male) into the natal den of this family group with the hope that they would successfully foster the pups.

Just before sunset on 1 April, the remaining two pups were placed in a cage outside of the den occupied by the radio-collared adult female of the foster family. The female exited the den around sunset but did not investigate the cage with the pups. Her pups were observed at a den approximately 100 m from this den. In the morning on 2 April, the two orphaned pups were placed in the den occupied by the resident pups. All pups remained in the den. That evening, biologists observed all four pups playing together, suggesting that the resident pups had accepted the orphaned pups. Supplemental food was left at this den each day until 10 April as natural prey remains found at the den indicated that the adult foxes were provisioning all of the pups.

The male pup was recaptured on 30 July and fitted with an adult radio-collar. He continued denning with his biological sister and the foster parents. He made an exploratory dispersal movement of 6 km on 7 October and returned to his original home range on 14 October. His signal could not be found after 27 October. On 29 April 1993, his signal was detected in an inaccessible area during an aerial search for missing radio-collared foxes. However, he was detected again on 9 July 1993 and tracked to a den 23 km from his release site. He had dispersed and appeared to have established a new home range. It is unknown whether he ever paired with a female and reproduced. Monitoring ended in August 1993 and no further information was available on this fox.

The female pup was recaptured on 25 May 1992 and fitted with an adult radio-collar. She was occasionally found denning alone and sometimes denning with one or both foster parents. She eventually established a home range that overlapped her natal range and was observed denning with an untagged fox presumed to be a male. On 10 March 1993, at least 5 pups were observed at the den of this female. Two of these pups were eventually captured and tagged. This female was still alive when monitoring ended in September of 1993. Later that year, one of her tagged pups was captured by EG&G staff approximately 10.5 km from his natal area and presumably had dispersed.

Case Study #3: In-situ human fostering

An urban population of San Joaquin kit foxes resides in Bakersfield, California, U.S.A. On 10 April 2019, multiple members of the public contacted both the Endangered Species Recovery Program (ESRP) and CDFW to report a dead fox near the northeastern edge of town and a nearby den with a litter of pups. ESRP staff examined the carcass and determined the fox was a lactating female that had died from a vehicle strike. The active natal den was easily located in an empty field near where the mother had died. A motion-sensing infrared camera was deployed at the den in order to determine if any other adult foxes were present. The next morning the camera showed that there were five pups, but no other adult foxes had visited the den. After two more nights of monitoring, it was clear that the pups had no adult to care for them. After consultation with CDFW and USFWS staff, the decision was made to attempt to supplementally feed the pups at the den. This decision was based on the fact that the pups appeared old enough to consume solid foods and that leaving the pups in place would provide a more natural rearing environment.

The natal den was monitored via field cameras every day from 10 April to 3 December. The cameras were checked daily with the intent to trap and capture the pups if any of them did not appear healthy. To prevent the pups from becoming habituated to humans, food was always deposited at the den before sunset when the pups were in the den. Each day, approximately 3 cups of high protein puppy kibble (Purina Pro Plan Savor Puppy shredded blend) was distributed inside the den entrances so as not to attract predators to the den area and to avoid consumption by other animals (e.g., ground squirrels, birds). The den was visited daily, and kibble was provided if the previous amount had been consumed. After a couple of weeks, thawed frozen feeder mice and rats (five per night) were hidden around the den area in the grass with the hopes of developing foraging and hunting behavior in the pups. Occasionally, raw eggs and cactus pads were provided for additional moisture. As the pups grew older, the food items were hidden farther and farther from the den to improve the pups' foraging skills.

The pups gradually expanded their movements and explorations, and they were documented using at least seven different dens during the monitoring. Within 11 days of the initiation of supplemental feeding, prey remains began appearing at the dens used by the pups. These included multiple California ground squirrel (*Otospermophilus beecheyi*) remains, a Pacific gopher snake (*Pituophis catenifer catenifer*), and some mourning dove (*Zenaida macroura*) feather piles. A pup with an unidentified prey item was detected on day 17 and a pup with a desert cottontail (*Sylvilagus audubonii*) was observed shortly after that. Soon, there were multiple detections on the cameras of the pups with natural prey including invertebrates, cottontails, ground squirrels, and birds as well as occasional anthropogenic food items (Fig. 2).

After 14 days of supplemental feeding, all five pups were no longer observed simultaneously on camera, and after 19 days only three pups were consistently seen. The three pups were trapped in late May to conduct health checks and mark them with a permanent non-toxic dye (Nyanzol-D) so that individuals could be identified on camera (Fig. 3). Sex, weight, and the unique dye mark was recorded for each pup. All three pups appeared healthy. The average weight of the one male and two females was 1.55 kg, which was comparable to other urban pups captured within two weeks of the same age (1.36 kg, n=16; ESRP unpublished data). No unmarked pups were detected on camera after the trapping and their fate is unknown. They may have died or dispersed early.

The final three pups survived for a minimum of 95 days at which point the male stopped appearing on camera after 14 July. While his final fate is unknown, it is believed that he may have dispersed at this time because males tend to disperse earlier than females.[14] The remaining two females were observed on camera

FIGURE 2. San Joaquin kit fox (*Vulpes macrotis mutica*) with a desert cottontail (*Sylvilagus audubonii*), Bakersfield, California, U.S.A. in May 2019.

until 12 August (124 days) and 2 November (206 days), respectively, after which their fate is unknown.

During monitoring, adult foxes were observed visiting the pups on three occasions. In two instances, the foxes apparently were just passing through and did not interact with the pups. The third instance was captured on video and pups were present. The adult fox had collected an egg left for the pups and the pups swarmed it. The adult was startled and backed away from the pups before leaving. The den was also visited by coyotes, domestic dogs (*Canis familiaris*), and an American badger (*Taxidea taxus*). The first coyote detections occurred in July but were infrequent. Coyote visitations increased in frequency after October.

Discussion

The three case studies describe different approaches to assisting orphaned San Joaquin kit fox pups. The second case study is perhaps the most unusual in that pups were fostered with a family that was completely unrelated. Adoption of pups by related family members or by unrelated individuals that are part of the social group from which the pups came is fairly common among canids.[15] However, rates of adoption by unrelated adults that were

FIGURE 3. San Joaquin kit fox (*Vulpes macrotis mutica*) pups with dye markings at a den in Bakersfield, California, U.S.A. in 2019.

not part of the pups' social group is unknown, although it has been documented in red foxes[16] and has commonly been used as a conservation strategy for red wolves (*Canis rufus*).[17] Fostering with related or unrelated groups may improve survival of the orphaned pups. Survival of red fox pups fostered by humans and then simply released was quite low.[18]

In all three cases, one or more of the pups survived to June when they typically become independent of their parents and some even begin to disperse from their natal range.[11] Survival of young of the year typically is low. In the Elk Hills study, mean annual survival of pups from 1 May to the following 15 February (presumptive birth date) was only 14%.[8] Among the 11 pups in the three case studies, a minimum of four (36%) survived until the fall and a minimum of two (18%) survived until the following breeding season with successful reproduction confirmed for one.

In the first two case studies, the pups had the advantage of being able to learn from adult foxes how to find food and dens, elude predators, and other life skills. The pups fostered in-situ did not have this advantage. However, the prey remains found at the den and the camera images of the pups carrying prey indicated that they were developing natural hunting behaviors even in the absence of a parent.

Less certain is how well they learned to avoid predators. They may have learned some amount of avoidance from their mother before she died, and some of this behavior likely is innate. Coyotes and domestic dogs were likely the main predators of concern at this peri-urban location. Other natural behaviors were observed as well. Over the course of the monitoring, the kit fox pups switched dens multiple times. This commonly occurs when pups are present because flea populations will build up in the natal den. Typically, the parents will move the pups to a new den when the flea load becomes unbearable. Without the presence of an adult, the pups still used at least seven dens located in the field where they were born, which may have been an instinctive response to being overwhelmed with fleas.

Across the cases, factors that likely contributed to success included remaining and interacting with litter mates, quickly being transitioned to natural foods, innate predator avoidance, minimal contact with humans, and not prematurely dispersing.[19] In the first two cases, the pups also benefitted from interactions with adult foxes that likely provided training. Behavioral plasticity on the part of the foxes also helped immensely including eating non-natural foods (e.g., puppy chow), tolerating some handling and human presence, and an ability to accept and build relationships with unrelated individuals. Caring for orphaned young and returning them to the wild is always challenging and time-consuming, regardless of the approach. We described three approaches that had some success with orphaned kit fox pups. Others are likely possible as well.

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Greg Warrick is a Regional Preserve Manager with the Center for Natural Lands Management where he oversees the management of approximately 50,000 acres of conservation lands in central California. Greg has been involved in research and management of kit foxes and other species in central California since 1987.

Linda Spiegel is an Environmental Scientist with the California Energy Commission. Linda conducted several research projects on San Joaquin kit foxes and other rare species in the southern San Joaquin Valley of California.