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Observations of predator activity at wildlife water developments in southern Arizona

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Abstract

Wildlife water developments have been constructed and maintained throughout the arid western United States to benefit big game and upland gamebird populations. There is debate, however, over possible detriments to wildlife from artificial water sources in deserts and other arid environments. One concern is that water developments attract predators, which then impact the prey populations that these developments are intended to benefit. To examine the extent of predator activity around water developments, we examined 15 paired water and non-water (random) sites for sign (scats, tracks, visual observations, animal parts such as feathers and bones, and carcasses) of predators and prey. Predator sign was 7x greater around water sites than non-water sites ($P = 0.002$). Coyote (*Canis latrans* Say) sign accounted for 79% of all predator sign and was 7x greater near water than away from water ($P = 0.006$). Amount of sign for all prey species combined was not different between paired sites ($P = 0.6$), but results for individual species and groups of species was variable; passerine and gallinaceous bird sign was greater around water sites ($P = 0.008$), ungulate sign was not different between water and non-water sites ($P \geq 0.20$), and lagomorph sign was almost 2x greater away from water than near water ($P = 0.05$). Predators were probably attracted to wildlife water developments to drink rather than hunt; without water developments, predators may be even more concentrated around the fewer natural water sites.

Key Words: carnivores, desert ecology, raptors, predator-prey relationships, ungulates, wildlife management

Resumen

A lo largo del árido oeste de Estados Unidos se han construido y mantenido aguajes para fauna silvestre para beneficiar las poblaciones de fauna silvestre mayor y las de aves para cacería de las mesetas. Sin embargo, hay un debate sobre los posibles detrimentos para la fauna silvestre en las fuentes artificiales de agua construidas en los desiertos y otros ambientes áridos. Una preocupación es que los aguajes artificiales atraen predadores, los cuales impactan en las poblaciones de presas que con estos aguajes se intentan beneficiar. Para determinar la magnitud de la actividad de predadores alrededor de los aguajes, examinamos 15 sitios apareados con aguaje y sin aguaje y elegidos al azar, en los sitios se examinaron señales de predadores y presas (huellas, observaciones visuales, partes de animal tales como plumas y huesos y cadáveres). La señal de predadores fue 7 veces mayor alrededor de los sitios con aguajes que en los sitios sin ellos ($P = 0.002$). Las señales de coyote (*Canis latrans* Say) contribuyeron con el 79% del total de las señales de predadores y fue 7 veces mayor cerca del agua que lejos de ella ($P = 0.006$). La cantidad de señales combinando todas las especies de presas no fue diferente entre los sitios apareados ($P= 0.6$), pero los resultados por especie individual y grupos de especies fue variable, las señales de aves gallinaceas fue mayor alrededor de los aguajes ($P = 0.008$), las señales de ungulados no fueron diferentes entre sitios con y sin agua ($P \geq 0.20$) y las señales de lagomorfos fue casi 2 veces mayor lejos del agua que cerca de ella ($P = 0.05$). Los aguajes para fauna silvestre probablemente atrajeron a los predadores para tomar agua mas que para cazar, sin aguajes, los predadores pueden estar aun mas concentrados alrededor de los pocos sitios con aguajes naturales.

Since the early 1900s, almost 6,000 wildlife water sites have been developed throughout the arid western United States in an effort to increase, stabilize, or otherwise benefit wildlife populations (Rosenstock et al. 1999). The Arizona Game and Fish Department spends up to $500,000–1,000,000 annually to develop and maintain water sites (deVos et al. 1997b), and 9 other western states currently have active water development programs with annual costs >$1,000,000 (Rosenstock et al. 1999).

In Arizona, the first wildlife water developments were built in 1941 (Broyles 1995), and since then >800 have been constructed (deVos et al. 1997b). Several designs have been used, including drinkers (cement, metal, or fiberglass troughs supplied by asphalt, metal, or fiberglass collection surfaces [aprons] capable of filling the drinker from 1 storm), tinajas (rain- or well-fed rock basins and potholes in impervious granite and basalt), and tanks (large depressions in soil or rock that collect and hold precipitation and runoff) (Broyles 1997, deVos et al. 1997b). Above or below ground water holding tanks, which increase storage capacity and reduce the need for hauling water, have been added at many sites.

Water developments are thought to be important mitigation against extensive loss and degradation of natural waters, including springs and perennially and intermittently flowing streams, caused by agricultural and urban development (Campbell and Remington 1981, deVos et al. 1983, Tellman et al. 1997), and for management and recovery of the endangered Sonoran pronghorn

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(*Antilocapra americana sonoriensis* Ord) (Hervert et al. 1997).

There has been debate over the benefit of water developments for wildlife (Burkett and Thompson 1994, Broyles 1995, Brown 1997, deVos et al. 1997b). Some researchers question whether artificially provided water benefits native wildlife that are adapted to desert or arid rangeland conditions, while others feel that water developments may actually be harmful, either by spreading disease, encouraging exotic species, or increasing predation (Broyles 1995, Brown 1997, Krausman and Czech 1997).

Avian and mammalian predators are attracted to water (Cutler 1996). Important questions are whether this attraction increases predation rates directly by increasing opportunities for predators, or indirectly by improving fitness (i.e., improved survival or reproduction) and thus abundance of predators. These population-level questions are difficult to address and require long-term study over broad geographic areas to answer (deVos et al. 1997a). Before that expense and effort are expended, however, wildlife managers need to know the extent or magnitude to which local populations of predators are attracted to water developments and whether there is evidence that predation occurs around water sites. Our objectives were to compare predator and prey abundance around water sites versus non-water sites to determine which species were attracted to water, to determine the magnitude of that attraction, and to investigate whether attraction to water sites increased mortality of prey due to predation.

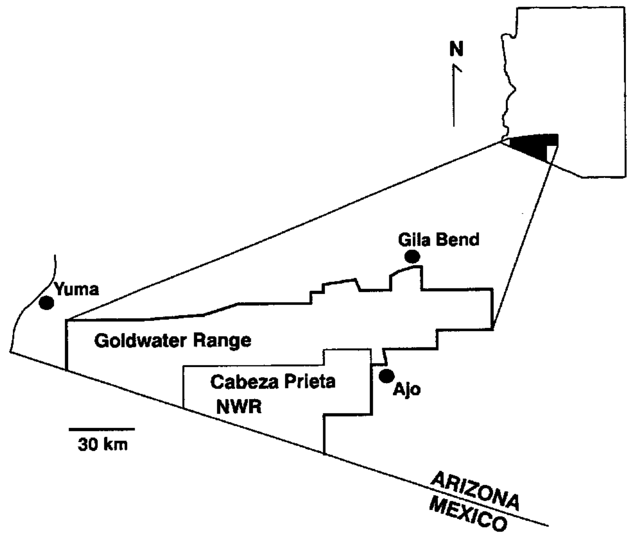

Fig. 1. The Barry M. Goldwater Air Force Range and the Cabeza Prieta National Wildlife Refuge in southern Arizona, where water developments have been constructed and maintained for wildlife populations.

Study Site

Surveys took place on the Barry M. Goldwater Air Force Range and the Cabeza Prieta National Wildlife Refuge in southern Arizona (Fig. 1); combined area size was about 11,000 km^2. Topography was primarily basin and range. The major plant community was Sonoran desert upland; dominant vegetation consisted of paloverde (*Cercidium* [Torr.] Rose and I. M. Johnston spp.), mesquite (*Prosopis* L. spp.), and ironwood (*Olyneya tesota* Gray) trees, ocotillo (*Fouquieria splendens* Engelm.), saguaro (*Carnegiea gigantea* [Engelm.] Britton and Rose), prickly pear and cholla (*Opuntia* Mill. spp.) cacti, creosote bush (*Larrea tridentata* [DC.] Cov.) and bursage (*Ambrosia* [Cav.] Payne spp.).

Annual rainfall was about 15 cm, falling in a bimodal pattern of scattered winter rains (50%) and intense late summer thunder storms (50%). High temperatures commonly exceeded 38°C in summer and 20° C in winter. The landscape was dominated by riparian areas and washes, but water flow in these streams was intermittent and unpredictable. For most of the year, washes were dry and, aside from artificial water developments, there was very little perennial water available in the area (Broyles 1997). There were about 65 water developments on the eastern half of the Goldwater Range and the Refuge where we conducted our surveys (T. L. Cutler, personal communication).

Methods

We surveyed 15 paired water and non-water sites during January–March of 1995–97. Water sites were selected based on accessibility in the eastern half of the Goldwater Range and Cabeza Prieta Refuge. For each water site, we selected a non-water site that was in a random direction and distance (but within 0.4–0.8 km) from the water development. Each random site had similar topographic and vegetative conditions as its paired water site. We blocked by location (Kuehl 1994) to control for some of the variation in predator activity that may occur among different portions of the study area. We searched for predator and prey activity at all sites by recording visual observations and looking for sign (scats, tracks, trails, feathers) and evidence of kills (carcasses, feather piles). We identified bones when found, but did not necessarily attribute these to predator kills, especially when bones appeared old and bleached from the sun. We refer to all feces as scats, including pellet groups from ungulates and lagomorphs. We attempted to identify sign to species; when we could not, we identified the sign to a higher classification (e.g., canid, carnivore, ungulate, lagomorph). Carnivore species on the study site included coyotes (*Canis latrans* Say), foxes (gray [*Urocyon cinereoargenteus* Schreber] and kit [*Vulpes velox* Say]), mountain lions (*Puma concolor* L.), bobcats (*Felis rufus* Schreber), and avian predators and scavengers (turkey vultures [*Cathartes aura* L.], common ravens [*Corvus corax* L.], loggerhead shrikes [*Lanius ludovicianus* L.], owls, hawks). The only ungulate sign that we consistently identified to species was from collared peccary (*Pecari tajacu* L.). We lumped sign from mule deer (*Odocoileus hemionus* Rafinesque), bighorn sheep (*Ovis canadensis* Shaw), and pronghorn as ungulates. Lagomorphs included black-tailed and antelope jackrabbits (*Lepus californicus* Gray, *L. alleni* Mearns) and desert cottontails (*Sylvilagus audubonii* Baird). Common avian prey included house finches (*Carpodacus mexicanus* Müller), gila woodpeckers (*Melanerpes uropygialis* Baird), and a variety of passerine and gallinaceous birds.

As we approached the water or the random non-water point we noted any animals that flushed from that spot. We then searched a 10-m^2 central plot around the water or random point, and continued this search along eight, 50-m transect lines radiating from the water or random point, looking for sign within about 5 m on either side of the transect. We tallied all sign and observations by species or species group for the center plot and the 8 transects, and summed that for each site. Groups of sign (pellet groups, a line of tracks, scattered but likely related bones, piles of feathers) were counted as 1 observation, but when we encountered similar sign (e.g., coyote tracks) at different points along a transect or on different transects, each track or line of tracks was counted as a separate observation. Because we could not determine if sign was from 1 or several individuals, we tallied total amount of sign, rather than trying to determine number of individuals that may have visited a site.

We used paired *t*-tests to compare differences in amount of predator and prey sign between paired water and non-water sites. We report mean differences ($\bar{x}_D$) and 95% confidence intervals (CI) $\bar{x}_D$ for our 15 paired sites; 95% CIs that do not contain 0 indicate a significant difference between water and non-water sites.

Results

Of 15 water sites examined, 73% (11) were drinkers; the remaining 4 were improved tinajas or rock potholes. For all water and non-water sites combined, the majority of sign was scats or pellets (65%), followed by tracks (including ungulate trails) (12%) and visual observations (7%). We also found bones (n = 23), feathers (n = 10), and carcasses (n = 4). Scats made up the majority of sign for both types of site.

We recorded 20 observations of birds as we approached water sites (where a flock counted as 1 observation). Of these, house finches (40%) and gila woodpeckers (20%) were most common. Other bird species observed at water sites included black-throated sparrows (*Amphispiza bilineata* Cassin), mourning and white-winged doves (*Zenaida macroura* L., *Z. asiatica* L.), and Gambel's quail (*Callipepla gambelii* Gambel). No other wildlife was seen at water sites except for 1 black-tailed jackrabbit.

The most common predator sign at water sites was from coyotes (79%), followed by foxes (7.5%), avian predators and scavengers (mostly turkey vultures) (7.5%), mountain lions (4%), and bobcats (2%). The most common prey sign at water sites was from ungulates (deer, sheep, pronghorn) (40%), followed by lagomorphs (36%), passerine and gallinaceous birds (19%), and peccaries (5%).

Comparison of paired water and non-water sites indicated that the amount of sign for all predator species was greater at water than non-water sites (P = 0.002). This was also the case for each species or group of predators, including coyotes, foxes, felids, and avian predators and scavengers (P ≤ 0.08; Table 1). Prey sign was not consistently more abundant at water sites than non-water sites (P = 0.57). Of the species or groups of prey that we examined (Table 1), sign was more abundant at water sites for only passerine and gallinaceous birds (P = 0.008). Sign for peccaries and all other ungulates was not different between water and non-water (P = 0.76 and 0.20, respectively). Sign for lagomorphs, although common at all water and non-water sites, was 1.7x greater at non-water sites than water sites (P = 0.05).

Discussion

Smith and Henry (1985) did not find a difference in predator sign on plots between 6 water and 5 non-water sites in Arizona. We, however, documented up to 7x more predator sign at water sites than non-water sites, indicating that predator use of water developments was high on our study area. This was especially true for coyotes, sign from which made up almost 80% of all predator sign that we observed. Cutler (1996) also reported high visitation rates by predators at water sites in the same area, where she used remote cameras at 2 water sites to document use by wildlife. About 55% of all photographs were of coyotes. Golightly and Ohmart (1984) reported that water needs for coyotes in deserts were greater during summer than winter (this was not true for kit foxes), and so the preponderance of coyote sign at our water sites could be even greater during summer.

Despite the abundance of predator sign at water sites, we found very little evidence of kills. This may be because not many kills were made at these sites, or the evidence of kills disappeared quickly. Of the 4 carcasses that we found, 2 were gila woodpeckers, 1 was a pecarry, and 1 was a turkey vulture. The woodpeckers were obviously predated by a raptor, probably a Cooper hawk (*Accipiter cooperii* Bonaparte), as evidenced by what appeared to be a sudden loss of large amounts of feathers due to impact. For passerine and gallinaceous birds, we believe that water sites may function in a similar fashion to backyard bird feeders; birds are attracted to the site, congregate and linger there, and a few individuals are subsequently killed by raptors. Some raptors may even include water sites in their foraging territories, but we do not believe that this contributes in any significant way to avian mortality. We could not determine the cause of death of the peccary or the turkey vulture because of the ages of the carcasses, but both were relatively intact and did not appear to be predated or even scavenged very much.

It is more difficult to speculate on the influence of water developments on interactions between large mammalian predators and ungulates. Carnivore territories are large and distribution of kills widespread. Based on our findings, we can only say that predators were attracted to water sites; we cannot say that water increased predation rates, improved predator fitness, or that ungulates avoided water sites because of the periodic presence of predators. Although peccaries have been documented drinking at some of these water sites (Cutler 1996), in at least some instances they do not need free-standing water because of their diet of succulent plants (Zervanos and Day 1977). Thus, we were not surprised to find no difference in

Table 1. Mean differences ($\bar{x}_D$) and 95% confidence interval (CI) of the difference for amount of predator and prey sign between 15 paired water development and non–water (random) sites in the Sonoran desert, Arizona.

Species	$\bar{x}_D$	95% CI	t_{Paired}	P
Coyote	6.7	2, 11	3.24	0.006
Fox	0.7	0.5, 1.3	2.32	0.04
Felid	0.5	0, 1	1.97	0.07
Avian predators[1]	0.7	–0.1, 1.4	0.67	0.08
Avian prey[2]	2.3	1, 4	3.12	0.008
Ungulate[3]	3.5	–2, 9	1.33	0.20
Peccaries	0.1	–1, 1	0.31	0.76
Lagomorph	–3.8	–8, 0	–2.17	0.048

[1]Includes predators and scavengers (turkey vulture, common raven, loggerhead shrike, hawks, owls).
[2]Includes passerine and gallinaceous species.
[3]Includes mule deer, bighorn sheep, and pronghorn.

peccary sign between water and non-water sites. The need for free-standing water by other ungulates is less clear; some authors report that ungulates do not seem to respond to water developments (Krausman and Leopold 1986, Krausman and Etchberger 1995), while others report that water developments are used by ungulates and may be beneficial (Leslie and Douglas 1979, Hervert and Krausman 1986, Ockenfels et al. 1991), depending on the species and season involved (deVos et al. 1997b). We did not document a difference in ungulate sign between water and non-water sites, but because we lumped all ungulate sign (except peccary) together, we cannot say how ungulate sign may have differed between water and non-water sites for individual species on our study area during winter. Lagomorph was the only taxon for which we found more sign away from water sites than around water sites. Although lagomorphs in desert environments will drink from water developments (Cutler 1996), they may not need free-standing water (Schmidt-Nielsen 1964, Nagy et al. 1976) and may not be compelled to visit water sites. In years of high numbers, rabbits and hares are probably important prey, especially for coyotes, and may act to disperse predation away from water sites.

Several researchers reported that free water is unnecessary for a variety of carnivores (Chevalier 1984, Golightly and Ohmart 1984, Green et al. 1984). Schmidt-Nielsen (1964) believed that the diet of most carnivores provides them with the water they need for most physiological functions, except perhaps heat regulation. Virtually all predators in the Sonoran desert will use free-standing water if it is available, and we suspect that predators come to these sites primarily to drink rather than to hunt. Kills at water sites do occur (Monson 1964, Cunningham and deVos 1992, Krausman and Etchberger 1993), but we speculate that kills at water sites in southern Arizona, when they do happen, are on an opportunistic basis and are trivial to prey population dynamics. We do not know whether providing water to predators increases their survival or reproduction.

Research and Management Recommendations

It has been established through this and other studies that predators frequent water developments. The next step is to determine what this means, if anything, to population dynamics. The Arizona Game and Fish Department identified key research needs for the study of water developments and their potential effects on wildlife populations (deVos et al. 1997a, 1997b). Of these, the effects of water developments on population performance (distribution, abundance, survival, reproduction) and predation rates of mammalian predators were considered important. Long-term experiments with marked animals are needed to determine the influence of water developments on predation rates and predator demography, including experimental approaches where water sites are closed (or new ones opened) while monitoring the demographics of predator populations.

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