WILDLIFE BEHAVIOR AT CULVERTS IN EAST TEXAS

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Supplemental material is available for this note online.

Roadways are frequently associated with negative effects on wildlife, including direct effects such as vehicular fatalities, barriers to transit, removal of vegetation, habitat loss, edge effects, and corridor effects (e.g., Bennet 1991; Seiler 2003; Coffin 2007; Fahrig & Rytwinski 2009; Chen & Koprowski 2019), as well as indirect effects such as vehicle noise and artificial light (Goodwin & Shriver 2011; Shannon et al. 2014; Bliss-Ketchum et al. 2016; Troïanowski et al. 2017). Yet, many species of wildlife occur along roadways (Fahrig & Rytwinski 2009; Sparks & Gates 2012) as roadways can provide some positive benefits. For example, vegetation along roadways can provide refuges (e.g., Ruiz-Capillas et al. 2013) and can support a diversity of small mammals (e.g., Gonzalez-Olimon et al. 2016). Roadways can provide foraging and scavenging substrates and use of structures along roadways such as powerlines and poles provide perches for hunting for birds (Morelli et al. 2014).

A point of interest for wildlife studies along roadways is the use of culverts. Most culverts were initially designed for drainage, allowing water flow under an obstruction such as a road, or to contain existing streams. Although not initially installed for use by wildlife, these structured tunnels connect contiguous landscape features, facilitating relatively safe passage of wildlife (Sparks & Gates 2012). However, the role of culverts in wildlife ecology may expand well beyond the safe passage of wildlife in urbanized areas, such as providing roosts for bats (e.g., Walker et al. 1996; Keeley & Tuttle 1999; Sandel et al. 2001; Meierhofer et al. 2019), and nesting locations for some species of birds (e.g., Shochat et al. 2005). Whereas most behavioral studies on wildlife use of culverts focus on passage of wildlife, culverts

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provide refuge where various behaviors can be performed (Donaldson 2007; Sparks & Gates 2012). While the use of culverts by animals outside of travel is often mentioned in passing in the literature, the breadth of behaviors performed—and by what species—remains relatively unknown and unquantified. In this preliminary investigation, our goal was to document species richness and the behaviors performed by wildlife at culverts located under Interstate 45 (I-45) in East Texas. We did not determine why different species use different culverts, but instead collected preliminary data on culvert use in this region that could inform or support future research endeavors.

Methods.–We chose six concreate box culverts along the I-45 in East Texas for data collection. These culverts all had two entrances, were not restricted by bars at the entrances, and were straight but differed in their dimensions (height: 1.31–1.68 m, width: 1.37–1.98 m, length: 110–183 m), and obstruction from vegetation at the entrances (0–70%). None of the culverts had a catwalk or sources of artificial light. All entrances were roughly oriented east or west due to the north-to-south direction of the highway. Constructed to assist with drainage, these culverts all had water in or around them.

We deployed one Browning Dark Ops Pro XD trail camera at each entrance of all six culverts for a total of 12 deployed cameras. We oriented trail cameras to face the culvert entrance and to cover as much of the entrance as possible within the frame. Cameras were programmed to take four standard still photos (i.e. four photos taken two sec apart) when triggered with a capture delay of 60 sec. To decrease the chances of detection by both animals and people, we used vegetation to cover each trail camera without blocking or encroaching on the trigger lens.

We collected data between 7 December 2019 and 24 January 2020. The period and length of time we collected data differed between each trail camera (35–50 d). As animals could not be individually identified, and our goal was to quantify behavior and activity of wildlife as opposed to abundance, we calculated the number of visitation events by species as a proxy for species' relative activity. A visitation event was defined as any animal of the same species triggering the same camera within one min of their previous photo trigger. For each visitation event, we recorded the taxon and species of the animal present, the date, the start time and end time, whether the animal entered the culvert, animal interactions (inter and conspecific), and all behaviors performed. We created two simple ethograms to describe basic mammal and bird behaviors likely to be observed on trail camera photos (see supplemental material, https://doi.org/10.32011/txjsci_73_1_Note1.SO1).

Results & Discussion.–We collected a total of 4,089 photos containing birds or mammals across 11 cameras placed at all six culvert sites. Due to placement errors, data were not collected from one trail camera. We documented 856 visitation events by 556 mammals and 300 birds. We identified nine mammal species: Nine-banded armadillo (*Dasypus novemcinctus*), North American beaver (*Castor canadensis*), bobcat (*Lynx rufus*), coyote (*Canis latrans*), fox squirrel (*Sciurus niger*), Virginia opossum (*Didelphis virginiana*), common raccoon (*Procyon lotor*), North American river otter (*Lontra canadensis*), and striped skunk (*Mephitis mephitis*). We also recorded unknown bat species, although previous research in these culverts suggests that they are likely tri-colored bats (*Perimyotis subflavus*, Walker et al. 1996; Sandel et al. 2001; Meierhofer et al. 2019). Of the mammals observed at the culverts, raccoons showed the greatest relative activity across culverts (52.3%) followed by bats (14.2%), beavers (13.5%), and opossums (9%). River otters, armadillos, skunks, and coyotes showed the least relative activity, accounting for less than 2% of mammal visitations when combined.

We identified seven bird species: American robin (*Turdus migratorius*), cedar waxwing (*Bombycilla cedrorum*), eastern phoebe (*Sayornis phoebe*), great blue heron (*Ardea herodias*), northern cardinal (*Cardinalis cardinalis*), white-throated sparrow (*Zonotrichia albicollis*) and yellow-rumped warbler (*Setophaga coronate*). Eastern phoebes and American robins showed the greatest relative activity across culverts (both 24.7% of visitations). White-throated sparrows, cedar waxwings, great blue herons and unknown owl species showed the least activity, accounting for 4% of bird visitations combined.

An animal (bird or mammal) entered the culvert during 44.9% of visitation events. Mammals entered the culvert more often than birds (61.7% of all mammal visitations and 13.6% of all bird visitations). We recorded 1,147 behaviors across all visitation events: a total of 693 behavioral events by mammals, and 454 by birds (Table 1). We classified these events into 14 behaviors, although 3.2% of visitation events had 'unknown' behaviors. The most common behavior performed across taxa was 'travel' (54.8%). Notable observations include use of water in and around the culvert entrance as foraging grounds for raccoons and beavers, scent-marking behavior by bobcats, copulation events by raccoons, drinking behavior by an armadillo, and an interspecific interaction between a beaver and raccoon (Fig. 1).

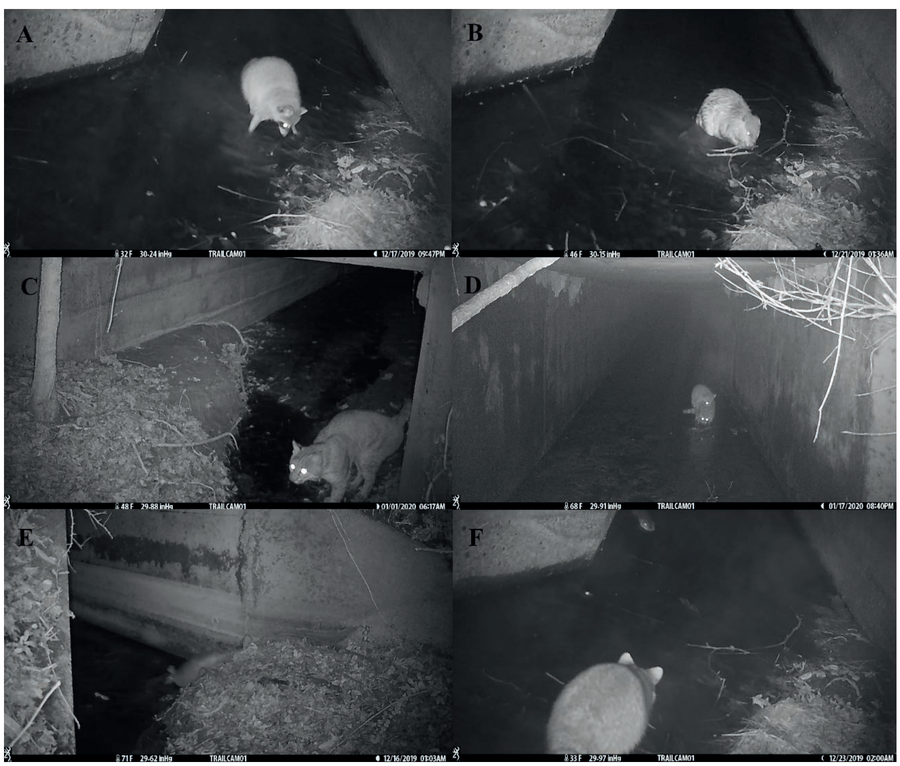

Figure 1. Trail camera photographs of wildlife behaviors performed at culverts in East Texas A) raccoon foraging, B) beaver foraging, C) bobcat scent marking, D) raccoons copulating, E) armadillo drinking, and F) interspecific interaction between a raccoon and a beaver.

Table 1. A count of behaviors performed by species as determined from trail camera photographs at six culverts in East Texas between December 2019 and January 2020.

Species	Alert	Camera interaction	Copulation	Conspecific interaction	Drink	Defecate	Forage	Groom
Armadillo	1	0	0	0	1	0	1	0
Beaver	0	0	0	0	0	0	27	10
Bobcat	2	0	0	0	0	0	0	0
Coyote	1	0	0	0	0	0	0	0
Fox squirrel	3	0	0	0	1	0	0	1
Raccoon	27	2	2	11	0	2	84	0
River otter	0	0	0	0	0	0	0	0
Striped skunk	0	0	0	0	0	0	0	0
Virginia opossum	3	0	0	0	0	0	0	0
Unknown bat	0	0	0	5	0	0	0	0
Unknown rodent	0	0	0	0	0	0	0	0
Unknown mammal	0	6	0	0	0	0	0	0
American robin	3	0	0	18	24	0	0	0
Cedar waxwing	0	0	0	0	0	0	0	0
Eastern phoebe	1	0	0	0	0	0	0	1
Great blue heron	1	0	0	0	0	0	0	1
Northern cardinal	1	0	0	2	0	0	2	0
White-throated sparrow	0	0	0	1	0	0	1	0
Yellow-rumped warbler	0	0	0	1	0	0	0	2
Unknown owl	0	0	0	0	0	0	1	0
Unknown sparrow	0	0	0	2	0	0	4	0
Unknown bird	0	0	0	0	0	0	0	0
Total across species	**38**	**8**	**2**	**40**	**26**	**2**	**120**	**15**

Table 1 Continued.

Species	Interspecific interaction	Investigate	Scent marking	Travel	Perch	Roost	Antagonistic	Unknown
Armadillo	0	0	0	2	N/A	N/A	N/A	0
Beaver	1	0	0	57	N/A	N/A	N/A	0
Bobcat	0	1	2	10	N/A	N/A	N/A	0
Coyote	0	2	0	4	N/A	N/A	N/A	0
Fox squirrel	0	0	0	10	N/A	N/A	N/A	0
Raccoon	4	16	0	210	N/A	N/A	N/A	17
River otter	0	0	0	1	N/A	N/A	N/A	0
Striped skunk	0	2	0	3	N/A	N/A	N/A	0
Virginia opossum	1	5	0	45	N/A	N/A	N/A	3
Unknown bat	1	0	0	79	N/A	N/A	N/A	0
Unknown rodent	0	2	0	17	N/A	N/A	N/A	1
Unknown mammal	1	0	0	3	N/A	N/A	N/A	3
American robin	2	N/A	N/A	34	53	0	0	9
Cedar waxwing	0	N/A	N/A	3	0	0	0	0
Eastern phoebe	1	N/A	N/A	43	60	1	0	0
Great blue heron	0	N/A	N/A	3	0	0	0	0
Northern cardinal	1	N/A	N/A	16	15	0	1	3
White-throated sparrow	0	N/A	N/A	2	0	0	0	0
Yellow-rumped warbler	1	N/A	N/A	27	17	0	0	0
Unknown owl	0	N/A	N/A	3	2	0	0	0
Unknown sparrow	2	N/A	N/A	12	5	0	0	1
Unknown bird	3	N/A	N/A	45	17	6	0	0
Total across species	**18**	**28**	**2**	**629**	**169**	**7**	**1**	**37**

Most culvert-wildlife interactions research focuses on the passage of an animal from one side to the other, and how this may reduce wildlife fatalities and wildlife vehicle collisions (WVC, e.g., Donaldson 2007). However, our research showed that, in more than half of the visitations recorded by birds and mammals combined, animals did not enter the culvert. Birds and mammals were recorded performing a number of behaviors in or around the culvert, including drinking, foraging, scent marking and investigating (see Table 1). The water found in our surveyed culverts may have had a significant influence of the behaviors found to be performed by both birds and mammals. Animals were observed using standing water for drinking and, on numerous occasions, raccoons and beavers were observed foraging in and around this water. Although not surveyed, we observed frogs, fish, and crayfish in and around the water at these culverts during previous wildlife surveys, which appears to provide foraging opportunities for raccoons. Similarly, small branches and twigs that gather at the entrances of the culverts due to water drainage provide foraging opportunities for beavers. Future research could further investigate the influence of water presence and depths at culverts and how this influences species presence, passage, and behaviors. Indeed, the incorporation of water features into culverts may act to encourage safe passage of semi-aquatic mammals such as beavers and otters.

There are several ways in which our findings could expand to future research and potentially assist with wildlife management. We acknowledge that our data is preliminary and collected over a short period of time, thus extending data collection across both time and space would allow researchers to establish the general use of culverts by wildlife in this heavily trafficked area of Texas. Such data could potentially determine the relationships between culvert use by wildlife, seasonal variation in behavior, and incidents of WVCs. Although we acknowledge a lack of independence in our data due to the inability to identify individual animals, our data indicates the amount of activity of each species at each culvert, which could be argued as a superior indicator of WVC threat than the number of animals using the culvert (e.g., one animal using the culvert over the course of 20 minutes may be more likely to cause a WVC than three animals using the culvert for one min each). Although deer are the main animal associated with reported WVCs in the United States, raccoons and coyotes—two species observed in and around our study culverts—are included in the top five animals most likely to be involved in reported WVCs (NICB 2018). Texas is third in the United States for reported WVC (NICB 2018) and eastern Texas—our study area—is considered a WVC hotspot within Texas (Burton et al. 2014). Our observations show that culverts may attract wildlife for uses other than passage (e.g., foraging), thus potentially attracting wildlife to culverts and with it, potentially increase chances of WVCs. In our study area, nine of the 12 entrances of our six study culverts were within only a few meters of a two-lane service road, which could potentially lead to increased wildlife presence and thus higher chances of WVCs on these service roads. Understanding the use of culverts as habitat features by wildlife may assist road infrastructure departments in planning for and mitigating potential WVCs threats, both to the benefit of the public and to species occupying these regions.

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