Western North American Naturalist 65(1), © 2005, pp. 87–90

INFLUENCE OF WATER SIZE AND TYPE ON BAT CAPTURES IN THE LOWER SONORAN DESERT

Michael J. Rabe[1] and Steven S. Rosenstock[1]

ABSTRACT.—We compared bat use by mist-netting at 4 different types of wildlife water developments in southwestern Arizona during summer 2000 and 2001. Scaling our results by netting effort, we caught bats more frequently and observed higher species diversity at tinajas (modified natural rock pools) with larger open-water area compared with "guzzler" type water developments that had less open water and more obstacles to bat flight. We caught the fewest bats at guzzlers with buried concrete vault drinkers, which impede bat access and have the smallest areas of open water. Water development designs that minimize evaporative water loss by reducing the amount of open water apparently reduce use by bats in this area.

Key words: bats, water development, Sonoran desert, guzzler, tinaja, southwestern U.S., Arizona.

Recent debates over the value of wildlife water developments (Broyles 1995) have direct implications for conservation of desert bats. In the arid Southwest, water developments are often the only free water sources available to bats (Burkett and Thompson 1994, Rosenstock et al. 1999). Desert bats are attracted to water sources in great numbers during the hottest and driest part of the summer (O'Farrel and Bradley 1970, Kunz and Kurta 1988), and availability of surface drinking water may limit bat distributions in these arid regions (Geluso 1978).

The desert landscape of southwestern Arizona is extremely arid, and natural, perennial surface water is rare. However, a large number of water developments have been built to benefit wildlife. Construction and maintenance of these water sources have been high priorities for federal and state resource management agencies since the 1950s (Rosenstock et al. 1999). While most of these water sources were intended to benefit mule deer (*Odocoileus hemionus*) and desert bighorn (*Ovis canadensis mexicana*), they are heavily used by other wildlife including bats, birds, and mammalian predators. Vegetation or cliffs surrounding a water source, or the structure of the water development itself, can impede access by bats (Kalcounis and Brigham 1995, Schmidt 1999). Because bats vary in size and maneuverability, some species may use some types of water developments more readily than other types (Aldridge and Rautenbach 1987, Aldridge and Brigham 1988). The area and configuration of open water vary among different types of water developments, and these are key variables that may affect bat use. The goal of our study was to assess bat diversity at and use of common types of wildlife water developments in the Sonoran Desert of southwestern Arizona.

STUDY AREA

The study area is north of Yuma in southwestern Arizona on Kofa National Wildlife Refuge (U.S. Fish and Wildlife Service) and Yuma Proving Ground (U.S. Army). Terrain is diverse, consisting of mountains, bajadas, and broad valleys dissected by ephemeral washes. Vegetation cover types within the area are approximately 25% Arizona Upland Sonoran Desertscrub and 75% lower Colorado River Sonoran Desertscrub (Brown 1994). Elevations within the area range from 98 m on valley bottoms to 1467 m on the highest mountain peaks. Mean yearly rainfall (1971–2000) at the nearest weather stations (Yuma Proving Ground, 98-m elevation, and Kofa Mine, 542-m elevation) was 9.8 cm and 18.44 cm, respectively. Mean summer temperatures (June–August) at Yuma Proving Ground and Kofa Mine weather stations were 33.0° and 31.9°C, respectively (NOAA 2001).

[1]Arizona Game and Fish Department, Research Branch, 2221 W. Greenway Road, Phoenix, AZ 85023.

The most common types of wildlife water developments within the study area are tinajas, precipitation catchments (guzzlers), and wells. Tinajas occur in canyons and rocky montane areas. Many have been modified by the addition of masonry structures (dams, diversions, or gabions) that increase water inflow and storage capacity and reduce sedimentation during flooding. Surface area of tinajas varies according to physical dimensions, evaporation, and water inflow. Access for flying bats may be restricted by steep cliffs surrounding the pool and by adjacent trees and other vegetation.

Guzzlers and wells are located on bajadas or in valley bottoms adjacent to large washes and have 3 distinct types of drinkers available to bats: buried vaults, buried troughs, and aboveground troughs. Buried vault drinkers are made of fiberglass or concrete and are filled by passive flow from 1 or more adjacent storage tanks. The drinker has vertical walls on 3 sides and a 4th side slopes outward at a 45° angle, forming a ramp that leads down to the water. When full, the drinker has an open-water area that measures approximately 1 m × 1 m and that is nearly level with the surrounding ground surface. Water level within the drinker drops and surface area decreases as water is depleted from the storage tank. When the drinker is nearly empty, its water surface measures approximately 0.1 m × 1 m and is approximately 0.8 m below ground level. At low water levels, bats must fly down to reach the water surface and then pull up quickly while exiting to avoid contacting the walls. Buried troughs are made of concrete or fiberglass and have surface areas similar to vault drinkers. However, water level and surface area are regulated by a float valve and are more or less constant. Aboveground troughs are made of concrete, have similar dimensions to buried troughs, and are equipped with float valves. The water surface is located 0.5 m above ground level and 0.1 m below the top of the trough. Surrounding vegetation usually has little influence on bat access to guzzlers because these waters are located away from trees or other dense natural vegetation, or vegetation is removed to prevent roots from damaging the structure.

METHODS

We captured bats at 7 wildlife water developments in summer 2000 and summer 2001. Our sampling sites included 2 tinajas, 2 buried vaults, 2 buried troughs, and 1 aboveground trough (Table 1). These water developments had been in place for a minimum of 12 years before we began our study. We visited each location and water type twice per month on a rotating schedule. Summer 2000 sampling occurred from 18 July to 26 August. We captured bats at 3 locations on 4 occasions for a total of 11 nights of sampling (1 visit to Horse Tank tinaja site was aborted because of a severe thunderstorm). In 2001 we increased our effort, sampling from 29 May through 30 August. We sampled 4 locations on 6 occasions for a total of 24 nights.

We captured bats with mist-nets set over open water in configurations that made it difficult for bats to drink without encountering nets. We erected nets each night by 2000 hours (approximately sunset) and removed them after 2200. Each captured bat was identified to species and gender and then released. We marked captured bats on the top of the head with a felt-tip marker to avoid multiple counting of recaptures during the same night.

To compare the number of bats caught among different water types and net sets, we scaled bat captures as the number of bats captured per m^2 of net area per hour of effort. Since surface algae often restricted the area of open water available to bats, we estimated open water during each netting occasion by removing the area covered by algae from the total water area available. We calculated Pearson bivariate correlations (Sokal and Rohlf 1995) for the open water estimates and the number of bats captured per m^2 of net area per hour of effort.

RESULTS

Over the 2 summers we captured 427 bats belonging to 6 species. Western pipistrelles (*Pipistrellus hesperus*) were most common (187 individuals, 43.8% of captures), followed by California myotis (*Myotis californicus*, 105 individuals, 24.6% of captures), pallid bats (*Antrozous pallidus,* 58 individuals, 13.6% of captures), big brown bats (*Eptesicus fuscus,* 31 individuals, 7.3% of captures), Townsend's big-eared bats (*Corynorhinus townsendii,* 22 individuals, 5.2% of captures), and California leaf-nosed bats (*Macrotus californicus,* 18 individuals, 4.2% of captures).

TABLE 1. Results of mist-netting effort at selected wildlife water developments in southwestern Arizona during summer 2000 and 2001.

Location	Water type	Total captures	No. of 2-hr netting occasions	Open water surface area (m^2), mean (s)[a]	Bats · m^{-2} net area · $hour^{-1}$, mean (s)
High Tank 7	Tinaja	207	7	6.1 (1.26)	0.41 (0.198)
Scott's Well	Buried trough	79	4	1.4 (0)	0.41 (0.258)
Horse Tank	Tinaja	65	3	6.6 (3.43)	0.34 (0.329)
Guzzler 534	Aboveground trough	44	6	1.1 (0.56)	0.15 (0.066)
Guzzler 736	Buried vault	16	6	1.1 (0.24)	0.06 (0.034)
Guzzler 531	Buried vault	12	6	0.9 (0.22)	0.04 (0.026)
Guzzler 967	Buried trough	4	6	0.6 (0.32)	0.04 (0)

[a]Open water equals total water surface area minus algae cover surface area.

Bat diversity varied among water types. We found the highest diversity at tinajas, where we captured 6 species, 3 of which were not captured at other types of waters (big brown bat, Townsend's big-eared bat, and California leaf-nosed bat). The fewest bat species were captured at buried vaults, which had only western pipistrelles and California myotis. We had no bat captures on 3 sampling occasions each at buried vaults and buried troughs.

Scaled by netting effort, the most bats (all species combined) were captured at tinajas and the fewest at buried vaults (Table 1). Mean number of bats captured (bats · m^{-2} net area · $hour^{-1}$) at the 2 tinajas was 0.39 (s = 0.23, n = 10 trapping occasions). In descending order this was followed by buried troughs ($\bar{x}$ = 0.23, s = 0.26, n = 8), the aboveground drinker ($\bar{x}$ = 0.15, s = 0.07, n = 6), and buried vaults ($\bar{x}$ = 0.05, s = 0.03, n = 12).

Captures were highest at wildlife waters with the most open water and lowest in locations with the least open water available to drinking bats. The Pearson bivariate correlation between open water and numbers of bats captured for all capture occasions (in bats · m^{-2} net area · $hour^{-1}$) was 0.600 ($P < 0.001$, $n = 36$).

DISCUSSION

Mist-net captures may provide biased estimates of bat use in some cases, but we believe they were reasonably accurate in our study. At sites with low captures and low diversity we observed few bats flying or attempting to drink. Because of the small size of the guzzler drinkers, we could usually assure that bats could not drink without encountering nets. Because tinajas were larger and had more flight approaches, many bats were able to drink and avoid nets despite our best efforts. Thus, our results likely underestimated bat use of these sites.

Given the concentration of bats frequently found around waters in desert habitats (O'Farrel and Bradley 1970, Schmidt 1999) and the additional water stress that arid environments impose on insectivorous bats (Geluso 1978, Basset 1986, Happold and Happold 1988), many, if not all, species probably require free water on occasion. Lactation imposes additional demands on insectivorous bats, and the requirement for free water is most acute for lactating females (Kurta et al. 1989). Although no studies have shown that desert-dwelling bats require water, non-desert bats have been shown to require drinking water. For example, during lactation, drinking water may account for 23%–25% of the daily water influx for little brown bats (*Myotis lucifugus;* Kunz and Kurta 1988, Kurta et al. 1989).

In our study area bat diversity and bat use at wildlife waters were positively correlated with surface area of open water. Some bat species (e.g., western pipistrelles and California myotis) are quite maneuverable and can drink from small water surfaces below ground level, such as those found at buried vaults. However, other less maneuverable species (e.g., big brown and pallid bats) may be excluded from these waters, and they may rely more on tinajas and other larger bodies of water.

The higher numbers and increased diversity of bats caught at tinaja sites were likely a combination of greater water surface area and close proximity to roosts. Distribution of bats may be constrained by availability of roost sites (Humphrey 1975). Our tinaja sites were located near cliffs and rocky canyons that offered roost sites, which may have accounted for higher use than was observed at wildlife waters located on bajadas and valley bottoms.

To be most useful to bats, water developments should have large surface area and be located close to possible roost sites such as cliffs and rock piles. Water development designs that minimize water surface area to reduce evaporation may therefore restrict use by bats. Management agencies should keep these considerations in mind when designing new wildlife waters in the Sonoran Desert.

LITERATURE CITED

ALDRIDGE, H.D., AND R.M. BRIGHAM. 1988. Load carrying and maneuverability in an insectivorous bat: a test of the 5% "rule" of radio telemetry. Journal of Mammalogy 69:379–382.

ALDRIDGE, H.D., AND I.L. RAUTENBACH. 1987. Morphology, echolocation and resource partitioning in insectivorous bats. Journal of Animal Ecology 56:763–778.

BASSET, J.E. 1986. Habitat aridity and urine concentrating ability of Nearctic, insectivorous bats. Comparative Biochemistry and Physiology 53A:125–131.

BROWN, D.E. 1994. Biotic communities of the southwestern United States and northwestern Mexico. University of Utah Press, Salt Lake City. 334 pp.

BROYLES, B. 1995. Desert wildlife water developments: questioning use in the Southwest. Wildlife Society Bulletin 23:663–675.

BURKETT, D.W., AND B.C. THOMPSON. 1994. Wildlife association with human-altered water sources in semiarid vegetation communities. Conservation Biology 8:682–690.

GELUSO, K.N. 1978. Urine concentration ability and renal structure of insectivorous bats. Journal of Mammalogy 59:312–323.

HAPPOLD, D.C., AND M. HAPPOLD. 1988. Renal form and function in relation to the ecology of bats (Chiroptera) from Malawi, Central Africa. Journal of Zoology 215:629–655.

HUMPHREY, S.R. 1975. Nursery roosts and community diversity of Nearctic bats. Journal of Mammalogy 56: 321–346.

KALCOUNIS, M.C., AND R.M.R. BRIGHAM. 1995. Intraspecific variation in wing loading affects habitat use by little brown bats (*Myotis lucifugus*). Canadian Journal of Zoology 73:89–95.

KUNZ, T.H., AND A. KURTA. 1988. Capture methods and holding devices. Pages 1–29 *in* T.H. Kunz, editor, Ecological and behavioral methods for the study of bats. Smithsonian Institution Press, Washington, DC.

KURTA, A., G.P. BELL, K.A. NAGY, AND T.H. KUNZ. 1989. Water balance in free-ranging little brown bats (*Myotis lucifugus*) during pregnancy and lactation. Canadian Journal of Zoology 67:2468–2472.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION. 2001. Climatological data—Arizona. United States Climatic Data Center, Asheville, NC.

O'FARREL, M.J., AND W.G. BRADLEY. 1970. Activity patterns of bats over a desert spring. Journal of Mammalogy 51:18–26.

ROSENSTOCK, S.S., W.B. BALLARD, AND J.C. DEVOS, JR. 1999. Viewpoint: benefits and impacts of wildlife water developments. Journal of Range Management 52: 302–311.

SCHMIDT, S.L. 1999. Activity patterns of California leaf-nosed and other bats at wildlife water developments in the Sonoran Desert. Master's thesis, University of Arizona, Tucson.

SOKAL, R.R., AND F.J. ROHLF. 1995. Biometry. 3rd edition. Freeman, New York. 887 pp.

Received 11 March 2003
Accepted 3 September 2003