COMPARISON OF EFFECTS OF HUMANS VERSUS WILDLIFE-DETECTOR DOGS

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ABSTRACT—The use of dogs (*Canis lupus familiaris*) trained to locate wildlife under natural conditions may increase the risk of attracting potential predators or alter behavior of target species. These potentially negative effects become even more problematic when dealing with threatened or endangered species, such as the Mojave Desert tortoise (*Gopherus agassizii*). We addressed three concerns regarding use of dogs trained to locate desert tortoises in the wild. First, we looked at the potential for dogs to attract native and non-native predators to sites at a greater rate than with human visitation alone by comparing presence of predator sign before and after visitation by dogs and by humans. We found no significant difference in predator sign based upon type of surveyor. Second, we looked at the difference in risk of predation to desert tortoises that were located in the wild by humans versus humans with wildlife-detector dogs. Over a 5-week period, during which tortoises were extensively monitored and a subsequent period of 1 year during which tortoises were monitored monthly, there was no predation on, nor sign of predator-inflicted trauma to tortoises initially encountered either by humans or wildlife-detector dogs. Third, we looked at movement patterns of tortoises after encounter by either humans or wildlife-detector dogs. Movement of desert tortoises was not significantly different after being found by a human versus being found by a wildlife-detector dog. Based upon these initial results we conclude that use of trained wildlife-detector dogs to survey for desert tortoises in the wild does not appear to increase attraction of predators, increase risk of predation, or alter movement patterns of desert tortoises more than surveys conducted by humans alone.

RESUMEN—Es posible que el uso de perros entrenados para ubicar la fauna silvestre bajo condiciones naturales aumente el riesgo de atraer depredadores potenciales o que cambie el comportamiento de la especie focal. Estos efectos potencialmente negativos se hacen todavía más problemáticos cuando se trabaja con especies amenazadas o en peligro de extinción, como la tortuga del desierto (*Gopherus agassizii*). Investigamos tres preocupaciones respecto al uso de perros entrenados para encontrar las tortugas del desierto en el campo. Primero, para investigar la posibilidad de que los perros atraigan a depredadores nativos e introducidos a los sitios con mayor rapidez que con visitas humanas solamente, comparamos la presencia de indicios de depredadores antes y después de la visita por perros y por humanos. No encontramos ninguna diferencia significativa entre los indicios de depredadores basado en el tipo de visita. Segundo, investigamos la diferencia entre el riesgo de depredación a las tortugas encontradas en la naturaleza por humanos vs. humanos con perros entrenados. En un periodo de cinco semanas durante el cual hubo monitoreo intensivo de las tortugas, y en un periodo siguiente de un año durante el cual se les observó cada mes, no hubo depredación ni indicación de trauma causada por depredadores a las tortugas encontradas inicialmente ya sea por humanos o por perros. Tercero, observamos los patrones de desplazamiento de las tortugas después de un encuentro con humanos o con perros. No hubo una diferencia significativa entre el movimiento de las tortugas del desierto después de ser encontradas por perros o por humanos. En virtud de estos resultados iniciales, concluimos que es improbable que el uso de perros para muestrear las tortugas en el campo aumente la atracción de depredadores o el riesgo de depredación, o que cambie los patrones de desplazamiento de las tortugas del desierto, en comparación con muestreos llevados a cabo por humanos solos.

Survey methods for animals typically involve use of humans to locate, approach, and handle target species. For certain species, mostly upland game birds and water fowl, trained dogs have a long history of assisting human surveyors. By locating and handling animals, humans and dogs may attract potential predators or cause an animal to alter its behavior, potentially to its detriment. This is commonly referred to as an investigator effect (Bart, 1977; Bety and Gauthier, 2001; Gutzwiller et al., 2002). While investigator effect relates to human influence on animals being studied, a similar impact of presence of wildlife-detector dogs is a concern. Controlled field experiments show no difference in predation on birds at sites visited by both humans or sites visited by humans and wildlife-detector dogs (Bety and Gauthier, 2001; Donalty and Henke, 2001). Several other studies investigated effects of humans and pet dogs on wildlife, albeit mostly within the context of recreational activities (Knight and Gutzwiller, 1995). In some cases, wildlife responds more negatively to humans (Miller et al., 2001; Kloppers et al. 2005), while in others they respond more negatively to pet dogs (Hamerstrom et al., 1965; MacArthur et al., 1982; Martinetto and Cugnasse, 2001).

The desert tortoise is a threatened species (United States Fish and Wildlife Service, 1994) and every effort should be made to minimize or ideally eliminate investigator effect. Humans as surveyors have not been shown to negatively impact desert tortoises other than possibly contributing to increased nest predation (Bjurlin and Bissonette, 2004) and increased voiding by tortoises from handling (Averill-Murray, 2002). In the closely related gopher tortoise (*Gopherus polyphemus*), no major human investigator effect has been reported (Pike et al., 2005; Kahn et al., 2007). Although not a study of investigator effect of humans or dogs, Schwartz and Schwartz (1974) and Schwartz et al. (1984) reported no negative impact from using Labrador retrievers to physically retrieve three-toed box turtles (*Terrapene carolina*) over a 19-year period. Their dogs recorded >6,700 captures, with individual rates of recapture as high as 45 times.

Harassment and killing of turtles by free-ranging feral or pet dogs has been reported in turtle species (Causey and Cude, 1978; Mendonca et al., 2001), including individuals much larger than the desert tortoise (MacFarland et al., 1974), and remains of desert tortoises have been found in scats of the coyote (*Canis latrans*) and kit fox (*Vulpes macrotis*; Berry et al., 2006; K. H. Berry and A. P. Woodman, in litt.). Because feral dogs have been observed to harm or harass desert tortoises (Woodbury and Hardy, 1948; Duda and Krzysik, 1998; C. D. Bjurlin and J. A. Bissonette, in litt.), pet dogs may pose a similar threat within or near the urban edge, although extent and magnitude of harassment has not been studied. Coyotes (Gese, 2001; Sequin et al., 2003) and feral dogs (Pal, 2003) defend territories against other canine intruders, both within species groups and among species (Bider and Weil, 1984; Allen et al., 1999; Fedriani et al., 2000; Kamler et al., 2003), although there is evidence that presence or scent of domestic canines could deter coyotes from investigating a location (Andelt, 1999; Kamler et al., 2003). Therefore, it is of interest to determine the extent to which presence of humans and dogs attract coyotes, kit foxes (*Vulpes macrotis*), and feral dogs, and to what extent, if any, use of wildlife-detector dogs increases risk of predation to desert tortoises or alters their behavior.

The three objectives of this research were to quantify the following for each of the two surveyor types, humans alone and humans with dogs: 1) response of predator, 2) risk of predation on tortoises, and 3) distance moved by tortoises post surveys. For the first objective, we assessed if coyotes, foxes, and feral dogs were more attracted to locations where humans with domestic dogs visited, than to locations where only humans visited. The second objective addressed risk of predation, or the probability of being killed by a predator in a given interval of time (Lima and Dill, 1990). Specifically we tested whether tortoises found by wildlife-detector dogs experienced a higher level of predation than those found by humans. The third objective was to investigate one aspect of behavior of desert tortoises, i.e., movement, that could be influenced if tortoises were stressed when encountered by wildlife-detector dogs.

Materials and Methods—*Attraction of Predators*—Data on attraction of predators were collected from three study sites in the Mojave Desert where desert tortoises are known to occur; two sites on the Marine Corps Air Ground Combat Center at Twentynine Palms, San Bernardino Co., California, and one site in Shadow Valley northeast of Baker, San Bernardino Co., California (Fig. 1). Fieldwork on the Marine Corps Air Ground Combat Center was conducted 1–7 October 2004. Site one, interior of the Marine Corps

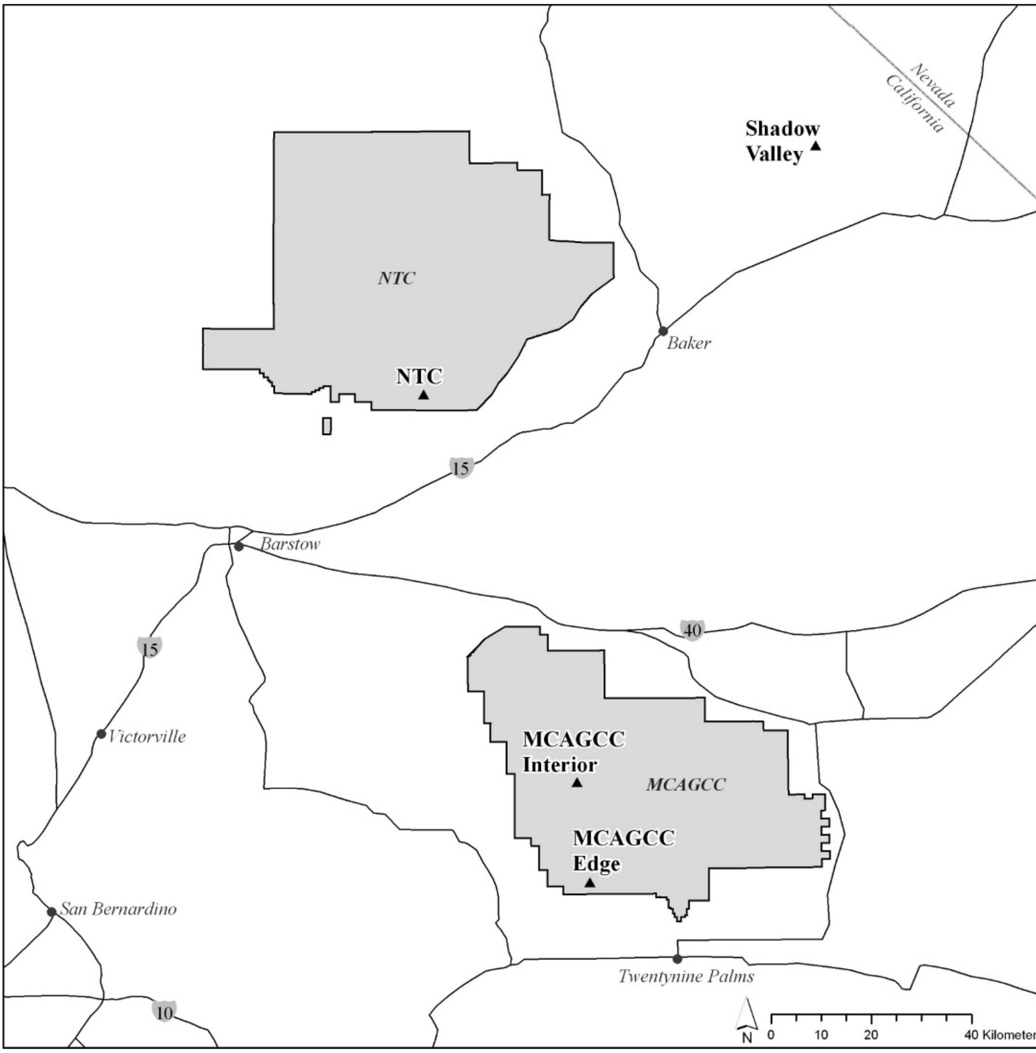

FIG. 1—Location of the four study sites (black triangles) in California. Predator-attraction data were collected from three study sites: Shadow Valley, interior of Marine Corps Air Ground Combat Center (MCAGCC), and edge of Marine Corps Air Ground Combat Center. Data on risk of predation and movement of desert tortoises (*Gopherus agassizii*) were collected from one study site, Fort Irwin National Training Center (NTC).

Air Ground Combat Center, was located near the center of the installation and covered an area ca. 3 by 7 km. Site two, edge of the Marine Corps Air Ground Combat Center, was located near the southwestern corner of the base adjacent to the small towns of Twentynine Palms, Joshua Tree, and Yucca Valley, California and covered an area ca. 6 by 7 km. The third site, Shadow Valley, northeast of Baker, California, was isolated from urban areas. Field work in Shadow Valley was conducted 21–23 October 2004 and covered an area ca. 10 by 6 km.

We established 166 plots, systematically placed at 300-m intervals along and 50-m perpendicular to dirt roads. Placement of the initial plot was randomly assigned along the beginning of each dirt road and successive plots were systematically placed off the first plot. Plots were visited with a human alone or a human with a pet dog to assess whether sites visited by dogs were more likely to attract predators. Although desert tortoises were known to inhabit all three study areas we were not specifically looking for tortoises; therefore, we did not use dogs trained to locate desert tortoises. Dogs used included a German shepherd dog and an Australian shepherd (Marine Corps Air Ground Combat Center), and Carolina dog (Shadow Valley). We established 26 plots in interior Marine Corps Air Ground Combat Center (12 visited by humans with a dog and 14 visited by humans alone), 52 in edge

Marine Corps Air Ground Combat Center (25 dogs and 27 humans), and 88 in Shadow Valley (44 dogs and 44 humans). Each plot consisted of an 8-m^2 area. When arriving at a plot, we recorded and photographed presence of any existing sign (scat, tracks, or both), then sat at the site for ca. 5 min (with the dog if appropriate), which is a reasonable average time for processing a desert tortoise during routine fieldwork. Before leaving, we raked the plot to allow detection of fresh tracks of predators at a later visit. We re-visited plots at delayed times ranging from ca. 15–25 h. In all cases, a night passed between initial establishment of plot and revisit. Any fecal material from our dogs was removed from the site; however, urination by dogs, although infrequent near plots, remained. Each survey plot was re-visited only once and no plot was crossed in the act of accessing another plot. We recorded presence (i.e., tracks or scat) or absence of canine sign upon re-visitation of each plot.

We used logistic regression to analyze effects of surveyor (human or dog), time after visitation, and prior sign of presence of predators, while controlling for effects of site, and all factor interactions. Given that the overall analysis was significant, we conducted a Wald Chi-Square test to examine which effects in the model showed significant differences. Differences among study sites in presence of existing sign when plots were established were analyzed using a Chi-Square contingency table analysis.

Risk of Predation—We collected data on risk of predation during experiments comparing efficacy of teams of humans and trained wildlife-detector dogs for population surveys (see Nussear et al., 2008, for description of experimental design). These experiments were conducted on 10 adjacent 1-km^2 plots on the southern boundary of the United States Army National Training Center at Fort Irwin, northeast of Barstow, California (Fig. 1), 3 October–8 November 2005. We monitored all tortoises found during this survey effort on a monthly basis for 12 months post-study.

Each of the 10 adjacent 1-km^2 plots at the National Training Center was surveyed twice by teams of wildlife-detector dogs and twice by humans. After each team (human or dog) made two passes of a plot on 2 consecutive days, teams switched plots and surveyed accordingly for 2 more consecutive days (Nussear et al., 2008), so that each plot was surveyed a total of four times. The human team consisted of nine individuals responsible for surveys and two support biologists for processing tortoises. There were six dog teams, each team consisting of one dog trained and certified to locate desert tortoises (Cablk and Heaton, 2006), a dog handler, and one support biologist permitted to handle and process tortoises. Support biologists, either for human or dog team, did not participate in the survey. The first time a tortoise was found it was radiotransmittered. Because each plot was sampled a total of four times and because tortoises moved during the 5-week period, individual tortoises were found repeatedly by humans and dogs in no particular order. For each observation of tortoises, we recorded the following data: geographic-location coordinate, date, time, surveyor type, and obvious signs of existing trauma caused by predators. Signs of existing trauma included chew or scratch marks on the carapace and plastron including the gular horn, puncture wounds, and missing or partially missing limbs.

Movement of Tortoises—We collected data on movement of tortoises at the same time we obtained data on risk of predation. In the absence of a direct measure of physiological change, we used movement patterns of desert tortoises after human or dog encounter as a surrogate for behavior of tortoise. We calculated distances that desert tortoises moved between the time they were initially captured and subsequently re-located by either human or dog teams. For the 5-week survey period only distance between initial capture and subsequent first recapture were used for analysis to avoid any potential confounding effects on movement associated with multiple encounters. We recorded spatial data using Global Positioning System receivers (GPS) in Universal Transverse Mercator Zone 11, North American Datum 83. We exported these data directly into ArcGIS, version 9.1 (Environmental Systems Research Institute, Redlands, California) shapefile format and calculated the distance a tortoise moved between captures using the straight-line-distance tool adjusted for changes in elevation. We used ANOVA to analyze distance moved as a function of surveyor type (i.e., human or dog) with model covariates of time between capture and recapture, sex and size of animal, temperature at time of initial capture, whether or not a transmitter was attached to the tortoise at time of initial capture and Julian date. We log transformed movement data to comply with assumptions of the statistical model.

Results—*Attraction of Predators*—Evidence of predators was present in 20.5% of plots before raking, with significantly more sign found on the Marine Corps Air Ground Combat Center (24 of 78 plots) than at Shadow Valley (10 of 88 plots; $\chi^2 = 9.725$, $df = 2$, $P = 0.002$). Across all sites, a total of 15 plots contained new sign of predators at the time of re-visitation, 7 of 85 (8.2%) human-only plots, and 8 of 81 (9.8%) human and dog plots.

No logistic model examining presence of sign of potential predators at re-visitation was significant. This included models analyzing difference in presence of sign as a result of which type of surveyor visited the plot ($\chi^2 = 0.136$, $df = 1$, $P = 0.710$), amount of time from establishment of plot to revisit ($\chi^2 = 2.37$, $df = 1$, $P = 0.120$), or site ($\chi^2 = 3.25$, $df = 2$, $P = 0.200$). There was no interactive effect among these variables. There was a marginally significant difference relative to presence of sign prior to installation of plot ($\chi^2 = 3.32$, $df = 1$, $P = 0.068$).

Risk of Predation—During surveys at the National Training Center, 51 tortoises were transmittered. Of these, 12 animals (23%) had some sign of predator trauma prior to being transmittered. During the 5-week study no tortoise suffered predation, nor did any tortoise show new signs of trauma caused by predators. For 1 year thereafter, no tortoise suffered predation or showed new signs of trauma caused by a predator, despite the fact that coyotes and kit foxes inhabited the area. We encountered no feral or free-ranging domestic dog at any time during the initial survey or during the subsequent 1-year tracking period.

Movement of Tortoises—For this analysis, 51 observations of tortoise movement after encounter by surveyors was considered. Of these tortoises, 18 were detected by dog teams and 33 by the human team. The overall model was significant ($F_{7,42} = 3.21$, $P = 0.008$), which was due entirely to the effect of time-elapsed (in minutes) between initial capture and first recapture of the tortoise ($F_{1,42} = 15.75$, $P < 0.001$). Most importantly, there was no difference in distance moved by tortoises regardless of who initially found the tortoise, human or dog teams ($F_{1,42} = 1.88$, $P = 0.180$). No other factor we analyzed contributed significantly to the model. Mean distance traveled between initial and first recapture was 214 m $\pm$ 191 *SD* (median = 169, range = 0–737 m); eight tortoises did not move at all.

Discussion—Domestic canines are known to investigate and re-mark locations where other domestic canines previously have marked (Bekoff, 2001). It is likely that feral dogs behave similarly and would be attracted to locations visited by domestic canines, such as trained wildlife-detector dogs used in surveys for desert tortoises. Plots in the edge Marine Corps Air Ground Combat Center site were located in areas where feral and domestic dogs have been seen (Duda and Krzysik, 1998; J. S. Heaton, pers. observ.) and dog tracks were found in areas near our plots. Despite presence of coyotes, kit foxes, and domestic dogs within the study area, and the likelihood that coyotes were aware of our presence (Hein and Andelt, 1996; Windberg, 1996; Harris and Knowlton, 2001; Sequin et al., 2003; Kamler et al., 2004), our mere presence, scent, or both did not appear enough to attract coyotes to the spot we raked within the first 24-h with any great frequency, whether visited by human or a human with a dog. Future work should include assessment of longer time periods. It is worth noting that the probability of a predator approaching a location where humans or dogs have visited is a function of both detection and subsequent attraction. As many as a dozen independent factors control these two functions (Harris and Knowlton, 2001), and coyotes may in fact be deterred from investigating a location by the presence or scent of a domestic canine (Andelt, 1999; Kamler et al., 2003).

We found no new injury or incident of predation on any of the 51 tortoises we handled during the 5-week survey or the subsequent 1 year of monthly visitations at the National Training Center. While we did not see a feral or free-ranging domestic dog in the area, not surprising due to the remote location (45 km from Barstow, California, and 19 km from the main base facilities at the National Training Center; Scott and Causey, 1973; Iverson, 1978; Butler et al., 2004; A. Demmon and K. H. Berry, http://www.deserttortoise.org/abstract/abstracts2005/dtc2005abstracts.pdf), we cannot say with certainty whether they were present.

Desert tortoises may live $\leq$50 years in the wild (Germano, 1992), and thus, signs of trauma on tortoises that survive encounters with predators likely are accumulated over relatively long periods of time. Additionally, desert tortoises may not serve as a consistent food resource for coyotes, such as high-ranking or abundant lagomorphs and rodents (Hernandez et al., 2002). Instead, tortoises may be taken during droughts when preferred types of foods would be less available. Despite ample signs of predatory trauma on desert tortoises in the wild, the only recorded acute episodes of predation are on two separate populations during times of drought (Turner et al., 1984; J. E. Lovich, unpublished data). Therefore, a desert tortoise living as long as 50 years may survive several such climatic episodes and accumulate predatory trauma over the course of decades. Our study was conducted following a year with record rainfall, so it is unknown if surveys plus drought would have increased risk of predation. However, our results suggest that even if overall risk of predation increased, it likely would not be different between dog and human surveyors, although this is worth further investigation.

We found no evidence that use of wildlife-detector dogs to survey areas in the Mojave Desert, either with or without tortoises present, increased apparent or realized risk of predation to desert tortoises or altered their movement patterns. This is in line with Kahn et al. (2007) who report no difference in movement patterns, including mean distance traveled, in handled versus unhandled gopher tortoises following much more physically invasive procedures. Our results should alleviate concerns expressed by stakeholders and land managers that use of trained dogs to survey for desert tortoises will increase the risk of predation on adult tortoises. Trained dogs are a viable tool for conducting surveys on the threatened desert tortoise (Cablk and Heaton, 2006; Nussear et al., 2008) and we suggest that they can now be deployed with minimal concern for causing increased predation pressure over the use of humans alone. Furthermore, results presented here may be generalized to other species of animals in deserts with similar canid fauna for which using trained wildlife-detector dogs could improve our knowledge of their abundance and distribution.

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