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THE NEGATIVE EFFECTS OF BARRIER FENCING ON THE DESERT TORTOISE (*GOPHERUS AGASSIZII*) AND NON-TARGET SPECIES: IS THERE ROOM FOR IMPROVEMENT?

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ABSTRACT: Barrier fences have been installed along roadsides in many parts of the Mojave Desert to protect the threatened Desert Tortoise (*Gopherus agassizii*) and other wildlife species from being killed by vehicles. Many studies have shown that these fences effectively protect not only the tortoises, but many other small vertebrates, as well. Some species, occasionally including the desert tortoise, manage to get across the barrier fences and, if not killed by collision with a vehicle, remain trapped in the small shoulder area next to the roads. We report several observations made in the Red Cliffs Desert Reserve near St. George, Utah, of reptiles that had been trapped by barrier fences. We make suggestions on how to improve the current design of tortoise barrier fences to avoid accidental entrapment and death.

Key Words: Road-kill mortality; Conservation; Desert Tortoise; Tortoise Fencing; Mojave Desert

INTRODUCTION

Because it is impractical, if not impossible, to manage for all species that reside in a given habitat, conservationists often seek to protect an umbrella species, which, at the same time, protects many other species inhabiting the ecosystem (Roberge and Angelstam 2004). Many broad-scale ecosystem management plans have adopted the Desert Tortoise (*Gopherus agassizii*) as an umbrella species for the protection of endangered Mojave Desert ecosystems (USFWS 2008). Since Mojave populations of the Desert Tortoise were federally listed as a threatened species in 1990, several protective measures have been put in place, including the establishment of numerous reserves (Keough and Blahna 2006).

According to the U.S. Fish and Wildlife Service Desert Tortoise Recovery Plan, the majority of threats to the survival of the Desert Tortoise can be linked to human activities (Tracy et al. 2005). Increased urban development in the Mojave Desert has led to the decline of tortoise populations in many ways. In addition to the destruction of tortoise habitat for housing developments, human activities have increased the presence of the Common Raven (*Covus corax*), one of the main predators of young tortoises (Boarman 2003).

As the human population has increased in the desert southwest, the numbers of roads, as well as the density of traffic on the existing roads, has also increased. These roads have become one of the foremost factors contributing to the decline in tortoise populations (Boarman 2002). Tortoises are attracted to roadsides for foraging because rainwater runoff allows for increased diversity and productivity of vegetation (Johnson et al. 1975). Roadsides are also attractive to other reptiles and amphibians because the increased vegetation provides cover and habitat for insects; we have observed many amphibians and reptiles foraging along roadsides. The attractiveness of roadsides puts tortoises and other animals at risk both from vehicles and predators (Boarman et al. 1997). Tortoise population densities show a drastic reduction within at least 400 m of roads (Boarman and Sazaki 2004). Similar patterns have been found in populations of snakes near roads (Rudolph et al. 1999). Although it is difficult to determine the cause of these depression zones, the large number of road-killed animals in or near the study sites suggests road-kill mortality is a major factor.

Many studies have investigated ways to reduce the road-kill mortality on tortoises and other organisms (e.g., Sazaki et al. 1994, Dodd et al. 2004). Dodd et al. (2004) found that the presence of barrier fences along a highway in Florida reduced the vertebrate mortality by 65–93%. Barrier fencing described by Boarman et al. (1997) has been very effective in reducing road-kill

deaths of tortoises (Boarman and Sazaki 1996). In fact, fenced sections of highways were shown to have 93% fewer tortoise carcasses and 88% fewer carcasses of other vertebrates than non-fenced sections (Borman and Sazaki 1996).

Although barrier fences are obviously effective at preventing vertebrate road-kill deaths, the fact that tortoises, as well as other vertebrates, are still being killed by vehicles suggests that there is room for improvement. Additionally, barrier fences have occasionally been problematic for some organisms. Boarman (1994) reported that, during surveys, five other reptiles were commonly found by the fence: the Leopard Lizard (*Gambelia wislizenii*), Zebra-tailed Lizard (*Callisaurus draconoides*), Mojave Rattlesnake (*Crotalus scutulatus*), Coachwhip Snake (*Masticophis flagellum*), and Western Whiptail Lizard (*Aspidoscelis tigris*). He reported that these reptiles were found climbing over, running through, or getting caught in the fence. Lahti and O'Donnell (2008) reported finding a dead Texas Horned Lizard (*Phrynosoma cornutum*) that had been trapped between overlapping sections of a hardware-cloth fence that was structurally similar to a tortoise fence. Engeman and Pipas (2004) reported that remains of the Texas Tortoise (*Gopherus berlandieri*) were commonly found on ranches in Texas near roadsides and along fences, where they apparently became entangled in the hardware cloth along the bottom of the fence. Furthermore, improperly installed or unmaintained barrier fences often develop gaps or holes that allow access to the road.

Despite the general effectiveness of barrier fences, some aspects of their design could be altered to make them better, especially in areas where constant maintenance is not possible. Here we report some observations and suggest minor alterations that could be made to the current system of barrier fencing that may help to protect multiple desert-dwelling organisms, both from road-kill deaths, and from entanglement.

METHODS

We made observations in and around the Red Cliffs Desert Reserve (RCDR) in St. George, Washington County, Utah, USA. The RCDR is one of 14 reserves established by the Desert Tortoise Recovery Plan to protect the Desert Tortoise and the diverse Mojave Desert biota (U.S. Fish and Wildlife Service 1994). The RCDR houses the northernmost populations of the Desert Tortoise and many other reptiles and amphibians that are restricted to hot desert environments (Oliver 1998). Three distinct desert habitats can be found in the reserve: the Mojave Desert in the low elevation areas, the Great Basin Desert in the higher elevations, and the Colorado Plateau in several areas. The variety of habitats in the RCDR enables a diverse reptile fauna to thrive there.

Several roads cross reserve boundaries, including an Interstate Highway (I-15), multiple state and county highways, and several dirt or gravel roads. All of the major roads, as well as many of the dirt roads, are lined with barrier fencing designed to keep tortoises and other wildlife off the roads. Some of the highways also have storm drain culverts under them, which allow for movement from one section of the reserve to another without the danger of crossing roads.

The majority of our observations were made on the dirt roads that cross the reserve. We expect reptiles to exhibit similar behavior along the major highways too, but no observations were made by us at these locations.

RESULTS AND DISCUSSIONS

Two separate noteworthy instances were observed involving Desert Tortoises and barrier fences. First, in October of 2005, we found a dead adult tortoise next to a barrier fence along a dirt road in the RCDR. The tortoise was on the road side of the fence and appeared to be uninjured, suggesting that a vehicle collision was not the cause of death. It appeared that the tortoise had become trapped on the road side of the fence, was unable to find shelter, and consequently died from exposure to the cold. The nighttime temperature at that time of year periodically reaches below freezing. After we walked along the fence, we found the location, based on the markings in the sand, at which the tortoise apparently crawled under the barrier at a section of the fence where the bottom edge had been exposed. The animal had then apparently walked over 200 m along the fence. We also discovered several locations where tracks and other marks in the sand indicated that the tortoise tried to dig its way back under the fence.

Our second notable observation was made in an area of the reserve where two fences join together, forming an acute angle. On at least three occasions, we found tortoises congregating near this junction of the two fences (Figure 1). At this site, it appeared that tortoises would follow the fence from either direction and would enter the "V" where the fences met. While in this area, they seemed to get disoriented and remain near the junction of the fences for several hours before they would disperse. On one of these occasions, a large adult pushed far enough into the "V" that its scutes got entangled in the wedge created by the two fences. Reserve employees subsequently freed the individual, and this particular area was re-fenced, eliminating the sharp angle, to prevent a future similar entanglement.

Figure 1. An adult Desert Tortoise (*Gopherus agassizii*) in an area where two fence lines met forming an acute angle. The angles of these fences seemed to cause tortoises to congregate in this area, and at least one large adult became trapped in the fences where the two lines met.

It is clear that fences protect the diverse desert biota; studies have shown that the abundance and diversity of native plants and animals are higher inside than outside the protected desert tortoise habitat (Brooks 2000). In general, fenced off areas in the Mojave Desert have a

higher overall community biomass and diversity than non-fenced areas (Brooks 1995). Total abundance and species richness of lizards and birds are higher inside than outside fenced areas (Brooks 1999).

However, our observations suggest that after some animals come in contact with a road, they turn and retreat back into the desert. Thus, tortoise barrier fences can, in many instances, prevent an animal's retreat and cause it to remain in danger or induce it to reattempt crossing the road. On many occasions, we closely observed the behaviors of other reptiles that had entered and remained in the area between the barrier fence and the road. Western Whiptail lizards, for example, approach the road and quickly retreat if vehicles are present. These lizards then run along the barrier fence until they find cover in a shrub, rather than simply climbing the barrier fence to escape. Because of these behaviors and the continued road-kill mortality of tortoises and other reptiles and amphibians in areas where tortoise barrier fences are present, we suggest that these fences must not be considered an impermeable barrier.

In addition to tortoise fences, other types of barrier fences are often used along roadsides to protect both the wildlife and the motorists (Putman 1997). In many parts of the world, large fences have been built along roadsides to keep deer off the highways. Putman (1997) suggests that some means of exit should be provided for deer that manage to make it onto the roadway. Some exits that are provided to deer on highways are structures like one-way gates or deer jump ramps, which are mounds of dirt piled next to the roadside of the fence that allow deer to climb over the fence easily from only one side (Putman 1997). We suggest that similar measures, scaled down for smaller animals, may be beneficial if implemented on tortoise barrier fences.

Recently, material for tortoise barrier fencing has been changed in many areas from small ½ inch mesh to 1 x 2 inch mesh, which allows many animals to pass through the fence, therefore eliminating many of the problems we have observed regarding tortoise barrier fences. Although this change undoubtedly will aid in reducing road-kill mortality, a large portion of the existing fences, especially those around the Red Cliffs Desert Reserve, remain constructed of ½ inch mesh, making them impermeable to many vertebrates. Perhaps inexpensive exits could be installed on stretches of these older fences as a way to reduce the possibility of road-kills until new fencing is installed. One option may be to simply dump a pile of large gravel on the road side of the fence only, creating a ramp similar to the deer jump ramp. Large gravel would prevent erosion of the ramp due to rain and wind. Depending on the height of the barrier fence, tortoises may not use these ramps. However, if the tortoise exit ramps were designed to intersect the walking path of a tortoise and direct it over the ramp in a low enough portion of the fence, such structures may reduce the road-kill mortality of snakes, lizards, and rodents, as well as tortoises. Extensive research is warranted before these suggested techniques should be widely implemented. However, in problem areas, they should be considered a first step toward alleviating road related mortalities.

In addition to exit structures, we suggest that acute angles be avoided in fences. We believe that rounded corners, rather than sharp ones, will facilitate movement of tortoises. Because tortoises often follow the fence line when they come in contact with a barrier fence (Ruby et al. 1994), rather than simply joining two fence lines into a corner, we suggest that fences should meet at a rounded bend, thus eliminating any potential for entrapment (Figure 2). In existing fences, patches can be erected out away from the corners to minimize the angles where fence lines meet. Upon encountering such a rounded curve, tortoises would be more likely to continue following the fence despite the change in direction.

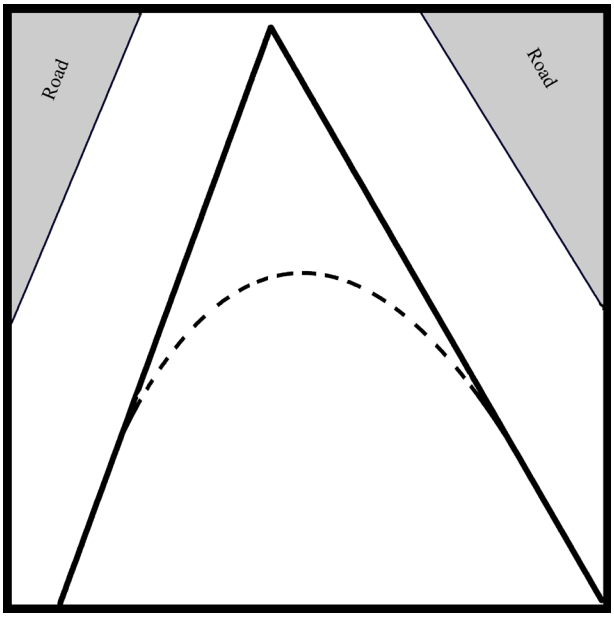

Figure 2. Illustration of the junction of two fence lines that formed an acute angle and caused Desert Tortoises (*Gopherus agassizii*) to aggregate at the site. The dark solid line indicates the original placement of the tortoise fence, and the dashed line represents our suggested changes.

In summary, barrier fences have been very effective in preventing road-kill mortality of Desert Tortoises and other small vertebrates. The addition of exit structures like gravel exit ramps could further reduce the number of road-kill deaths of these animals. Also, areas where two fence lines meet at a sharp angle should be amended to create rounded corners that minimize the risk of entrapment. Such simple modifications could improve the existing barrier fences, but clearly more research on the design and efficacy is needed.

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