The Effects of a Major Flooding Event on a Large Urban Population of Free-tailed Bats *(Tadarida brasiliensis)*

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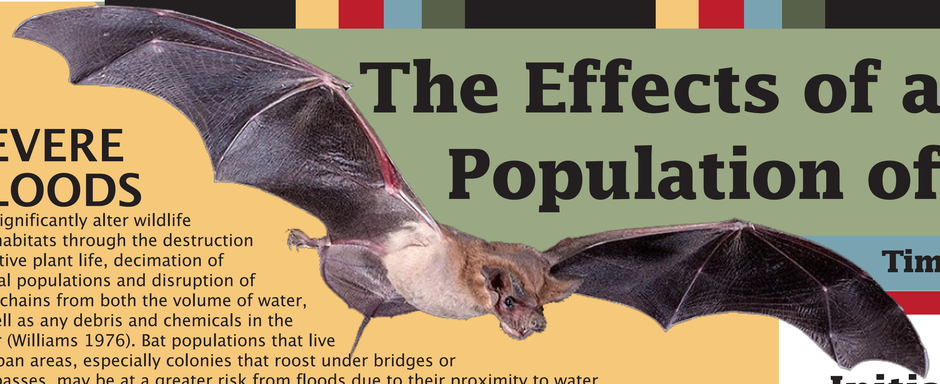


INTRODUCTION

SEVERE FLOODS can significantly alter wildlife and habitats through the destruction of native plant life, decimation of animal populations and disruption of food chains from both the volume of water, as well as any debris and chemicals in the water (Williams 1976). Bat populations that live in urban areas, especially colonies that roost under bridges or overpasses, may be at a greater risk from floods due to their proximity to water, and a significant flood can damage a colony by drowning a population or forcing it to disperse (Gillam et al. 2010). A significant flood can permanently destroy an active bat colony, or at the very least reduce the size of the population (Chamberlain and Leopold 2002).

Houston (Harris Co., Texas) is home to a sizeable colony of free-tailed bats (Tadarida brasiliensis) living under the Waugh Bridge (Conlan et al. 2017). Until recently the colony could be seen exiting the bridge roost every evening from spring through fall, as well as periods of winter. The roost site has access to fresh water and provides a consistent temperature. However, the situation may have changed after the recent Hurricane Harvey and associated flooding.

The purpose of this note is to document observations of the colony and behavior of the resident bats after Hurricane Harvey events. We hypothesize that the flood had negative effects upon population size and behavior, which we will discuss herein.

METHODS

THE SOURCE of Buffalo Bayou (85 km) is near the town of Katy (Ft. Bend Co.), flowing through Houston to the mouth in Galveston where it empties into the Gulf of Mexico. A section of the river that passes through downtown Houston has been converted into the public Buffalo Bayou Park, with several bridges spanning the water.

Figures 1 and 2:
The Waugh Bridge before and during Hurricane Harvey

The Waugh Bridge spans north and south Buffalo Bayou Park via Waugh Drive, and connects Allen Parkway to Memorial Drive. The underside of the bridge is divided into five different sections, with crevices in each section that provide a safe roost for bats. The colony has been present at the bridge since the 1990's, with an estimate of first sightings in 1993 (D. Foss, in lit.)

Data were collected from the time of flooding through the end of the year (late August -December), from late dusk to early nightfall to target the times that bats emerged from the bridge. Durations and concentrations of emergences were recorded, as well as behavioral observations.

Durations were recorded by substracting time of emergence terminations - time of first emergence from the bridge (Table 1). Concentrations of emergences were compared to a control recording made in July 2017 with a handhold phone video recorder (Samsung Galaxy S5). In the absence of emergences, bat presence/absence was detected through unidirectional vocalizations, fresh guano and ammonia odor.

Initial Effects of Hurricane Harvey

On 25 August 2017 Hurricane Harvey made landfall along the Gulf-Coast of Texas. While the greater Houston area was not hit directly by the storm, the region was flooded by 0.9 m of rain. The bats began dispersing from the bridge 26-27 August, with individuals flying to the American General Building (2929 Allen Parkway) across the street to seek temporary shelter from the rising flood water.

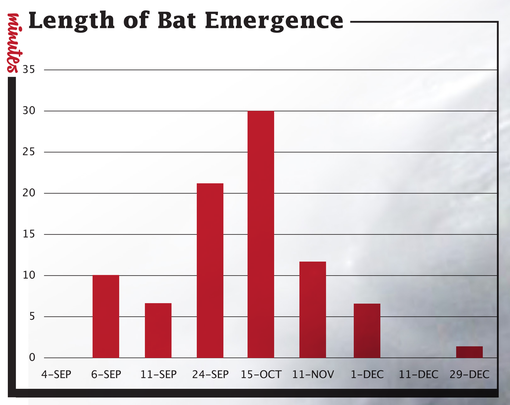
On the morning of 29 August controlled releases of water began from the Addicks Reservoir to prevent further flood damage from excessive rains. The results of these releases inundated the bayou such that significant flooding completely deluged the area. This submerged the roosting area (Fig. 2), and bats were seen flying out of the bridge in the early afternoon. By 31 August the storm had fully moved out of the city, though water levels along the bayou remained high.

We found several deceased bats. Although most of the carcasses were not salvageable as study skins, 20 individuals were vouchered at HMNS as skeletal specimens and tissues were preserved for genetic analyses from at least 10 of these specimens. Interestingly, all individuals that had sufficient genitalia remaining to determine gender were males (no females).

Table 1 – Dates of post-flood emergence times from Waugh Bridge (Houston, Tx)

Date	Time of Flight	Length of Exit
4 September	Bats Did Not Emerge	N/A
6 September	20:05 to 20:15	10 minutes
11 September	19:58 to 20:05	7 minutes
24 September	19:40 to 20:00	21 minutes
15 October	19:20 to 19:50	30 minutes
11 November	18:03 to 18:15	12 minutes
1 December	17:50 to 17:58	8 minutes
11 December	Bats did not emerge	N/A
29 December	Individuals exited at 18:18	1 minute

2017



Emergence Observations

Table 1 and Figure 3 illustrate dates of post-flood emergence times and durations, respectively, from Waugh Bridge. On 4 September bats were beginning to repopulate the roost as vocalizations were heard under the bridge, even though they did not exit the roost that evening. On 5 September bats were observed flying out of the 4th section of the bridge, confirming their utilization of part of the bridge. On 6 September bats could be seen flying out from the 2nd and 4th sections of the bridge at 20:05 hrs, with higher numbers under the bridge than the previous evening.

Observations made on 11 September revealed a larger population of bats compared to the previous week, with a larger group exiting the bridge at 19:58 hrs. Fewer bats remained under the bridge after 20:05 hrs than previous evenings, though most of the colony appeared to still be living in the 4th section of the bridge. However, when exiting bats would leave from one side of the bridge, circle around and fly under the 2nd section of the bridge. Similar activity was seen on the evening of 24 September, with activity initiating at 19:30 hrs and the first group of bats emerging at 19:40 hrs, and a second group emerging between 19:50 - 20:00 hrs.

Further observations were made on 15 October, with the bats becoming active between 18:50-18:55 hrs. Vocalizations could be heard from the 1st, 2nd and 3rd sections of the bridge, though the bats did not start to fly out until 19:20 hrs. The bats moved to the 2nd and 3rd sections before flying out in a continuous stream, with two large bursts at 19:32 and 19:35 hrs, with most of the colony exited by 19:50 hrs. Also on this day more guano was found under the bridge than on previous evenings.

Visits made in November and December showed limited change in the bats behavior, just an alteration of the time when the bats flew after Daylight Savings. The colony still exited after sundown, just 1 hr earlier (e.g., 18:03-18:15 on 11 November, and 17:50-17:58 on 1 December), though on two occasions (11 and 29 December) the bats could be heard, but very few or none emergee from the bridge, most likely due to the cooler temperature. The smell of ammonia, as well as guano quantity increased since the flood, though the piles of guano were not as prominent as before Harvey.

Discussion

The duration it took for bats to exit the roost ranged up to 30 min, concordant with findings of Lee and McCracken (2001). The variation in the emergence duration is not only different compared to before the storm, but also compared to other populations of T. brasiliensis (Richard et al. 2009) not subjected to events of a storm catastrophe.

The most obvious deleterious effect was the presence of many dead individuals, which is apparent in any population affected by a natural disaster such as flooding (cf., Williams 1976). The deceased individuals combined with 'population scatter' likely attributed to the bats not emerging from the bridge at all prior to 5 September despite at least some individuals repopulating the bridge.

Several behavioral differences were noted post-storm. For example during mid fall bats made a 'false exodus' from the bridge, immediately circling back to join other individuals in a different section before the colony permanently emerged for the evening. The driving force behind for this behavior is unknown; it is plausible that the bats active at the earliest times were waiting for numbers to build before making a mass exit from the bridge.

Another change in the bats behavior pre- vs post-storm is bats exited in smaller groups or individuals post-storm rather than a large continuous group (pre-storm). While the groups could be relatively large and close together during some evening viewings, on others the groups would be smaller with longer lags between exiting groups. When emerging the bats would remain in tight groups regardless of the numbers of individuals. There was very little consistency among emerging group size, and emergences diminished with temperature, concordant with Hristov et al. (2010). On a related note, later in the fall bats flew out of the bridge after sundown, compared to before Hurricane Harvey when they left earlier at dusk.

Future Work

Future monitoring of the colony will help estimate current population size, and pinpoint increases or decreases in colony population numbers. Additional observations will be made to verify if behavioral changes are a reaction to the flood, seasonal temperature fluctuations, or other possible factors (Lausen and Barclay 2006, Allen et al. 2010). For example, the two different subspecies of T. brasiliensis in the region are known to behave very differently during winter. T. b. mexicana live in large colonies, exit in large groups, and is migratory - disappearing from the region during the winter. In contrast, T. b. cyanocephala tends to live in much smaller groups and is non-migratory so is present during winter (Schmidly 2004). These patterns are similar to what we observed in the cooler winter months. The best method for confirming the role of subspecific behavioral differences is through genetic analysis, which are currently underway.

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