

Mass die-off of juvenile Ornate Box Turtles, *Terrapene ornata* (Agassiz, 1857), in Chaves County, New Mexico, USA

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Terrapene ornata (Agassiz, 1857) is a terrestrial turtle species widely distributed throughout central North America in grassland, desert, and prairie-forest ecotones (Doroff et al., 1990). *Terrapene ornata* is widespread throughout the U.S. state of New Mexico, except for its northwestern region (Degenhardt et al., 1996). Declines in the states of Illinois, Nebraska, and Wisconsin have been associated with direct mortality due to habitat loss, fragmentation, and harvest pressure from the pet trade (Doroff et al., 1990; Converse et al., 2005; Refsnider et al., 2011). However, non-anthropogenic box turtle mass mortality has been rarely observed in nature. For example, Agha et al. (2017) reported a die-off of 17 free-ranging Eastern Box Turtles, *Terrapene carolina* (Linnaeus, 1758) in Berea, Kentucky, USA, due to upper respiratory disease caused by atypical weather fluctuation.

The Mescalero Sands are located in east Chaves County, New Mexico, USA, and are managed by the Bureau of Land Management. The dunes are made of two distinct layers of aeolian sand (upper and lower) that differ in age (Hall and Goble, 2008). The dominant vegetation is Shinnery Oak (*Quercus havardii*) and cottonwood trees (*Populus fremontii* var. *wislizeni*) due to a shallow water table (Goble and Hall, 2008; BLM, 2021). On 6 June 2021, while surveying invertebrates, we accidentally discovered multiple juvenile *T. ornata* shells in one of the depressions near a patch of cottonwood trees. On 9 June 2021 we conducted a thorough search of the ca. 1900 m² area and recovered 83 juvenile *T. ornata* shells with a mean straight line carapace length of 53.8 ± 7.0 mm. There were very few remnants of bone and flesh, which may be attributed to scavenging by turkey vultures in the area (Fig. 1A).

Absence of claw, beak, or tooth marks on the shells likely rules out predation as a possible cause. On 4 July 2021, we recovered an additional 11 shells and anticipate that more may be covered by sand. To our knowledge, this is the largest mass die-off of ornate box turtles reported to date.

From March–May, the Mescalero Sand Dunes received 0.4 cm, 3.9 cm, and 6.9 cm of precipitation in 2018, 2019, and 2020, respectively. From November 2020–April 2021, the area was placed in the D4 exceptional drought index for the first time since 2014 (NOAA, 2021). This drought index corresponds to and will be further amplified with a La Niña phase of El Niño–Southern Oscillation, which the southwest USA was positioned to enter in 2021 (NOAA, 2021). Therefore, drought should be considered a major contributor to this mass die-off. However, from March–May 2021, the dunes received 9.6 cm of precipitation, with May being the wettest month (7.3 cm) through a series of eight thunderstorms (NOAA weather station GHCND:USC00291445). These episodic heavy precipitation events coupled with a shallow water table could have alternatively caused the juvenile turtles to drown, although we are not certain how deep the water could have been since the dunes are actively moving.

Terrestrial turtles and tortoises are known to use relatively large water bodies and have excellent swimming abilities (Donaldson et al., 2005; Sirsi et al., 2017; Forrester et al., 2020). Nevertheless, terrestrial turtles must support their entire body mass during locomotion, whereas aquatic turtles can partially support their body mass through hydrostatic pressure during aquatic locomotion (Marvin and Lutterschmidt, 1997). The absence of any adult *T. ornata*, which have more strength and higher load-bearing abilities than juveniles, raises the question of whether the die-off was caused by drowning. The survey site is at the centre of a depression formed between outlying sand dune slopes and surrounding cottonwood vegetation which coincides with the accumulation of the possibly drowned turtle carcasses and debris found in the area during the survey (Fig. 1B).

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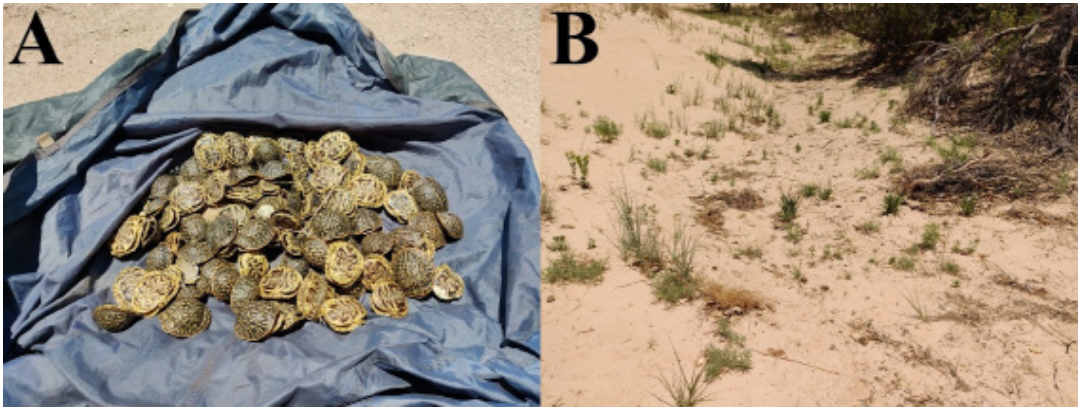


Figure 1. (A) 83 juvenile *Terrapene ornata* collected at Mescalero Sands in Chaves County, New Mexico, USA, in June 2021. (B) Accumulation of debris, indicative of the flooding, at the site where the highest concentration of juveniles was found.

Lightning strikes were considered a potential cause of the mass die-off but it was ruled out due to the lack of fulgurites, which are formed when lightning strikes sand and forms a superficial glass coating (Galliot, 1980). There were no atypical drops in temperature that would cause upper respiratory disease. We also tested the sand and the shells for radiation using a Geiger counter and found no abnormalities in the surrounding soil or the turtles themselves compared to normal background radiation levels. Additionally, we have not observed any large predatory birds in the area.

Mass mortalities of wildlife due to extreme weather conditions have been documented in the past (Goodbody, 1961). Heavy precipitation events have been observed during El Niño years and have resulted in the mass mortality of endemic marine sea life, death and/or departure of guano birds, and reduction in coastal fishery and fish meal production (Quinn et al., 1987). MacGinitie (1939) described an isolated instance when the Santa Ana River in California overflowed into Newport Bay and killed large numbers of sessile organisms due to an episodic heavy precipitation event (Goodbody, 1961). *Terrapene ornata* is not sessile but slow-moving, which poses challenges when trying to escape extreme weather conditions such as drought, cold, and flood (Claussen et al., 2002). Similar to other chelonians, *T. ornata* populations likely rely on high adult survivorship that offsets low survivorship of eggs and hatchlings (Rachmansah et al., 2020). However, juvenile die-offs of this magnitude will likely have a negative impact on overall population growth in this area, especially if another similar event causes complete lack of recruitment. To further examine other possible causes for this event, we recommend

conducting systematic surveys in this region to determine whether *T. ornata* populations persist in this area and testing *T. ornata* for potential disease outbreaks (i.e., *Mycoplasma*, *Ranavirus*).

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