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Cover Photograph: Eastern Red Bats washed ashore at Long Beach, IN. Photograph © R.M. Kurta.

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Death on the Beach: Mass Mortality of Eastern Red Bats over Lake Michigan

Ashley K. Wilson¹, Allen Kurta^{1*}, Thomas Kovacs², Bradford J. Westrich³, Kathryn M. Benavidez Westrich³, and Robin M. Kurta⁴

Abstract - On 29 July 2023, numerous dead bats washed onto the shore of Lake Michigan near Long Beach, Indiana. Based on our field observations, first-hand accounts of residents, and social media posts, hundreds of bats were involved. Almost all were *Lasiurus borealis* (Eastern Red Bats). The animals probably were part of an early migratory wave that encountered severe thunderstorms over the lake the previous night. Future weather-related mortality seems inevitable as surface temperatures of the Great Lakes rise and lead to an increased frequency and severity of storms, which may exacerbate the current downward trend in the number of Eastern Red Bats and possibly impact other species.

Understanding the suite of mortality factors that impact individuals or entire populations is critical for conserving any species (Brand 2013). For bats, with over 1400 species worldwide, most threats come from human-related activities (Frick et al. 2020, Soto-Centeno and Calderón-Acevedo 2023, Wilson 2019). In addition, bats are susceptible to mass-mortality events (defined as death of ≥ 10 individuals) because of the gregarious nature of many species (O’Shea et al. 2016). Herein, though, we describe the death of hundreds of non-colonial bats, coincident with thunderstorms over Lake Michigan, the fourth largest freshwater lake in the world.

Overnight on 28–29 July 2023, multiple severe thunderstorms passed over the southern end of Lake Michigan and the adjacent land of Illinois, Indiana, and Michigan (US National Weather Service 2023a). The storms were characterized by localized wind gusts up to 120 km/h, rainfall up to 13 cm, hail up to 3 cm in diameter, and frequent lightning. After sunrise on 29 July, numerous accounts of dead bats washing onto the southeastern shore of Lake Michigan began to appear on social media platforms, such as Facebook.com and Nextdoor.com, and the incident was eventually reported by local news outlets (e.g., Audacy 2023). The center of this event appeared to be Long Beach, Indiana (41°44’44” N 86°51’5” W).

A concerned citizen contacted us early on 30 July, and we traveled to the area later that day. The lakeside in Long Beach is densely populated with large beachfront homes, but public access to the lake is maintained by multiple narrow corridors between houses that are termed “stops.” A resident gave us 15 bats that she had collected from the beach and the water near Stop 16 prior to our arrival at about 14:00 hours. We then walked southwesterly along the shore, about 2 km from Stop 21 to Stop 11, and gathered another 14 carcasses for a total of 29 recovered bats.

On the day of our visit, the weather was warm (28 °C) and sunny, and the beach was crowded with hikers and sunbathers. As we searched for bats, we received numerous first-hand accounts from people who had encountered 10–25 bats on different segments of beach on 29 July. Multiple witnesses described bats tumbling in the surf or washed onto shore,

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with beachgoers collecting the animals and depositing them in garbage cans or burying them in the sand. Other observers noted that gulls (*Laridae*) were frequently snatching the dead bats and flying away.

All 29 bats were *Lasiurus borealis* Müller (Eastern Red Bats), which roost individually within foliage (Kurta 2017). Near Lake Michigan, all young-of-the-year would be volant by 28 July, but all the collected animals were adults, based on the degree of phalangeal ossification. Fourteen recovered bats were female, and 12 were male; sex could not be determined for 3 individuals with damaged bodies. All males had well-developed testes; average length, measured externally, from the proximal end of the right testis to the distal end of the cauda epididymis, was 11 ± 0.4 (*SE*) mm, indicating a readiness for mating (Cryan et al. 2012). The reproductive condition of the females was not apparent because of the decay that had occurred over 36 or more hours; however, by late July, all adult females would have been classified as post-lactating or non-reproductive (Kurta 2010). Mean forearm length for the 29 bats (39.6 ± 0.3 mm) was typical of adult Eastern Red Bats (Kurta 2017).

Through Nextdoor.com, we requested that citizens send us the locations and photographs of bats they had seen. Sixteen photos resulted, and 15 were of Eastern Red Bats; however, 1 photograph taken near Stop 11 clearly showed a *Lasiurus cinereus* (Palisot de Beauvois) (Northern Hoary Bat). Based on the in-person accounts, social media posts, e-mail messages that we solicited, and descriptions in the news media, we determined that dead bats appeared on the beach from Stop 36, which is about 45 m southwest of the Indiana-Michigan border, through Long Beach, to Washington Park, in the city of Michigan City, Indiana, a distance of 7.5 km. The numerous sightings of 10–25 dead bats by different people over multiple kilometers of beach suggested that hundreds of bats had died, and possibly even more, because many carcasses were removed by gulls. Furthermore, other bats were probably eaten by fish or sank to the bottom without reaching the beach (Diehl et al. 2014, KING5 2023).

To determine whether the bats had been feeding on the night of their death, we analyzed stomach contents under a dissecting microscope (Whitaker 1988). Five bats had been submitted to the Animal Disease Diagnostic Laboratory (ADDL) at Purdue University for clinical evaluation, and 4 bodies were too damaged to collect food remains, leaving 20 animals for the analysis (Whitaker 1988). Eighteen of the 20 bats lacked intact internal organs due to autolysis, so to obtain dietary information, we examined about 0.5 ml of amorphous material taken from the approximate location of the stomach. The other 2 individuals still had intact stomachs, although 1 was empty. Overall, insect fragments recovered from these 19 bats were primarily pieces of Lepidoptera ($77 \pm 6\%$ volume) and Coleoptera ($14 \pm 4\%$), with the remainder including small amounts of Neuroptera, Hymenoptera, Diptera, and Trichoptera. Lepidopteran remains were found in every individual (100% frequency), and coleopterans were recovered from 12 (63%) bats. Although we could not quantify the amount of food ingested, the types and relative proportions of insects consumed were typical of Eastern Red Bats (Clare et al. 2009, Whitaker and Mumford 2009). Pathologists at the ADDL recorded insect pieces inside the 5 animals they inspected (Bromin and Lakin 2023), so 24 of 25 bats had evidence of recent foraging. A typical dietary composition and recent consumption by 96% of the bats suggested normal feeding behavior.

Although the bats had eaten recently, we posit that they were not residents involved in nightly foraging over the lake. Instead, we propose that these animals were early migrants heading south, based on published observations of the behavior of this species. Eastern Red Bats often follow coastlines or fly over large expanses of open water, including the Great Lakes, during migration (Dowling 2018, Hatch 2015, Hatch et al. 2013, Jonasson 2017, True et al. 2023), so their presence over Lake Michigan would not be unusual. Late-summer

migration by Eastern Red Bats begins in late July (Kunz 1971, Walters et al. 2006), when this particular event occurred. Furthermore, numerous reports exist of these bats migrating in groups or waves (Carter 1950, Hall 1946, Howell 1908, Jackson 1961, Thomas 1921, Whitaker and Mumford 2009), which could explain the large number of animals that were impacted over a small geographic area in just a few hours. Finally, males constitute 74% ($n = 326$) of the adult population during July on the nearby mainland (Kurta 2010), but only 46% of the 29 bats that died over the lake were male; these percentages are significantly different ($\chi_1^2 = 9.45$; $P = 0.002$) and suggest an influx of females from the north during the night of 28–29 July.

We excluded several potential causes for this incident that had been proposed by various residents, reporters, and biologists. For example, Eastern Red Bats are often killed at North American wind farms, and such fatalities increase immediately before and after the passage of storm fronts (Arnett et al. 2008). Nevertheless, interactions with turbines likely were not involved because the closest industrial-scale wind development along the coast of Lake Michigan is 225 km north of Long Beach, in Mason County, Michigan (Indianamap.org 2023, Thumbwind 2023). The bats submitted to the ADDL, although badly decayed, displayed no signs of gross trauma or histological markers of inflammation (Bromin and Lakin 2023), indicating that disease or toxicological exposure probably was not involved. Lightning or hail also were not likely explanations for the deaths. Lightning would cause severe burns, but we observed none in our sample or the submitted photos. Hail of sufficient size to kill the animals outright should have fractured some bones (e.g., Gates 1933), but we did not record any broken forearms or damaged skulls in the animals recovered from the beach.

A more plausible explanation involves the winds and rain typically associated with thunderstorms (Barry and Chourey 2003, Stull 2000). As a distant thunderstorm approaches, the wind direction initially is toward the storm. Radar images shortly after midnight CDT on 29 July show the stormfront advancing over southern Lake Michigan, from west to east (US National Weather Service 2023a), and the inflowing air would have nudged any bats flying over mid-lake or along the eastern shore toward the advancing storm. As the warm inflow approaches the leading edge of a thunderstorm, the winds slant upward and become a high-velocity updraft (Nowotarski and Markowski 2016). The speed of the updraft is directly related to the “convective available potential energy” (CAPE) of the air (US National Weather Service 2023b). For this storm, CAPE reached an unusually high value of 5000 J/kg (US National Weather Service 2023a), indicating that the upward velocity conservatively exceeded 100 km/h (Stull 2000). If still aloft at this point, the bats would pass from the inflow into the downdraft, in which air descends rapidly with heavy rain and possibly hail. Radar reflectivity of the storm on 28–29 July was up to 50 dBz (US National Weather Service 2023a), and Diehl et al. (2014) calculated that a storm of that magnitude could deposit up to 15 g of water on a small animal every 5 minutes.

Resisting these forces would be difficult for an Eastern Red Bat that weighs only 7–13 g (Kurta 2017) and has an average flight speed of about 24 km/h (De la Cueva et al. 1995). Rain alone doubles the energetic cost of flight (Voigt et al. 2011), and the bats probably became fatigued and fell or were forced into the water by the downdraft and intense rainfall. Although these mammals can swim for short distances, using a motion similar to the butterfly stroke of humans (Craft et al. 1958), bats have difficulty taking flight from the water’s surface, especially when the fur is saturated (Borell 1937, Whitaker and Mumford 2009). We doubt that exhausted animals could have traversed even a few hundred meters while swimming among waves up to 2 m in height (NOAA 2023).

Migrating Eastern Red Bats consistently collide with tall buildings in Chicago, on the southwestern shore of the lake (Timm 1989). However, there are no previous records of

mass mortality in this species due to storms over Lake Michigan or elsewhere, although 5 Eastern Red Bats washed ashore after a severe thunderstorm over the lake during September 1953 and 4 bats did so in April 1960 (Mumford 1973). Migrating birds, in contrast, are frequently killed in large numbers during severe weather events (Newton 2007), including those associated with Lake Michigan (Diehl et al. 2014), so it is surprising that large-scale death of Eastern Red Bats has never been reported. Nevertheless, migration is an inherently risky venture (Alerstam et al. 2003), and we suggest that the death of these bats resulted simply from an inopportune encounter with a somewhat infrequent event—a severe thunderstorm that intersected their migratory path over the lake.

Data from mistnetting, acoustic detections, and submissions to governmental health laboratories for rabies testing suggest that the population of Eastern Red Bats that summer in the Great Lakes region is declining (Long 2008, Kurta et al. 2023, Mallinger et al. 2023, Winhold et al. 2008). Although the death of Eastern Red Bats via thunderstorm appears rare, such a mode of mortality could become more frequent. Global warming is already causing higher surface temperatures in the Great Lakes, which, in turn, are leading to increased severity and frequency of storms over the water (Hayhoe et al. 2010). Future storm-related mortality seems inevitable, and it may exacerbate the current downward trend in the number of Eastern Red Bats and perhaps other imperiled species, such as the Northern Hoary Bat (Frick et al. 2017).

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