

A potential predator-prey interaction of an American badger and an Agassiz's desert tortoise with a review of badger predation on turtles

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The federally threatened Agassiz's desert tortoise (*Gopherus agassizii*) was listed under the U.S. Endangered Species Act in 1990, but thus far, recovery efforts have been unsuccessful (U.S. Fish and Wildlife Service [USFWS] 2015). Predation has been identified as a contributing factor to declining *G. agassizii* populations range-wide (e.g., Esque et al. 2010, Lovich et al. 2014). Understanding and managing for predator-prey dynamics is thus an important part of the recovery and conservation of this threatened species (USFWS 2011). Desert tortoises have a host of predators at all stages of their life cycle. Over 20 species of birds, mammals, and reptiles have been recorded as known or suspected predators (Woodbury and Hardy 1948, Luckenbach 1982, Ernst and Lovich 2009). American badgers (*Taxidea taxus*, family: Mustelidae) are confirmed excavators of desert tortoise nests (Turner and Berry 1984). They are also suspected predators of adult desert tortoises, a possibility which has been presented in some studies but without empirical verification (Luckenbach 1982, Turner and Berry 1984). Active mostly at night, badgers are solitary, secretive predators (Lindzey 1978, 1982; Armitage 2004) that are extremely difficult to observe in predatory encounters. Recently, strong circumstantial evidence presented by Emblidge et al. (2015) suggests that badgers do prey on adult Agassiz's desert tortoises based on observations of more than two dozen dead tortoises in the Western Mojave Desert of California. In this note, we present another case of potential badger predation on a large adult desert tortoise in the Sonoran Desert of California. Collectively, these recent two cases potentially indicate that badger predation may be more common and widespread than previously thought. In

addition, we review the worldwide literature of badger predation on turtles in general and summarize reported badger observations in Joshua Tree National Park, where our observation occurred, over a period of 55 years.

We initiated research on tortoise demography and reproduction in the vicinity of the southern Cottonwood Mountains of Joshua Tree National Park in March 2015. This area is characterized by gently sloping bajadas to the south and steep hills and boulder piles to the north. Vegetation at the study site is typical of Sonoran Desert plant communities with creosote scrub (*Larrea tridentata*) on the bajadas interspersed with ironwood (*Olneya tesota*), blue palo verde trees (*Parkinsonia florida*), and ocotillos (*Fouquieria splendens*). During our surveys on 1 April 2015, we found one of the two largest tortoises in our marked population—a large (29.6 cm carapace length, 5,000 g) and outwardly healthy male *G. agassizii*—and marked it for future identification. No signs of physical distress or upper respiratory tract disease (URTD) were observed in this tortoise or any other tortoise in the population. The tortoise was in the mouth of a burrow under the caliche layer in a large wash that curves around a southern toe of the Cottonwood Mountains at an elevation of 639 m. The wash contained scat from coyotes (*Canis latrans*) and bobcats (*Lynx rufus*) and had many mammal tracks. On 13 April 2015, we found the same tortoise dead (Figure 1) approximately 80 m from the point of first capture and 4–5 m away from another burrow that it had presumably used at some time, which we concluded from the burrow's well-maintained appearance, lack of cobwebs or debris, presence of tortoise tracks, and a large size and shape consistent with the dead tortoise. No animal tracks or sign were otherwise observed near the dead tortoise. The carcass was overturned onto its carapace with the limbs intact and the head nearly severed from the neck. There was a small hole in the left inguinal pocket through which the tortoise had been eviscerated as intestines were pulled



FIGURE 1.—Adult male *Gopherus agassizii* as found dead in southern Joshua Tree National Park on 13 April 2015. The tortoise was eviscerated through the left rear limb pocket and the neck was nearly severed, implicating the American badger (*Taxidea taxus*) as the predator. Intestines can be seen in the foreground.

away from the body. No tooth marks, scratches, or punctures were observed on the shell or limbs. We concluded that death occurred recently, possibly within 24 hours of discovery, based upon the presence of tacky blood on the carcass and lack of a strong decomposition odor or insects. The recent death of an overtly healthy tortoise would suggest injuries were due to predation as opposed to scavenging. Additionally, scavengers are likely to break or crack bones and scutes as they dry following the death of a tortoise (Berry et al. 2013), which we did not observe.

We were puzzled by the fact that the limbs of the carcass were intact because common predators like coyotes, foxes, and bobcats would be expected to injure or consume these muscle-rich parts of adult tortoises (Woodbury and Hardy 1948, Peterson 1994). This was the first time since we started conducting research in the park in 1997 (Lovich et al. 1999) that we observed a tortoise killed in this manner. Common canid and felid predators are known to chew and scratch tortoise shells, even breaking parts of the shell bones and scutes in the process (Coombs 1977, Peterson 1994, Lovich et al. 2014), but none of those characteristics were noted. Esque et al. (2010) identified coyote predation in the Mojave Desert by looking at two common features among carcasses—bite or chew marks on the shell and limbs of desert tortoises and tracks surrounding the carcasses. Additionally, Esque et al. observed higher mortality rates of smaller adult tortoises within their population that they hypothesized were due to the limited gape of a coyote in relation to tortoise body size. The mountain lion (*Puma concolor*), a less common carnivore in Joshua Tree National Park, is also known to leave teeth marks and puncture wounds on tortoise shells, or even remove large portions of the shell (Medica and Greger 2009, Riedle et al. 2010, Medica et al. 2012). Another potential predator of desert tortoises, the feral dog (*Canis lupus familiaris*) (Boyer and Boyer 2006; Berry et al. 2013, 2014), is not known to inhabit our study area. Common ravens (*Corvus corax*), a highly visible predator of juvenile and immature desert tortoises (Berry et al. 2016), are observed infrequently at our study site. Ravens are less known as predators of adult desert tortoises, but they have been observed attacking adult desert tortoises in the Mojave Desert on a few occasions (Woodman et al. 2013). The attacks resulted in injuries that differ from what we observed. Woodman et al. found tortoises overturned onto their carapaces (the mechanism by which this occurred was not seen), and injuries were observed only in the cloacal region above the tail.

Following the consideration of potential predators but finding little in common with our observations, it was suggested that the tortoise may have been killed by an American badger (R. Averill-Murray, Desert Tortoise Recovery Office, USFWS, personal communication). As a result, we were directed to the research of Emblidge et al. (2015) who recently documented a case of suspected badger predation on a desert tortoise population in the Mojave Desert. Their observations included 27 tortoise carcasses over a period of two years which shared many similarities with ours. Emblidge et al. found tortoise carcasses overturned onto their carapace. They describe their suspected badger kills as characteristically eviscerated through a prefemoral socket with limbs remaining intact. Heads were often removed completely, but occasionally were left incompletely severed. None of their carcasses displayed scratch or chew marks on the shell, and were often found inside or nearby tortoise burrows.

Badgers were not directly observed killing or eating tortoises in the Emblidge et al. (2015) study. However, the use of camera trapping strongly implicated badgers in the deaths of the tortoises. Photo sequences in the Emblidge et al. study showed badgers investigating or digging at tortoise burrow entrances where tortoises were recently observed alive, or

following in the direction of tortoises. The tortoises were later found dead. The similarity of conditions for carcasses observed by Emblidge et al. and our observation suggested that a badger was also the predator at Joshua Tree National Park.

In an effort to determine if a badger was the potential predator of the tortoise in our study, two trail cameras were placed in pinch points of the wash on 29 April 2015, just above the dead tortoise's burrow at first capture. After two months with no carnivore activity captured on camera, the camera angles were adjusted on 15 June 2015 to provide a wider view of the ground. On 27 June 2015, 75 days after the tortoise carcass was found, a badger was photographed by the trail camera (Figure 2). It was walking down the wash,



FIGURE 2.—An American badger (*Taxidea taxus*) photographed by a trail camera on 27 June 2015 in southern Joshua Tree National Park near the site where the tortoise carcass displayed in Figure 1 was discovered.

toward the former burrow of the dead tortoise. At the time the badger was captured on camera, the tortoise carcass remained at the location where it was discovered. The carcass was completely mummified and was missing additional anatomical parts since its initial discovery: three appendages, the head, and the eviscerated intestines. It is unlikely that the mummified carcass would have attracted the badger to the area. No other potential predators, mammalian or avian, were captured on camera during the time it was deployed. The camera trap was located approximately 80 m linear distance up the wash from the known tortoise burrow, and the carcass was discovered another 86 m linear distance down the wash from the burrow (a total linear distance of 160 m from camera trap to carcass).

Miller and Stebbins (1964) noted that, while the climate and environment in Joshua Tree National Park were suitable for badgers, they are not found in great numbers in the

park. However, Luckenbach (1982) stated that badgers are more common in the California desert than is generally recognized. This latter statement is supported by records of reported wildlife sightings maintained by staff at Joshua Tree National Park. Between 1960 and 2015 there were at least 90 reported badger sightings (both young and adults) throughout the park, including in the Cottonwood area, and occasionally sightings were of two to three badgers at once (Figure 3). It is not known how many sightings in contiguous years were of the same individual badger, but given the numbers reported from throughout the park, badgers are not necessarily rare or localized in the park.

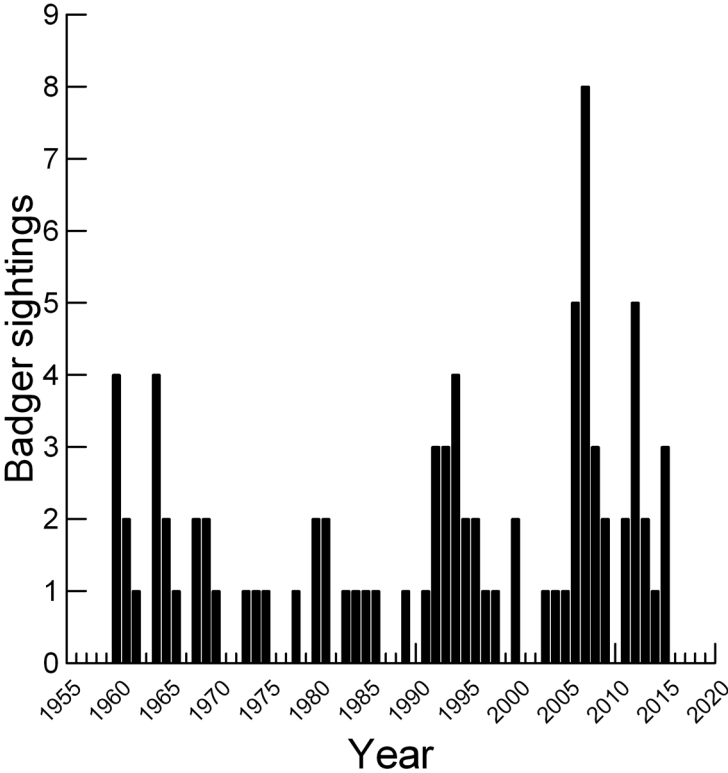


FIGURE 3.—The number of badger sightings reported per year in Joshua Tree National Park for the years indicated. Data are from a database maintained by the Park, and encompass sightings from all areas of the park which includes sightings in the Cottonwood area. A very small number of sightings involved 2-3 badgers at once, possibly of females with young.

The American badger diet in non-desert ecosystems is mostly fossorial or semi-fossorial mammalian species (biomass 95.4%), with the second highest portion comprised of reptilian prey (biomass 3.9%) (Lampe 1982, Marti et al. 1993). However, some studies indicate that reptiles are a larger part of predator diet in desert ecosystems than in prairie or other regions (Delibes and Hiraldo 1987, Hernández et al. 1994). The preferred prey of badgers includes ground squirrels (previously *Spermophilus* spp., but see Helgen et al. 2009) and prairie dogs (*Cynomys* spp.) (Snead and Hendrickson 1942, Messick and Hornocker 1981, Goodrich and Buskirk 1998), only the former of which (including three species: whitetail antelope squirrel [*Ammospermophilus leucurus*], California ground

squirrel [*Otospermophilus beecheyi*], and round-tailed ground squirrel [*Xerospermophilus tereticaudus*] occurs in Joshua Tree National Park.

In non-desert ecosystems, badgers forage opportunistically, and can have a widely varied diet depending on the availability and abundance of local prey (Lampe 1982). If ground squirrels are not available, badgers will switch to alternative sources, including birds, eggs, reptiles, amphibians, or even plant material (Verts and Carraway 1998). This prey-switching in carnivores can occur during periods of persistent drought when low rainfall causes a reduction in prey populations (Woodbury and Hardy 1948, Chew and Butterworth 1964, Kenagy and Bartholomew 1985, Prugh 2005). Desert rodent populations are influenced by winter precipitation rates and show declines following 10-12 months of low rainfall (Beatley 1976, Whitford 1976, Dickman et al. 1999). Prey-switching response in coyotes from rodents and lagomorphs to tortoises has previously been documented in Joshua Tree National Park and other parts of the Mojave Desert (Peterson 1994, Esque et al. 2010, Lovich et al. 2014), and may be occurring in badgers as well. Precipitation rates at Joshua Tree National Park were at historic lows at the time of our observations due to protracted drought in California (Mann and Gleick 2015). Our study area in the Park was categorized as being in a Severe Drought during the entire 12 months preceding the initiation of our study, and remained in this category during the entirety of the tortoise activity season of 2015 (USDM 2016). Switching from favored prey as it becomes less available has been documented in badgers (Messick and Hornocker 1981), but whether or not the drought conditions caused the suspected badger to prey upon the tortoise is unknown.

Badgers capture their prey by cornering them underground and digging at the entrance (Coulombe 1971), although they occasionally catch prey above ground (Sawyer 1925). Badger presence can be confidently inferred from the existence of extensive diggings at burrow sites of prey items, such as with the removal of large rocks and excavation of burrows (Long and Killingley 1983, Desmond et al. 2000, Armitage 2004, Eldridge 2004). Both of these characteristics were exhibited in a maze of tunnels and excavations occurring in the area around the former burrow of the dead tortoise (Figure 4). Searches for these types of badger sign yield a higher likelihood of detecting badger presence than camera trapping, and therefore it is one of the most useful ways to determine badger presence (Harrison 2015). In conjunction with such diggings, another indicator of badger presence is the decapitation or partial decapitation (Emblidge et al. 2015) of their prey. For example, badgers are known to decapitate prairie dogs, and then consume the entirety of the animal except the head and dorsal fur (Lindzey 1994). Armitage (2004) noted a few marmot (*Marmota flaviventris*) mortalities attributed to badgers in which only the head of the marmot was later discovered.

Uniquely, all suspected badger predation events on desert tortoises described by Emblidge et al. (2015) and this study report evisceration while the limbs remained untouched. It is possible that the armoring provided by the antebrachial scales on the front legs of tortoises are an impediment to badgers, but that seems unlikely since other predators such as coyotes are capable of consuming these portions of a tortoise (Peterson 1994, Lovich et al. 2014). The method of predation observed by Emblidge et al. and this study could also be related to available nutrients and water content of differing portions of the tortoise. According to the United States Department of Agriculture Nutrient Data Laboratory (2015), the internal organs of livestock animals contain a higher content of vitamins and most minerals, as well as slightly higher water content than the same amount of animal muscle tissue. It is possible that, due to lack of available water, a badger may consume only the parts of the tortoise



FIGURE 4.—Cut bank in the wash adjacent to where the desert tortoise carcass shown in Figure 1 was discovered. Note extensive excavations under the caliche layer of the soil horizon attributed largely to a badger digging to excavate rodent prey. When first captured alive, the male desert tortoise was using one of the burrows (not shown) in the same bank, and he may have enlarged some of the holes started by the badger. Overburden above excavations ranges from 0.5 - 1.0 m in thickness.

highest in nutrients and water content (internal organs), including the bi-lobed bladder of a tortoise (located just inside the inguinal area where our tortoise was eviscerated) which acts as a reservoir for water (Nagy 1988), and leave less nutritious parts of the tortoise which would require investment of water to digest with a lesser return in nutritional value. It's possible the tortoise was overturned onto its carapace in order for a badger to facilitate access to this area. While bladder contents of tortoises may be distasteful to some predators (e.g., kit fox [*Vulpes macrotis*], Patterson 1971), this may not act as a deterrent during drought conditions. Additionally, badgers might decapitate their tortoise prey in order to easily drink blood, which would provide another means of water intake.

Badgers of various species have been documented as predators of adult turtles for roughly 123,000 years (Kahlke et al. 2015) as detailed in Table 1. Although badgers in the genera *Meles*, *Taxidea*, and *Mellivora* are not closely related, their general ecomorphological convergence allows them all to be occasional predators of turtles (Koepfli et al. 2008). Although the published literature on this poorly documented predator-prey interaction is scarce, there is at least one account of an American badger carrying off an adult ornate box turtle (*Terrapene ornata*) in its mouth (Legler 1960). In a study by Lloyd and Stadler (1998) in South Africa, honey badgers (*Mellivora capensis*) were indicated as predators of

TABLE 1.—Citations of American, European, and honey badgers as predators of turtles and tortoises. Only citations with direct evidence of badger predation or strong evidence of the possibility of badger predation are included. There are many references in which predation by badgers, especially on turtle or tortoise nests, is speculated or listed based only on the fact that the area is within the distribution of a certain species of badger.

Turtle/Tortoise Species	Badger Species	Citation	Comments
Hermann's Tortoise (<i>Testudo hermanni</i>)	European badger (<i>Meles meles</i>)	Swingland & Stubbs 1985	Documented nest predation in the south of France
		Bertolero et al. 2007	Documented predation on at least one adult in the western Mediterranean
European Pond Turtle (<i>Emys orbicularis</i>)	European badger (<i>Meles meles</i>)	Kahlke et al. 2015	Dates predation on adults to the Eemian interglacial period
		Mosimann & Cadi 2004	Documented predation upon nests and hatchlings in Switzerland
Pond Slider (<i>Trachemys scripta</i>)	European badger (<i>Meles meles</i>)	Mosimann & Cadi 2004	Predation upon nests and hatchlings of introduced red-eared sliders in Switzerland
Loggerhead Sea Turtle (<i>Caretta caretta</i>)	European badger (<i>Meles meles</i>)	Durmus et al. 2013	Badgers and foxes depredated 58.1% of eggs studied over one year on Dalyan Beach, Turkey
		Türkozan & Yilmaz 2008	Depredated 7% of eggs studied over one year on Dalyan Beach, Turkey
		Baskale & Kaska 2005	Five sea turtle nests on Dalyan Beach, Turkey depredated over the period of one year
Green Sea Turtle (<i>Chelonia mydas</i>)	European badger (<i>Meles meles</i>)	Yilmaz et al. 2015	Depredated 0.6% of green turtle nests over a period of six years on Akyatan Beach, Turkey
	Honey badger (<i>Mellivora capensis</i>)	West 2009	Depredated nests on multiple beaches in Tanzania
		West 2010	High levels of nest predation in the Temeke District of Tanzania
Tent Tortoise (<i>Psammobates tentorius</i>)	Honey badger (<i>Mellivora capensis</i>)	Lloyd & Stadler 1998	Strong evidence of predation on adults based on unique method of killing paired with tracks at fresh tortoise carcasses
Ornate Box Turtle (<i>Terrapene ornata</i>)	American badger (<i>Taxidea taxus</i>)	Legler 1960	Observed badger carrying off an adult turtle in its mouth
Painted Turtle (<i>Chrysemys picta</i>)	American badger (<i>Taxidea taxus</i>)	Platt et al. 2009	Observed badger excavating painted turtle nest in southwestern South Dakota
		Lampe 1982	Found evidence of <i>Chrysemys</i> eggs in badger scat in east central Minnesota
		Errington 1937	Found evidence of <i>Chrysemys</i> eggs in badger scat in northwestern Iowa
Agassiz's Desert Tortoise (<i>Gopherus agassizii</i>)	American badger (<i>Taxidea taxus</i>)	Emblidge et al. 2015	Strong evidence of predation on adults based on unique method of killing paired with camera trap documentation
		Turner & Berry 1984	Nests: Excavated by badgers in at least four cases Juveniles/ Adults: Deduced predation from indirect signs of badger presence/ abundance (e.g. scats, burrows)
Unidentified	American badger (<i>Taxidea taxus</i>)	Sovada et al. 1999	Found evidence of turtle eggs in badger gastrointestinal tract
		Lampe 1982	Found evidence of turtle eggs (<i>Chelydra</i> or <i>Chrysemys</i>) in badger scats and stomach contents

the tent tortoise (*Psammobates tentorius*) after discovering many tortoise carcasses killed in a unique and similar manner. Anterior plastrons were ripped away from the body, but there was no evidence of tooth marks on the removed portion or any other part of the shell - a characteristic similar to that found in both our and Emblidge et al.'s (2015) studies. This indicated the predator had the capability to pull apart a shell using only the strength and force from its forelimbs and without chewing or biting. Additionally, badger tracks were present near a fresh tortoise carcass killed in this manner. European badgers (*Meles meles*) were identified as predators of adult European pond turtles (*Emys orbicularis*) based on microstratigraphic fossil evidence from Germany. Similar to modern badgers, prehistoric badgers killed the turtle by biting the head and then opening the carcass from the posterior portion of the shell (Kahlke et al. 2015). These accounts, along with additional references detailed in Table 1, establish badgers from three genera as predators of all life stages of turtles. Our observation, coupled with the photographic evidence and report of Emblidge et al. (2015), suggest that modern badgers continue to be periodic predators of large adult desert tortoises. With so many tortoise deaths attributed to badgers in their study, Emblidge et al. (2015) noted that a single American badger has the potential for substantial impacts on *G. agassizii* populations. Similarly, Bertolero et al. (2007) found that a single event of European badger predation on an adult Hermann's tortoise in one year reduced survivorship of a population of reintroduced tortoises significantly in comparison to other years. Lloyd and Stadler (1998) also found substantial predation on tent tortoises (31 shells) attributed to honey badgers in South Africa which totaled 49% of all shells and carcasses found over a period of four years. Ironically, American badgers have also been documented to cohabitate with *G. agassizii* with no predatory behavior (Germano and Perry 2012), suggesting that tortoises are not a preferred prey item but may be killed opportunistically or during times of stress.

We strongly suspect, but cannot confirm, that the tortoise we observed was killed by an American badger based on three lines of supporting evidence: 1) the tortoise exhibited signs of mortality consistent with other reports of potential predation by a badger, 2) signs of badger excavations were abundant in the area, and 3) a badger was the only potential predator subsequently photographed by a trail camera in the vicinity of the dead tortoise. Although the evidence appears to indicate badger predation, we approach this conclusion with caution and note that further research on the enigmatic predator-prey relationship of the desert tortoise and the American badger is needed. If correct, our conclusion suggests that occasional badger predation of tortoises is more widespread than is generally appreciated, and our review of badger predation on turtles worldwide supports that conclusion. Understanding predator-prey relationships as well as the effects of climate change on these relationships is an important component in the conservation of the desert tortoise. Currently, there is a paucity of information on interactions between desert tortoises and badgers, indicating that the ecology of these predators and their potential effects on desert tortoise populations in the desert ecosystems of the southwestern United States is understudied.

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