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Wildlife road mortalities during COVID-19 pandemic-related lockdown in south Texas: a comparative survey

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Mortalities of wildlife caused by collisions with vehicles along roads are increasing in prevalence, threatening the existence of various species and populations. The COVID-19 pandemic-related lockdown provided an opportunity to gain a better understanding of how wildlife vehicle mortality occurrences change in response to anthropogenic variables and how varying survey methods influence obtaining mortality data. In this study, data were collected in three observation periods: pre-lockdown (PreL), during lockdown (DL), and post-lockdown (PostL) in south Texas. There were 194 wildlife mortalities recorded during weeks 4–27 of 2020. Results of this study showed that road mortality survey counts did not change PreL, during COVID-19 pandemic-related lockdown (i.e., DL), and PostL. This study also investigated number of mortality survey observers, a key element in road mortality surveys. We observed that two observers detected more wildlife road mortalities than one observer. Information on these novel findings would be useful in the wildlife road mortality survey methods in the future.

KEYWORDS

mortality, state highway, pre-lockdown, post-lockdown, carcasses, COVID-19, wildlife, south Texas

1 Introduction

Worldwide, roads serve important roles in the transportation of humans and goods. As human populations grow, more roads are built to accommodate them. For this reason, road coverage worldwide is increasing and is predicted to keep increasing (Meijer et al., 2018). Road development is of concern to global and regional biodiversity as roads directly degrade and destroy habitats, impede the dispersal of wildlife, and may lead to wildlife mortalities via motor vehicle traffic (Bennett, 2017).

The beginning of the coronavirus disease-2019 (COVID-19) pandemic in March 2020 initiated global change to existing patterns of road vehicle traffic (Khan et al., 2020; Yasin et al., 2021). Countries and localities adopted different measures to stymie the transmission of COVID-19 such as public mobility restrictions and populations voluntarily modifying their travel for the same purpose (Gupta et al., 2020; Kamerlin and Kasson, 2020; Yasin et al., 2021). While legal mandates and personal responses of populations varied globally, a global reduction in traffic and a global reduction of human road traffic collisions occurred (though the level of reduction or increase varied by country; Yasin et al., 2021). Traffic congestion in terms of commuter delay dropped 36% between 2019 and 2020 in Brownsville, Texas (Schrank et al., 2021). However, less traffic does not necessarily result in safer driving. Yasin et al. (2021) showed that during the COVID-19 pandemic, there were higher levels of driving over speed limits during reduced traffic congestion, and that drivers in the USA were more likely to drive distracted or while impaired by alcohol or drugs. Remarkably, the crash rates of single vehicles increased during a stay-at-home order in Connecticut, USA (despite a decrease in multivehicle crashes; Doucette et al., 2020). Previous work in India has shown that speed limit compliance on urban arterial roads such as highways increases during peak traffic volume (Gargoum et al., 2016). This likely translates to rural roads given greater or similar compliance in urban versus rural driving environments as respectively found through simulated driving scenarios in India (Yadav and Velaga, 2021) and estimation of real traffic speed using loop detectors under the road surface in Michigan, USA (Thornton and Lyles, 1996).

Changes in traffic may have implications for wildlife road mortalities. Analyzing wildlife road mortalities during traffic reduction related to COVID-19 in 10 European countries and Israel, Bil et al. (2021) found decreases in large mammal road mortalities in 7 countries but no significant change in mortalities in the other countries. A reduction in wildlife road mortalities occurred in the USA states of California, Idaho, Maine, and Washington during the COVID-19 pandemic (Shilling et al., 2021). Moreover, there were species-specific differences in mortality rates due to the COVID-19 lockdowns in Slovenia (Pokorny et al., 2022).

Notably, in 2020, the COVID-19 pandemic presented challenges for road mortality surveys on state highways and offered unique opportunities for research in Cameron County in south Texas. The lockdown provided an opportunity to analyze the effects of a potentially large reduction in traffic on wildlife road mortality on 4 roadways in Cameron County. Importantly, the lockdown shelter-in-place rules should have eliminated most traffic in Cameron County. Moreover, to prevent COVID-19 transmission, University rules necessitated a reduction in the number of observers in a vehicle from two to one for road mortality surveys, partway through the study. Although Collinson et al. (2014) found no difference in detection rate for observers in the driver seat versus the passenger seat, the overall detection rate may be lowered by the observer number reduction. The main objective of this study was to identify and analyze patterns in wildlife road mortalities related to the COVID-19 pandemic along the state highways in Cameron County in south Texas. We hypothesized that the COVID-19 pandemic-related lockdown and reduced traffic would lower the number of local wildlife road mortalities. We also hypothesized that performing stop and exit (SE) road mortality surveys with one person instead of two would lower recorded mortality abundance during COVID-19

Abbreviations: COVID-19, coronavirus disease-2019; FM, farm to market; SH, state highway; SE, stop and exit.

2 Materials and methods

2.1 Study area

Wildlife road mortality data from SE surveys were collected each week from September 2019 through June 2021 for a total of 92 surveys. During most weeks in this time range, two observers in a Dodge Ram 1500 pickup truck (the passenger was seated in the front passenger seat) drove down 15-km transects on the roads state highway (SH) 48, SH 100, farm to market (FM) 106, and FM 510 in Cameron County, Texas USA (Figure 1). Each individual road mortality survey encompassed all transects surveyed on a given day, surveying 60 km in total. All road mortality surveys were conducted weekly, with observers driving at 64 km/hr along transects. SH 48 and SH 100 were four-lane, divided highways with maximum speed limits of 121 km/hr. They were driven both in easterly and westerly directions during each survey as mortalities could not be seen in all lanes going only one way due to the presence of concrete traffic barriers. FM 106 and FM 510 were two-lane undivided roads with maximum speed limits of 97 km/hr and 89 km/hr respectively. They were driven in just one direction during each survey as mortalities could be seen in both lanes while going in either direction. The direction FM 106 and FM 510 were driven and the order all roads were driven were alternated weekly. The alternation lessened the chance of missing persistent mortalities with greater visibility while driving in one direction than the other. Surveys were conducted between 08:00 and 13:00.

2.2 Wildlife road mortality surveys

Before participating in road mortality surveys and data collection, all observers were required to review photos and videos from a database of wildlife previously observed in the area on a computer. All trainees began road mortality surveys by conducting a practice survey with review from an experienced surveyor before any data was collected. Before beginning a survey, the number and identity of observers and road survey order of each week's survey were recorded. While conducting surveys, the truck's hazard lights and an additional lightbar (Code3 21TR, Code3, St. Louis, MO) mounted on a BackRack (BackRack, Oakville, Canada) rack behind and above the cab were used to enhance public and observer safety. When a carcass within 10 m of the road was

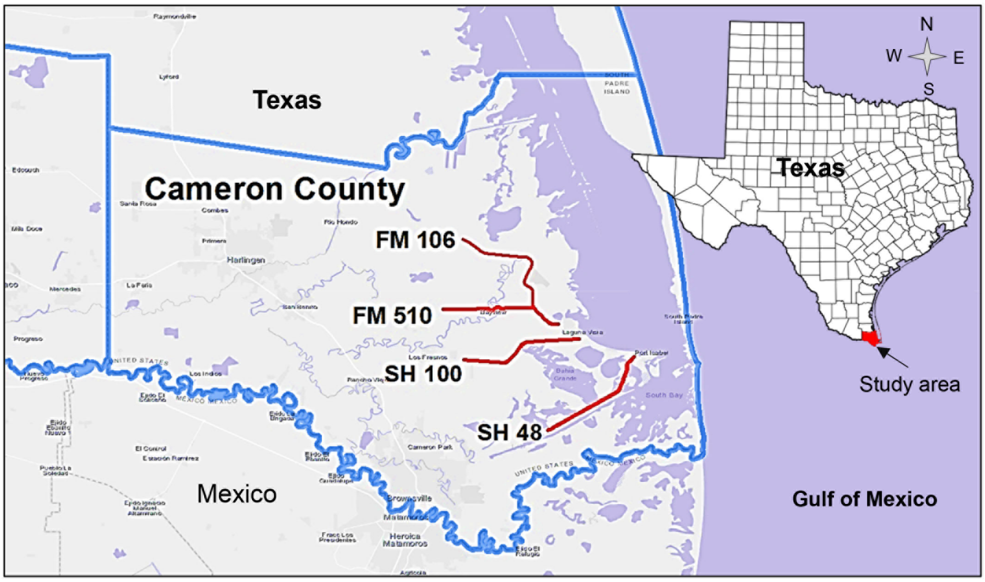

FIGURE 1
Map of the roads surveyed for wildlife road mortalities in south Texas, USA. Wildlife crossing structures are located on State Highway (SH 48), SH 100, and Farm to Market (FM) 106. FM 106 happened to be excluded from all analyses as surveys there began only in August 2020. Only portions of the road that were surveyed are outlined (red). A map highlighting Cameron County within Texas is inset.

observed, the driver stopped the vehicle on the road shoulder and the passenger (or driver, if solo) checked the ArcGIS collector (Esri Inc., Redlands, CA, USA) on a tablet computer (2019 Samsung Galaxy Tab A, Samsung Electronics America, Inc., Ridgefield Park, NJ, USA) to see if the mortality event was new or if it had been previously recorded. Carcasses that had been recorded in a previous week had their continued presence recorded. Analyses in this study included only the first records of mortalities. If new, the passenger (or driver, if solo) exited and used ArcGIS collector and tablet to take a picture of the carcass and record information. Data recorded included species (or most precise taxon) identification, latitude and longitude, location of carcass on the road (e.g., left or right lane), which road was being surveyed, time and date of collection. Helmets and reflective safety vests were worn while outside the vehicle and the data collector waited for a pause in traffic to collect data if the carcass was not on or past the right shoulder. While the passenger collected data, the driver kept watch for approaching traffic, to warn the data collector of oncoming traffic if necessary. For 2-lane roads, location on the road was recorded in terms of “north” and “south” as opposed to “left” and “right”. Several times during surveys precipitation noticeably hindered observation. In such cases, the driver pulled over until conditions became acceptable. On 4-lane roads, driving only in the right lane (unless necessary to switch to the left lane due to construction or another such issue) was crucial to obtaining consistent data. Given surveyors typically drive at a lower speed than the speed limit, slow vehicles ahead of the survey vehicle were typically not an issue. If a safety issue presented itself and passing a vehicle would mitigate the safety issue (such as a car driving slowly with hazards on), passing was performed. Otherwise, slowing down or even pulling over and waiting for a slow vehicle to move out of the area was preferred. On 2-lane roads, when driving under the speed limit, the survey vehicle was parked on the shoulder to let other vehicles pass to maintain community goodwill and for safety purposes.

Near the beginning of the COVID-19 pandemic, to impede its spread, the University of Texas Rio Grande Valley (UTRGV) issued restrictions on vehicle travel with more than one person until vaccinations became available. From March 2020 through May 2021, 58 SE surveys were performed. For 46 surveys in this period, only one observer performed the survey while another person drove behind them and monitored road safety. For the other 12 surveys during this period, two observers performed the survey; one observer was a trainee in these instances.

Daily two-way traffic count data on SH48 for weeks 4–27 were retrieved for station S236 from the Texas Department of Transportation (TxDOT) Statewide Traffic Analysis and Reporting System (https://www.txdot.gov/data-maps/traffic-count-maps/stars.html) and averaged by week. Weekly data for Pre, During and Post lockdown showed a substantial decrease occurring during the lockdown period as compared to Pre and Post lockdown periods (Supplementary Figure 1). No traffic data were available for the other three survey roads.

2.3 Statistical analyses

2.3.1 COVID-19 pandemic-related lockdown

To examine differences in road mortality due to the 2020 COVID-19 lockdown in Cameron County, Texas, USA, data across all road mortality surveys were constrained to weeks 4–27 of 2020 (20 January to 29 June 2020) to enable equal time blocks for comparison. This timeframe included surveys on SH 48, SH 100, and FM 510. Data were then divided into three observation periods encompassing the lockdown period and equal amounts of time before and after: pre-lockdown (PreL) encompassed weeks 4–11, during lockdown (DL) encompassed weeks 12–19, and post-lockdown encompassed weeks 20–27 (PostL). There were 194 mortalities recorded during weeks 4–27 of 2020 (Table 1). The proportions of mortalities located on each individual road in each survey were compared across the three observation periods and road using a one-way analysis of variance (ANOVA). ANOVA was also performed on the dataset with road and observation period as factors to test for differences in the mean number of mortalities per survey between the observation periods. This and all analyses further in the study utilize an alpha value of 0.05 for determining statistical significance, test normality using the Shapiro-Wilk test, and test homogeneity of variances using Levene's test. All univariate analyses were performed using IBM SPSS Statistics 26 (IBM, Armonk, NY).

A second dataset was then created to test for differences in the individual species recorded per survey between the observation periods using permutational multivariate analysis of variance (PERMANOVA) (Anderson, 2001; McArdle and Anderson, 2001) in PRIMER v7 (with the PERMANOVA+ add-on) (PRIMER-e Ltd., Ivybridge, United Kingdom). As many individual species recorded on mortality surveys were not recorded in high enough numbers to provide for robust analysis using PERMANOVA, species with relatively low numbers were consolidated into biologically relevant taxonomic groups with the goal of having groups containing at least 10 individuals recorded in the dataset (Table 2). One unknown mortality which could not be placed in any taxon was removed from the dataset. Coyotes (*Canis latrans*), dogs *(Canis lupus familiaris*), and unknown canids were aggregated as "canid." Eastern cottontails (*Sylvilagus floridanus*) and black-tailed jackrabbits (*Lepus californicus*) were aggregated as "lagomorph." Long-tailed weasels (*Neogale frenata*), striped skunks *(Mephitis mephitis)*, and raccoons (*Procyon lotor*) were aggregated as "musteloid." Birds (Aves) and snakes (Serpentes) were aggregated as "bird" and "snake" respectively. Virginia opossums (*Didelphis virginiana*) retained their own category. Groups with less than a frequency of at least 10 mortalities were excluded from further analysis: artiodactyl (Artiodactyla) (n = 6), felid (Felidae) (n = 3), nine-banded armadillo *(Dasypus novemcinctus*) (n = 6), rodent (Rodentia) (n = 4), and turtle (Testudines) (n = 4), resulting in 194 mortalities in the focal dataset. Survey count data were ln(x+1) transformed, and a resemblance matrix was generated using S_{17} (Legendre and Legendre, 2012) and Bray-Curtis similarity (Bray and Curtis, 1957). The similarity percentages (SIMPER) procedure was run on the matrix one-way with the number of observers as a factor (Clarke, 1993) and using Bray-Curtis similarity as the measure.

Using the resemblance matrix, the homogeneity of the dispersion was tested using permutational multivariate analysis of dispersion (PERMDISP) (Anderson, 2004) using deviations from the centroid. PERMANOVA was performed with the observation period as a factor, both as main and pairwise tests, with an unrestricted permutation of the raw data.

To analyze the one- and two-observer data set with PERMANOVA, count data were $\ln(x+1)$ transformed and resemblance matrices were generated using S_{17} Bray-Curtis similarity for the "all" and "size" datasets and D_1 (Legendre and Legendre, 2012) Euclidean distance for the "total" dataset. Using the resemblance matrices, the homogeneity of dispersion was tested using PERMDISP for each dataset. PERMANOVA was performed for each with number of observers as a factor, both as main and pairwise tests, with an unrestricted permutation of the raw data. For the "all" and "size" datasets, if significant differences were found then the SIMPER procedure was run on the transformed data one-way with number of observers as the factor using S_{17} Bray-Curtis similarity as the measure.

Differences in total, only large animal, and only small animal survey mortality counts between 1 observer and 2 observers were tested using ANOVA in SPSS. Although a seasonal analysis was potentially confounded by required use of one observer in our 2020 surveys later in the COVID pandemic, an ANOVA on total survey mortality counts with year and month as factors was used to check for any effect of seasonality. If assumptions for ANOVA failed to be met, independent-sample median tests (Mood's median test) and Mann-Whitney U tests were used instead.

2.3.2 Number of observers and size of carcasses

Data across all road mortality surveys were subset to 10 September 2019 through 15 June 2021. This encompassed all weeks of March 2020 (when 1-observer surveys started) through the final survey in the dataset plus enough weeks prior to March 2020 to balance the number of 1- and 2-person surveys in the subset to 46 each. Data from FM 106 were not included in the analysis because it was not studied during the entire range of dates. This dataset contained 835 mortalities. Species with relatively low numbers were consolidated into biologically relevant taxonomic groups with the goal of having groups containing at least 10 individuals in the dataset. Eight mortalities were unable to be categorized and were removed from the dataset. Bird wingspans ranged more than 180 cm between small passerines and brown pelicans. Out of concern that this large range could interfere with comparing species group observations by the number of observers, a "bird" group was created but split into "large birds" and "small birds." A wingspan measure was chosen to categorize birds as the wingspan of birds tends to be longer than body length and splayed wings were observed to be common for birds struck by vehicles and exposed to wind. Average wingspan ranges for species were obtained using the Cornell Lab of Ornithology (2019) website. Using the lower number of each average wingspan range, birds ≥70 cm were categorized as "large" and those < 70 cm were categorized as "small."

All non-bird species were also designated "small" or "large" so that changes in observations of mortalities of different sizes due to differing numbers of observers could be analyzed. Published sources were used to obtain average measurements of mammals (Schmidly and Bradley, 2016), turtles (Hibbitts and Hibbits, 2016), and snakes (Dixon, 2013).

TABLE 1 Species groups in analysis comparing wildlife road mortalities recorded during pre-lockdown, during lockdown (DL), and post-lockdown (PostL) for the COVID-19 pandemic on Texas State Highway (SH) 48, SH 100, and Texas Farm to Market Road (FM) 510 in Cameron County, Texas, USA, 20 Jan 2020 through 29 Jun 2020.

Analysis group	Common name	Scientific name	PreL	DL	PostL
Bird	Barn owl	*Tyto alba*	3	4	2
	Bird (unknown)	*Aves*	9	8	4
	Bird of prey (unknown)	*Aves*	0	0	1
	Black-bellied whistling duck	*Dednrocygna autumnalis*	0	0	3
	Black-crowned night heron	*Nycticorax nycticorax*	0	0	1
	Brown pelican	*Pelecanus occidentalis*	1	1	0
	Common pauraque	*Nyctidromus albicollis*	1	0	0
	Eastern meadowlark	*Sturnella magna*	0	1	1
	Great-tailed grackle	*Quiscalus mexicanus*	0	0	1
	Gull (unknown)	*Laridae*	9	8	1
	Laughing gull	*Leucophaeus atricilla*	0	0	9
	Nighthawk (unknown)	*Chordeiles spp.*	0	1	0
	Northern bobwhite	*Colinus virginianus*	2	1	0
	Northern mockingbird	*Mimus polyglottos*	2	0	1
	Small bird (unknown)	*Aves*	4	0	0
Canid	Coyote	*Canis latrans*	3	2	2
	Domestic dog	*Canis lupus familiaris*	2	1	0
Lagomorph	Black-tailed jackrabbit	*Largeepus californicus*	1	0	0
	Eastern cottontail	*Sylvilagus floridanus*	14	11	1
Musteloid	Long-tailed weasel	*Mustela frenata*	0	0	1
	Northern raccoon	*Procyon lotor*	3	4	3
	Striped skunk	*Mephitis californium*	4	2	0
Snake	Great Plains ratsnake	*Elaphe emoryi*	0	0	1
	Snake (unknown)	*Serpentes*	0	5	0
	Texas indigo snake	*Drymarchon melanurus erebennus*	0	0	2
	Western coachwhip	*Masticophis flagellum testaceus*	0	1	0
	Western diamondback rattlesnake	*Crotalus atrox*	3	11	4
Virginia opossum	Virginia opossum	*Didelphis virginiana*	16	12	6
Total			77	73	44

Excepting snakes, terrestrial animals were designated "large" if they are, on average, ≥ the average head-body length (42 cm, rounded down to the nearest cm) and ≥ the average mass (3.15 kg) of a Virginia opossum in Texas, male or female. Virginia opossums were chosen as a threshold out of consideration for their abundance (n = 107) and potential to obscure differences in the detection of the smallest animals if placed in the "small" category. Snakes had very different body shapes than other animals seen on surveys. Their small girth made it more difficult to be seen at 42 cm in head-body length. To account for this, they were designated "large" if the average of their average length range is ≥1 m. The 1 m threshold was chosen by doubling 42 cm and rounding to the nearest meter.

Mortalities of unknown size (n = 114) were excluded from further analysis, resulting in 713 mortalities in the focal dataset (Table 2). Three more datasets were created from this dataset for analysis by PERMANOVA and ANOVA: "all," counts of each

TABLE 2 Species groups in analysis comparing wildlife road mortalities recorded with 1 observer versus 2 on Texas State Highway (SH) 48, SH 100, and Texas Farm to Market Road (FM) 510 in Cameron County, Texas, USA, 10 September 2019 through 15 June 2021.

Analysis group	Common name	Scientific name	Size	*n*
Artiodactyl	Javelina	*Pecari tajacu*	Large	2
	Nilgai	*Boselaphus tragocamelus*	Large	4
	White-tailed deer	*Odocoileus virginianus*	Large	5
Bird (large)	Black skimmer	*Rynchops niger*	Large	1
	Black-bellied whistling duck	*Dednrocygna autumnalis*	Large	7
	Black-crowned night heron	*Nycticorax nycticorax*	Large	2
	Brown pelican	*Pelecanus occidentalis*	Large	63
	Caspian tern	*Hydroprogne caspia*	Large	2
	Crested caracara	*Caracara plancus*	Large	1
	Great blue heron	*Ardea herodias*	Large	1
	Great egret	*Ardea alba*	Large	1
	Gull (unknown)	*Laridae*	Large	38
	Gull-billed tern	*Gelochelidon nilotica*	Large	1
	Laughing gull	*Leucophaeus atricilla*	Large	55
	Osprey	*Pandion haliaetus*	Large	1
	Ring-billed gull	*Larus delawarensis*	Large	1
	Roseate spoonbill	*Platalea ajaja*	Large	1
	Turkey vulture	*Cathartes aura*	Large	1
	Vulture (unknown)	*Catharidae*	Large	1
	Yellow-crowned night heron	*Nyctanassa violacea*	Large	1
Bird (small)	Barn owl	*Tyto alba*	Small	16
	Barn swallow	*Hirundo rustica*	Small	1
	Belted kingfisher	*Megaceryle alcyon*	Small	1
	Common pauraque	*Nyctidromus albicollis*	Small	2
	Common yellowthroat	*Geothlypis trichas*	Small	1
	Eastern meadowlark	*Sturnella magna*	Small	9
	Golden-fronted woodpecker	*Melanerpes aurifrons*	Small	1
	Great-tailed grackle	*Quiscalus mexicanus*	Small	25
	Killdeer	*Charadrius vociferus*	Small	1
	Least bittern	*Botaurus lentiginosus*	Small	2
	Long-billed thrasher	*Toxostoma longirostre*	Small	2
	Mimid (unknown)	*Mimidae*	Small	1
	Mourning dove	*Zenaida macroura*	Small	2
	Nighthawk (unknown)	*Chordeiles* spp.	Small	1
	Northern bobwhite	*Colinus virginianus*	Small	10
	Northern mockingbird	*Mimus polyglottos*	Small	19
	Small bird (unknown)	*Aves*	Small	22
	Spotted sandpiper	*Actitis macularius*	Small	1

(Continued)

TABLE 2 Continued

Analysis group	Common name	Scientific name	Size	*n*
	Western kingbird	*Tyrannus verticalis*	Small	1
	Yellow-billed cuckoo	*Coccyzus americanus*	Small	1
Canid	Coyote	*Canis latrans*	Large	22
	Domestic dog	*Canis lupus familiaris*	Large	12
Felid	Bobcat	*Largeynx rufus*	Large	3
	Domestic cat	*Felis catus*	Large	13
Lagomorph	Black-tailed jackrabbit	*Largeepus californicus*	Small	8
	Eastern cottontail	*Sylvilagus floridanus*	Small	65
	Rabbit (unknown)	*Largeeporidae*	Small	1
Musteloid	Long-tailed weasel	*Mustela frenata*	Small	2
	Northern raccoon	*Procyon lotor*	Large	45
	Striped skunk	*Mephitis californium*	Large	21
Nine-banded armadillo	Nine-banded armadillo	*Dasypus novemcinctus*	Small	20
Rodent	Cricetid rat (unknown)	*Cricetidae*	Small	1
	Mexican ground squirrel	*Spermophilus mexicanus*	Small	1
	Murid rat (unknown)	*Muridae*	Small	1
	North American beaver	*Castor canadensis*	Large	1
	Rodent (unknown)	*Rodentia*	Small	18
Snake	Bullsnake	*Pituophis catenifer sayi*	Large	1
	Great Plains ratsnake	*Elaphe emoryi*	Small	2
	Snake (unknown)	*Serpentes*	Unknown	0
	Texas indigo snake	*Drymarchon melanurus erebennus*	Large	3
	Western coachwhip	*Masticophis flagellum testaceus*	Large	1
	Western diamondback rattlesnake	*Crotalus atrox*	Large	29
Turtle	Red-eared slider	*Trachemys scripta elegans*	Small	5
	Testudinidae (unknown)	*Testudinidae*	Small	1
	Texas spiny softshell turtle	*Apalone spinifera emoryi*	Small	1
	Texas tortoise	*Gopherus berlandieri*	Small	15
	Turtle (unknown)	*Testudine*	Small	6
Virginia opossum	Virginia opossum	*Didelphis virginiana*	Large	107
Total large				447
Total small				266
Total (all)				713

species group per survey, "total," total mortality counts per survey, and "size," total counts of large animals and total counts of small animals per survey. In the "all" dataset, species groups were designated "small," "large," or "both" based on whether the groups contained only small or large animals or both. While large turtle mortalities are possible, none were present in the dataset, so the turtle group was designated "small."

3 Results

3.1 Wildlife road mortalities during COVID-19

Proportions of mortalities from each individual road did not all meet the assumption of normality (Shapiro-Wilk test, FM 510, $P<0.01$), so were normalized by applying the natural logarithmic function. Using ANOVA, no difference was found in the mean proportion of mortalities coming from SH 48 between observation periods (P=0.113). Differences were found for SH 100 (P<0.05) and FM 510 (P<0.05). However, *post-hoc* Tukey test showed differences only between DL and PostL on SH 100 (P<0.05, 95% CI [0.385, 2.3685]) and PreL and PostL on FM 510 (P<0.05, 95% CI [0.2461, 1.9752]). A Kruskal-Wallis H test (the data were not normal, Shapiro-Wilk, P<0.05 for all observation periods for FM 510 and PreL and PostL for SH 100 and transformation could not normalize the data) was also performed on the mortality counts per survey by road. This showed that mortalities per survey were not different across roads (P=0.186). Therefore, only observation period was included as an independent variable in analyses of whether a COVID-19 lockdown lowered the number of local wildlife road mortalities. During lockdown period, data were normal (Shapiro-Wilk, P>0.05). The assumption of homogeneity of variances was violated (Levene's test, P<0.05), so a one-way Welch's ANOVA was utilized. One-way Welch's ANOVA showed that mean number of mortalities per survey were not different between the three observation periods (Welch's $F_{2,\ 13}$ = 2.542, P=0.116).

The resemblance matrix data had homogeneous dispersion (PERMDISP, $F_{2,\ 21}$ = 0.85491, P >= 0.472) and PERMANOVA was run. No significant differences were found for each of the three combinations of observation periods; DL and PreL (P = 0.499); DL and PostL (P = 0.346); and PreL and PostL (P = 0.099). The SIMPER procedure (Table 3) showed that both interactions involving the observation period itself (between DL and PreL and between DL and PostL) were more similar than the PreL and PostL interaction. For that interaction, lagomorphs contributed more (23.43% versus 18.23% for DL and PreL, and 18.73% for DL and PostL) and snakes contributed less to the total dissimilarity versus the other interactions (12.89% versus 20.80% for DL and PreL, and 20.51% for DL and PostL).

3.2 Number of observers and size of carcasses

Pairwise PERMDISP was run for each dataset ("all," "total," and "size") and each showed homogeneous dispersion between 1 and 2

TABLE 3 SIMPER[a] (Clarke, 1993) results of wildlife road mortality data collected weeks 4–27 of 2020 on Texas State Highway (SH) 48, SH 100, and Texas Farm to Market Road (FM) 510 in Cameron County, Texas, USA.

Species Group (G)	G_1 Average Abundance	G_2 Average Abundance	Average Dissimilarity	Contribution %[b]
Total DL (1) and PreL (2)	4.45	4.50	41.99	100.01
Snake (n_1 = 17, n_2 = 3)	0.95	0.26	8.73	20.80
Bird (n_1 = 24, n_2 = 31)	1.24	1.37	7.87	18.75
Lagomorph (n_1 = 11, n_2 = 15)	0.76	0.90	7.65	18.23
Virginia Opossum (n_1 = 12, n_2 = 16)	0.79	1.00	7.37	17.56
Musteloid (n_1 = 6, n_2 = 7)	0.45	0.57	5.65	13.46
Canid (n_1 = 3, n_2 = 5)	0.26	0.40	4.71	11.21
Total DL (1) and PostL (2)	4.45	2.79	49.50	100.01
Bird (n_1 = 24, n_2 = 24)	1.24	1.21	10.60	21.41
Snake (n_1 = 17, n_2 = 7)	0.95	0.53	10.15	20.51
Lagomorph (n_1 = 11, n_2 = 1)	0.76	0.09	9.27	18.73
Virginia Opossum (n_1 = 12, n_2 = 6)	0.79	0.48	8.34	16.84
Musteloid (n_1 = 6, n_2 = 4)	0.45	0.31	6.66	13.45
Canid (n_1 = 3, n_2 = 2)	0.26	0.17	4.49	9.07
Total PreL (1) and PostL (2)	4.50	2.79	49.88	99.98
Lagomorph (n_1 = 15, n_2 = 1)	0.90	0.09	11.69	23.43
Bird (n_1 = 31, n_2 = 24)	1.37	1.21	10.80	21.65
Virginia Opossum (n_1 = 16, n_2 = 6)	1.00	0.48	8.95	17.95
Musteloid (n_1 = 7, n_2 = 4)	0.57	0.31	6.51	13.04
Snake (n_1 = 3, n_2 = 7)	0.26	0.53	6.43	12.89
Canid (n_1 = 5, n_2 = 2)	0.40	0.17	5.50	11.02

The data were sectioned into 3 observation periods: pre-lockdown (PreL, weeks 4–11), during the lockdown (DL, weeks 12–19), and post-lockdown (PostL, weeks 20–27).
The data were transformed by $\ln(x + 1)$. Total mortality n = 194.
[a]Similarity percentages.
[b]Do not total to 100 due to rounding.

observers for all species group counts ($F_{1,90}$ = 4.0155, P = 0.062) and for total mortality counts ($F_{1, 90}$ = 0.24672, P = 0.621) but not for the "size" dataset ($F_{1, 90}$ = 5.2896, P<.05). PERMANOVA was therefore only performed on the "all" and "total" datasets. There were differences in the centroids between 1 and 2 observers for both the "all" dataset (t = 1.6735, P<0.05) and the "total" dataset (t = 4.4155, P<0.005). SIMPER analysis of the transformed "all" dataset revealed that differences in numbers of mortalities observed with 1 observer versus 2 included contributions from both large (41.41%) and small (40.76%) animal mortalities (Table 4).

Subsets of large, small, and total animal mortalities observed with 1 and 2 observers all failed tests of normality (Shapiro-Wilk, P<0.05), as did various transformations of the datasets. Therefore, independent-samples median tests were used to compare median mortality counts and Mann-Whitney U tests were used to compare mortality count distributions.

A difference ($P \leq 0.001$) in the median number of mortalities recorded per survey with 1 observer versus 2 was found using an independent-samples median test (Figure 2). The same test found such difference among both only large animals (P<0.01) and only small animals ($P \leq 0.001$). Mann-Whitney U tests revealed significant differences in the distribution of the 1-observer data versus 2-observer data for all animals (U = 1617, z = 4.382, $P \leq$ 0.001), for just large animals (U = 1424, z = 2.879, P<0.01), and for just small animals (U = 1566, z = 4.020, $P \leq 0.001$) (Table 4).

The ANOVA on weekly survey mortality counts showed no significant differences in month (p=0.340) and year (p=0.346) indicating no strong seasonality variation in the number of mortalities observed.

4 Discussion

4.1 Wildlife road mortalities during COVID-19

An important finding of this study is that the COVID-19 lockdown mandated by Cameron County did not lower wildlife road mortalities as compared to before or after the lockdown, so the hypothesis that it did was not supported. Mortality counts did not differ between observation periods and were closest to differing between PreL and PostL. A reduction in average weekly traffic was evident on State Highway 48, similar to other studies of the COVID lockdowns (Bíl et al., 2021; Shilling et al., 2021). While our results contrast with another study that found reduced wildlife road mortalities across four USA states (California, Idaho, Maine, and Washington) with reduced traffic during COVID-19 lockdowns (Shilling et al., 2021). Based on monthly automobile insurance claims, Abraham and Mumma (2021) reported reduced traffic volumes during the COVID pandemic nationwide but despite this, traffic collisions were unchanged and wildlife vehicle collisions increased as the pandemic went on. Moreover, they found that rural areas away from city centers saw no change in wildlife vehicle collisions during the lockdown period, similar to the

TABLE 4 SIMPER[a] (Clarke, 1993) results of road mortality surveys on Texas State Highway (SH) 48, SH 100, and Texas Farm to Market Road (FM) 510 in Cameron County, Texas, USA between 10 September 2019 and 15 June 2021.

Species Group	1 Observer (n = 46) Average Abundance	2 Observers (n = 46) Average Abundance	Average Dissimilarity	Contribution %[b]
Large (Total) (n = 362)	1.71	2.2		41.41
Bird, Large (n = 194)	0.84	0.91	9.94	15.91
Virginia Opossum (n = 107)	0.52	0.78	7.48	11.98
Canid (n = 34)	0.21	0.25	4.26	6.81
Felid (n = 16)	0.12	0.12	2.49	3.99
Artiodactyl (n = 11)	0.02	0.14	1.70	2.72
Small (Total) (n = 247)	1.09	1.87		40.76
Bird, Small (n = 103)	0.40	0.73	8.23	13.17
Lagomorph (n = 74)	0.29	0.57	7.23	11.57
Turtle (n = 28)	0.17	0.21	3.90	6.23
Rodent (n = 22)	0.11	0.20	3.32	5.31
Nine-banded Armadillo (n = 20)	0.12	0.16	2.80	4.48
Both (Total) (n = 104)	0.48	0.81		17.81
Musteloid (n = 68)	0.27	0.55	6.78	10.85
Snake (n = 36)	0.21	0.26	4.35	6.96

Data were transformed by $\ln(x + 1)$. Total mortality n = 713.
[a]Similarity percentages.
[b]Do not total to 100 due to rounding.

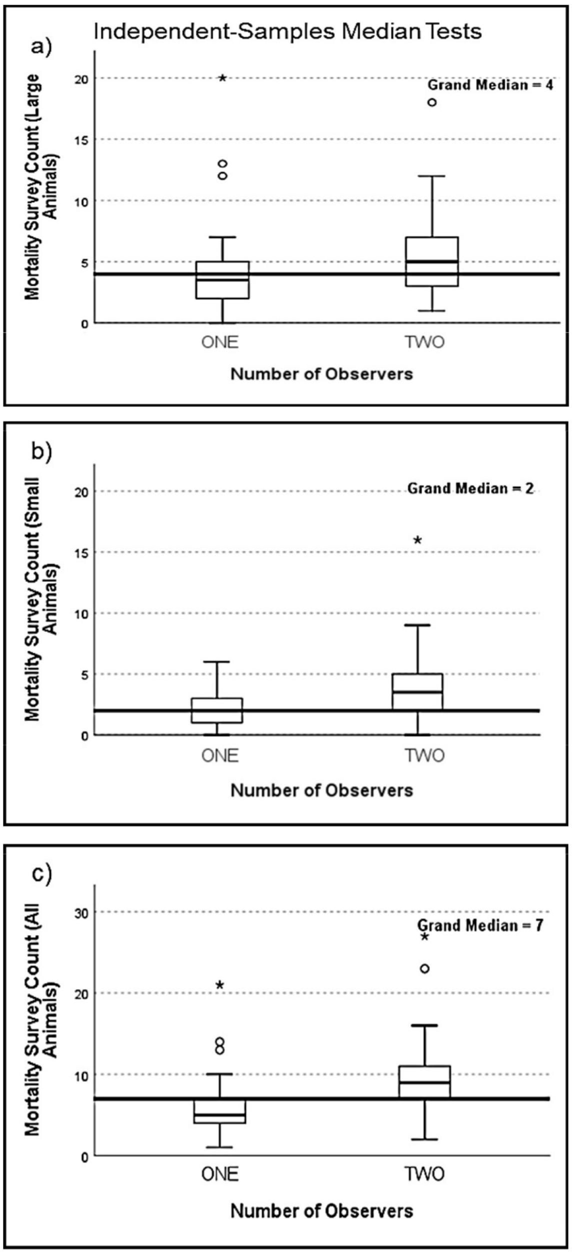

FIGURE 2
Results of independent-samples median tests of road mortality survey counts by number of observers for **(A)** large animals only, **(B)** small animals only, and **(C)** all animals. Surveys were performed in Cameron County, Texas on State Highway (SH) 48, SH 100, and Farm to Market Road 510 between 10 September 2019 and 15 June 2021. Circles indicate outliers and asterisks indicate extreme outliers (> Quartile 3 + 3 × interquartile range). Total N = 92. Medians of counts by number of observers differ for each: **(A)** $\chi^2_{(0.05,\ 1)} = 7.379$, $P \leq 0.001$, **(B)** $\chi^2_{(0.05,\ 1)} = 12.619$, $P<0.01$, **(C)** $\chi^2_{(0.05,\ 1)} = 15.883$, $P \leq 0.001$.

result of the present study. Indeed, traffic reduction has been shown to potentially lead wildlife to be less wary of traffic and attempt to cross roadways more often (Seiler and Helldin, 2006). In urban areas there was a trend of wildlife being detected closer to roads, based on GPS tracking data during the COVID-19 lockdowns (Tucker et al., 2023). This also could have happened with scavengers removing more roadkill on our study roads due to decreased traffic, however it could have increased their mortalities as well. However, iNaturalist observations around North American urban centers of bobcats and coyotes did not increase during the pandemic whereas puma (*Puma concolor*) sightings increased (Vardi et al., 2021). This finding of no change in sightings of smaller mammals such as bobcats and coyotes is similar to our findings for road mortalities in the present study. Reduced traffic during the lockdown on our study roads likely resulted in faster driving (Gargoum et al., 2016; Yasin et al., 2021; Abraham and Mumma, 2021), leaving wildlife less time to avoid oncoming vehicles. In addition, seasonal variation and movements of some species may have masked any changes in mortalities due to the lockdown, such as lagomorphs and snakes (Canova and Balestrieri, 2018; Mata et al., 2009). There were two types of roads surveyed in this study, four-lane divided highways and two-lane undivided highways. The four-lane highways had wider rights-of-way that could have resulted in missed mortality counts due to reduced mowing and visibility in these areas during the pandemic. A limitation of our study was the lack of traffic data for three of the roads, but this was unavoidable given the pandemic. Due to the lack of traffic counts on the smaller two-lane highways, traffic may have been higher than predicted on these roads leading to fewer changes in road mortalities.

4.2 Number of observers and size of carcasses

There was a significant difference in observed mortalities between number of observers for large animals, small animals, and overall, supporting hypothesis 2. The difference was stronger for small animals than for large animals. As large animals are easier to see, they may be easier for a solo driver to spot, especially on the edge of their field of view (FOV) at any given moment. Foot surveys of birds and bats near wind turbines showed smaller species to have lower detection rates (Morrison, 2002). Surveys of road mortalities in Brazil both on foot and via SE surveys showed SE surveys involve lower detection rates than walking surveys, especially for smaller animals (Santos et al., 2016). Vehicle observers in a 3-year study of wildlife road mortalities on 5 major Tasmanian road networks failed to detect any frogs or small lizards despite their likely presence and despite over 15,000 km of total survey effort (Hobday and Minstrell, 2008). There was no difference in the number of felid mortalities, the most important target taxa for road mortality research in south Texas. If such species are the main aim of a project, choosing 1 observer over 2, safety considerations notwithstanding, may be preferred. Canids and artiodactyls, other taxa that are common conservation targets, contributed relatively little to the difference as well. The 1-observer and 2-observer datasets differed in months covered, with the 1-observer data being biased toward earlier in the year than the 2-observer data. Collectively, these findings suggest that seasonality may have played a role in the observed differences, so a longer study period would have been preferable, but not possible due to the unique circumstances of the COVID pandemic

The finding of a significant effect on observer number difference still does not explain our initial finding of no effect on road mortalities due to the reduced traffic during the lockdown period. One and two observer surveys occurred throughout the pre- and during-lockdown periods and were only strictly required two weeks into the lockdown period and post lockdown period. Due to the unequal distribution of one- and two-observer surveys during the COVID lockdown period, this was a confounding factor that could not be tested. However, if an effect of one observer surveys occurred during the lockdown period, this would have reduced the observed mortalities, an effect that we did not detect in our analyses.

5 Conclusion

In conclusion, analysis of wildlife road mortalities before, during, and after a county lockdown for a pandemic did not support the hypothesis that mortalities would be lower during the lockdown. The COVID-19 pandemic necessitated a change in road mortality survey methodology from using 2 observers to 1. Analysis of survey mortality counts with differing numbers of observers supported the hypothesis that reducing the number of observers lowers the number of mortalities detected.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material. Further inquiries can be directed to the corresponding author.

Ethics statement

Ethical approval was not required to study/observe/count road mortality for wild animals.

Author contributions

BB: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. KR: Conceptualization, Investigation, Visualization, Writing – review & editing. MR: Software, Writing – original draft, Writing – review & editing. JY: Funding acquisition, Writing – review & editing. RK: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fevo.2025.1493875/full#supplementary-material

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