Managing Visitors to Prevent Disruption of Emergence of Bats

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Abstract: Public interest in viewing emergences of bats has increased in recent years, and possible disruption by visitors of emergence time of colonies has become a concern for wildlife biologists. Consequently, the objectives of this study were to assess the influence of visitors on time of emergence and flight behavior of a colony of Mexican free-tailed bats (*Tadarida brasiliensis mexicana*). In summer 1992, we studied dynamics of the bat colony at the Old Tunnel Wildlife Management Area near Fredericksburg, Kendall County, Texas. Data were not recorded until the start of a continuous flight of bats emerged from the tunnel. We compared times of emergence of the colony with sunset and flight behavior relative to the presence or absence of visitors. A regression comparing the number of visitors and time of emergence with sunset indicated a 3% variation in time of emergence was attributed to number of visitors. On average, bats emerged 5.3 minutes after sunset on nights with visitors in the viewing area compared with 6.3 minutes after sunset on nights with no visitors. However, in late summer as the population of bats increased, flight behavior of the emerging colony was affected by the presence of visitors, causing congestion and reduced flight space. For the wildlife manager, the potential disturbance of the colony of bats by visitors must be weighed against the positive benefit of public education about these ecologically beneficial mammals.

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A task of wildlife managers is to balance effects of non-consumptive recreation on the functioning of fragile ecosystems. Caves, caverns, abandoned mines, and tunnels occupied by bats are unique, fragile ecosystems (Belwood 1993). Visitors to such natural areas represent a low consumptive use of natural resources that may generate substantial educational, recreational and economic benefits. Public interest in viewing an emergence of a colony of bats has in-

creased in recent years, but passive visitation may not be as benign as it would seem (Hensley pers. commun.). Possible disruptions to the time of emergence by visitors and other human uses of roost-sites have become a concern for wildlife biologists (Tuttle 1980, Sidner 1988, Petryszyn 1989, Thorne 1990). The conspicuous nature of a large colony of bats may be an important factor in their decline by attracting visitors to watch the crepuscular emergence of bats from their diurnal roost sites. However, immense colony size is not a safeguard against population decline (Tuttle 1979, 1980). Gore and Hovis (1992) found site-specific disturbances caused a considerable decline in populations of the colonial southeastern bat (*Myotis austroriparius*). The population of Mexican free-tailed bats at Eagle Creek Cave, Arizona, plummeted from 25 million to about 30,000 individuals, and the population at Carlsbad Caverns decreased from about 8.7 million to about 500,000 bats (McCracken 1986).

Little is known about the disturbance threshold that causes disruption of the behavior of bats, but at some point harassment of the bats causes abandonment of roost sites and population decline (Tuttle 1979, 1980; McCracken 1986; Stafford 1989; Schmidly 1991). Little information exists on management on visitors at roosts accessible to the public (Tuttle 1979, Hensley pers. commun.). In the design of our study objectives, we asked specific questions about the management of bats and visitors at the Old Tunnel. Do passive visitation and number of visitors cause a delay in emergence time? Do visitors cause changes in the emergence behavior of bats?

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Methods

The Old Tunnel Wildlife Management Area (Old Tunnel), which is owned and managed by the Texas Parks and Wildlife Department, is a summer roost-site for about 1.2 million bats. The Old Tunnel, a 4.2-ha tract encompassing the south end of the abandoned Fredericksburg and Northern Railroad tunnel, is located about 24 km southeast of Fredericksburg, Kendall County, Texas, near the community of Grapetown. The tunnel, about 280 m long and 6 m high with a 5-m wide ceiling, extends north to south through an outcropping of Glen Rose limestone. The south exit opens into a narrowly confined draw defined by steep cliffs about 12 m high that gradually decrease in height to the south. Rail operations through the tunnel ceased in 1942. Populations of bats in the tunnel increased sometime thereafter, perhaps 5 years later (Schmidt 1973). Davis et al. (1962) and Constantine (1967) found the Mexican free-tailed bat as well as the cave myotis (*Myotis velifer*) in the tunnel. The evening exodus of bats is impressive.

Initial observations of flight patterns and behavior of bats during emergence were conducted weekly from March through June at the south-tunnel exit. This exit had the longest duration and greatest number of bats during an emergence. Few visitors viewed emergences of bats during this time, and we assumed these small numbers of visitors caused no disruption to the behavior of bats during emergence. The first sign of a continuous flight of bats emanating from the south-tunnel exit marked the start of an emergence. The starting and ending times of the emergence, flight steadiness, and relative density, as determined by observation or using a Mini-2 Bat Detector (Ultra Sound Advise, Ltd., UK), behavior of the bats, and number of visitors were recorded for each emergence.

We studied the effects of visitors on the resident bat colony at the Old Tunnel for 63 consecutive nights from 2 June through 3 August 1992. By initiating daily collection of data in June, we assumed spring migration was completed, a resident population of bats occupied the tunnel, and data collection would be finished before the staging of autumn migrant bats at the tunnel.

Visitors stood in a viewing area located above and to the side of the south-tunnel entrance at a restraining cable about 3 m from the western edge of the cliff and 10 m from the tunnel entrance. No visitors congregated in front of the south-tunnel exit before or during an emergence. No visitors viewed the emergence of bats at the north-tunnel exit because of the restrictions of private ownership. Restrictions on talking by visitors were not enforced, unless they became too loud. Use of flashlights and camera flashes to view or photograph bats was discouraged.

The design of the study consisted of 3 experimental units. In the first unit, the visitor viewing area at Old Tunnel was closed to the public. Visitors were either turned away or retained in the parking area during emergence. Although we attempted a randomized closure of Old Tunnel, public dissatisfaction with this protocol resulted in Monday and Thursday night closures.

In the second experimental group, visitors remained in the parking area until the data on nightly emergence were collected. Visitors then moved into the viewing area during the emergence of bats. We observed the emerging bats to detect differences in flight behavior as visitors approached the restraining cable and during the remaining emergence.

In the third experimental group, visitors assembled immediately in the viewing area upon their arrival before the beginning of the emergence. Nights classified as experimental groups 2 or 3 were determined by a random-numbers table (Cox 1990).

Emergence times of bats with no visitors in the viewing area (experimental groups 1 and 2) functioned as a control in subsequent statistical analyses. However, behavioral observations of bats associated with experimental groups 1 and 2 were recorded and analyzed separately.

A baseline time for the emergence of bats was established by subtracting or adding the starting time of an emergence from or to the official time of sunset.

Any significant delays in the emergence starting time caused by visitors were determined by a *t*-test [$a = 0.05$ (1)]. We used a paired *t*-test [$a = 0.05$ (2)] to assess differences in the starting time of emergence between nights with visitors and no visitors (Zar 1984). We paired (21 pairs) specific nights, the 2 nearest nights of visitors, and no visitors, over the length of the study. We assessed the effects of number of visitors on emergence time of bats by a simple linear regression and ANOVA.

Results

Before the study, 104 visitors viewed bats at Old Tunnel in April and 163 in May. During the study, 1,306 visitors $\bar{x} = 23$ per night, 3 to 74) viewed emergences of bats; of these, 441 composed experimental group 2 and 661 group 3. The other 264 visitors came on closure nights. In late summer and autumn, visitation during week nights increased, but weekends remained the most crowded. After the study, an additional 887 visitors in August, 719 in September, 333 in October, and 26 in November viewed emergences of bats. A total of 3,515 visitors viewed emergences at Old Tunnel in 1992. Analysis using a nearest-pair *t*-test showed that observed variation in time of emergence (Fig. 1) during our study was due to chance, not number or presence of visitors at the time of emergence ($t = 0.19$, df = 21, $P = 0.8$).

Time of emergence by bats ranged from 67 minutes before sunset to 33

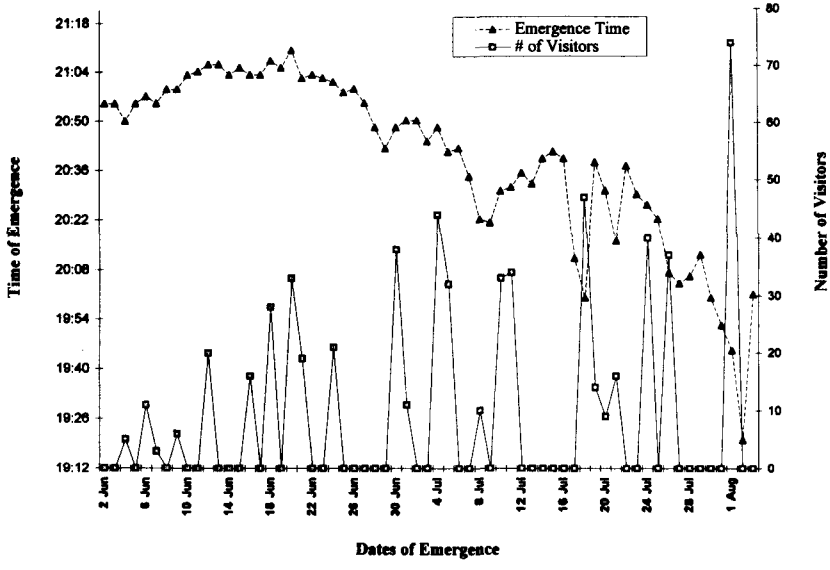

Figure 1. A comparison of the emergence time by a colony of Mexican free-tailed bats with the number of visitors from 2 June to 3 August 1992 at the Old Tunnel Wildlife Management Area, Kendall County, Texas.

minutes after sunset. On average, bats emerged 5.3 minutes after sunset (41 minutes before sunset to 33 minutes after sunset) on nights ($N = 24$) with visitors present in the viewing area compared with 6.3 minutes after sunset (67 minutes before sunset to 32 minutes after sunset) on nights ($N = 39$) with no visitors in the viewing area. Variations in time of emergence occurred with or without the presence of visitors (Fig. 2). Passive visitation did not delay the time of emergence of the bat colony at Old Tunnel ($t = 0.25$, df = 51, $P = 0.4$). The hypothesis that presence of visitors caused a delay in timing of emergence of bats was rejected ($F = 1.9$, $P = 0.27$). In this study, 3% ($r^2 = 0.029$) of variation in timing of emergence was explained by presence of visitors. Conversely, 97% ($1-r^2 = 0.971$) of the variation in time of emergence was attributed to some factor, such as weather, other than visitors.

In early July, a temporal shift in time of emergence occurred as the population increased (Fig. 2). Previously, the colony exited the tunnel after sunset, but in July the colony began to emerge before sunset. Comparisons of times of emergence on consecutive nights revealed only slight differences in times of emergence regardless of the presence or absence of visitors. Dark, stormy weather caused an anomaly in times of emergence on 16 and 18 July. The 26 minutes delay in time of emergence on 2 August remains unexplained; however, the colony may have been disturbed earlier in the day.

Emergence began almost simultaneously from the north and south ends of the tunnel. However, bats ceased emerging from the north exit long before the

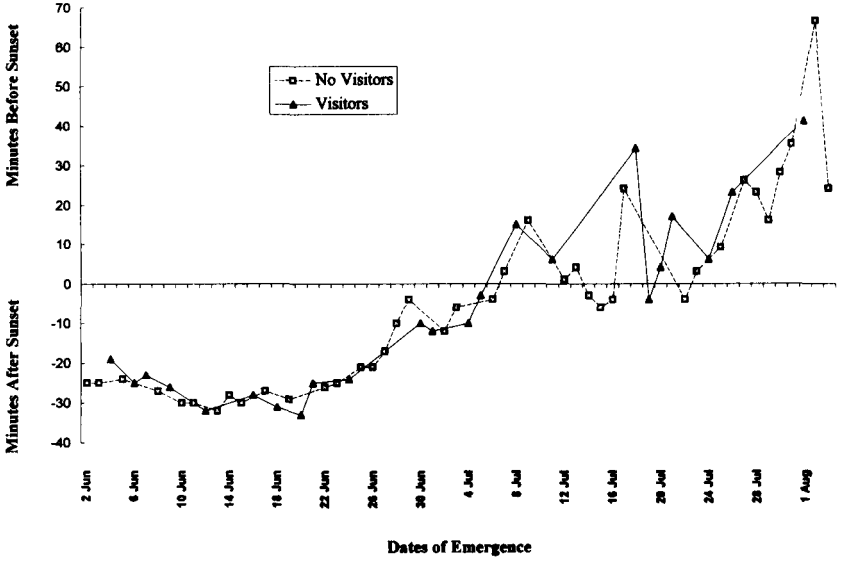

Figure 2. A comparison of the nightly emergence time with sunset and number of visitors for a colony of Mexican free-tailed bats from 2 June to 3 August 1992 at the Old Tunnel Wildlife Management Area, Kendall County, Texas.

completion of emergence at the south exit. We concluded that passive presence of visitors did not force the bats to shift their emergence to the north exit where public viewing was prohibited.

Loud noises and bright lights were 2 important disturbance factors. Higher pitched female and children voices perturbed the emerging bats. Bats abruptly altered their flight away from the noise source. These bats were out of rhythm with the emerging mass of bats and congestion of the air space resulted. Lights caused varying degrees of disturbance. A weak, diffuse flashlight beam into or over the emerging bats caused no flight disruption; however, sharp camera flashes and video-recorder lights beamed toward the emerging bats caused them to veer away. Television bank lights at the tunnel entrance stopped an emergence. Television camera lights from the visitor viewing area did not stop the emergence but caused disorientation and the crash of some bats into vegetation.

In late summer and autumn, the greatest numbers of bats were present in the tunnel. Because of congestion during emergence, bats required maximum flight space to emerge from the tunnel and lift out of the 12-m deep draw. Congestion and saturation of the air space caused the bats to expand their flight space out and over the cliff edge into the public viewing area and surrounding vegetation by 50 m. Changes in flight behavior of bats during emergence occurred on nights when visitors were present compared with control nights. When visitors were present in the viewing area, bats deflected their flight back toward the mass of bats exiting from the tunnel; thus, a bottleneck occurred immediately in front of the tunnel. This curtailed the rate of emergence and prolonged the duration of the emergence. The seemingly benign presence of visitors at the restraining cable diminished available air space for bats.

Discussion

The physical relationship of the tunnel exit and public viewing area was an important factor affecting the extent of disruption by visitors on the rate and timing of emergence. At Old Tunnel, bats exited from the tunnel about 6 m below where visitors stood. Bats roosted at least 12 m inside the tunnel and were insulated from viewing or hearing visitors, and until the bats exited the tunnel, they may not have been aware of visitors. Thus, bats were not subjected to the pressures of activities by visitors before the emergence, and this probably explains why the presence of visitors caused no delay in the time of emergence of the colony in our study. The results of our study contrasted with the findings of Hensley (pers. commun.) at the Eckert James River Cave, Mason County, Texas. She found the emergence time of the colony of Mexican free-tailed bats was delayed in proportion to the number of visitors. Our results would not necessarily be applicable to roosts where the viewing area is directly in front of the cave or tunnel exit and visitors can be viewed and heard by bats from within the roost, such as at Eckert James River Cave and other roost-sites, where bats fly out toward and over visitors during emergence.

Management Implications

Stringent rules should be instituted governing activities of visitors at Old Tunnel. Visitors should not be allowed into the area in front of or near the entrance to the tunnel while bats are in residence. A viewing area should be restricted to the side of the tunnel entrance, and visitors should not congregate above the tunnel entrance. If necessary, a limit on the number of visitors in the viewing area could be imposed.

The population of bats is greatest during late summer and autumn at Old Tunnel, and all available air space is needed for the emergence of bats from the tunnel. Intrusion into the bats' flight space by visitors standing at the restraining cable could be diminished by seating visitors in an amphitheater configuration 3 to 6 m from the cable. Also, the flight space could be enlarged by trimming vegetation along the edges of the cliff.

Illumination of bats during emergence by flashlights and other bright lights should be controlled. Use of camera flashes should be restricted. Several options are available relative to photo opportunities. All photographic activities could be restricted to a 1 to 2 minute-time-window. Another option would ban flashes on cameras and encourage visitors to return in late summer (July to mid-September) when flashes are not necessary. Alternatively, Texas Parks and Wildlife Department could sell postcards or color slides for those wishing to have a photo record. The use of lights for video or television cameras should be prohibited. The intensity, duration, and frequent use of these lights could cause serious disruption and congestion of flights. The long-term effects could be deleterious to the stability of colonies. Television stations can acquire file footage of emergences of bats at Old Tunnel from Texas Parks and Wildlife Department. Bright lights are detrimental to the emerging bats and their use while viewing bats should be considered inappropriate behavior for passive visitation.

During data collecting, we informed visitors about the study. This provided an opportunity to educate visitors about the ecology of bats, wildlife, and conservation. Some visitors returned to view the bats several times through the season, often bringing friends. Tourists are directed to the tunnel from Austin, Fredericksburg, Comfort, Boerne, Kerrville, and San Antonio. Many visitors were from different regions of the nation and foreign countries where such a spectacle of nature does not exist. It became obvious that the public lacks correct information about bats and wildlife, and abundant misinformation and myths are still entrenched in society. The opportunities to influence and enhance the public's perceptions of wildlife, ecology, and conservation are enormous at Old Tunnel. For the wildlife manager, the potential disturbance of the colony of bats by visitors must be weighed against the positive benefits of recreation and public education about these ecologically beneficial mammals.

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