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Diversity, Seasonality, and Context of Mammalian Roadkills in the Southern Great Plains

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Abstract Thousands of mammals are killed annually from vehicle collisions, making the issue an important one for conservation biologists and environmental managers. We recorded all readily identifiable kills on or immediately adjacent to roads in the southern Great Plains from March 2004–March 2007. We also recorded distance traveled, whether a road was paved or divided, the number of lanes, and prevailing habitat. Surveys were opportunistic and were conducted by car during conditions of good visibility. Over our 239 surveys and >16,500 km traveled, we recorded 1412 roadkills from 18 different mammal species (size ranged from *Sciurus* squirrels to the white-tailed deer, *Odocolieus virginianus*). The overall kill rate was 8.50 / 100 km. Four species were prone to collisions: the Virginia opossum (*Didelphis virginiana*), nine-banded armadillo (*Dasypus novemcinctus*), striped skunk (*Mephitis mephitis*), and northern raccoon (*Procyon lotor*). Together they accounted for approximately 85% (1198) of all roadkills. Mortality rate differed significantly between 2- and 4-lane roads (8.39 versus 7.79 / 100 km). Kill rates were significantly higher on paved versus unpaved roads (8.60 versus 3.65 / 100 km), but did not depend on whether a road was divided. Roadkills were higher in spring than in fall (1.5×), winter (1.4×), or summer (1.3×). The spring peak (in kills / 100 km) was driven chiefly by the armadillo (2.76 in spring/summer versus 0.73 in autumn/winter) and opossum (2.65 versus 1.47). By contrast, seasonality was dampened by a late winter/early spring peak in skunk mortalities, for which 41% occurred in the 6-week period of mid-February through March. The raccoon did not exhibit a strong seasonal pattern. Our data are consistent with dispersal patterns of these species. Our results underscore the high rate of highway mortality in the southern plains, as well as differences in seasonality and road type that contribute to mortality. Conservation and management efforts should focus on creating underpasses or using other means to reduce roadkill rates.

Keywords *Dasypus novemcinctus* · *Didelphis virginiana* · Dispersal · *Mephitis mephitis* · *Procyon lotor* · Reproductive cycle · Roadkill · Seasonality

Introduction

"Long, narrow slaughterhouses" is an apt description of roads throughout the world (Spellerberg 2002). In a less gruesome vein, roads have been described as barriers, or at least filters, to movement of animals, even to the point of blocking gene flow (Alexander and others 2005; Mader 1984). Whether slaughterhouses, filters, or barriers, one has to drive only a short distance on any highway to remove doubt that a great deal of animals are killed daily. If we hope to mitigate our ever-increasing impact on wildlife, we need to understand the ecological implications of our ever-expanding network of roads.

The United States alone contains >6,300,000 km of public roads. In the coterminous states one will, on average, encounter a road every 35 km (Watts and others 2007), and one "can drive to within a kilometer of 82% of all land" there (Riitters and Wickham 2003). Many places within the United States, the southern Great Plains

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included, have such high road densities that there is <500 meters on average to the nearest road (Watts and others 2007). Road density is even more striking when viewed using the per capita roadless volume metric described by Watts and others (2007): the roadless areas of the southern Great Plains are almost exclusively <1 km^3 / person, an uncomfortable similarity to the much more heavily populated eastern seaboard.

Roads have a variety of ecological effects, including outright destruction of habitat for road construction and concomitant displacement of animals; pollution from pavement, vehicles, and litter; erosion; sedimentation of waterways; chemical alteration of soils; functioning as dispersal corridors for both native and exotic plants and animals; and changing behavior of animals from as small as snails to as large as bears (Spellerberg 2002; Trombulak and Frissell 2000). Impacts can extend >1 km beyond a road's edge (Forman 2000; Forman and Deblinger 2000; Spellerberg 2002).

Yet to the general public, animal mortalities are the most apparent and immediately recognizable ecological effect of roads. Animals of all sizes are affected, from insects to large cervids (Spellerberg 2002; Trombulak and Frissell 2000). Even humans are not immune, but more often we are simply the perpetrators or sympathetic witnesses of the aftermath. Estimates from the hundreds of thousands to well into the millions of roadkilled animals per year have been made for various regions around the world, leading one to realize that, collectively, billions of animals are killed around the globe annually (Spellerberg 2002).

Why are roads so attractive to animals when they present such a high risk of mortality? Many mesopredators occur preferentially near roads, levees, or other linear features in the landscape if their surrounding habitat remains suitable (Frey and Conover 2006). Vertebrates are drawn to roads because they provide a variety of food resources including "spilled grain, roadside plants, insects, basking animals," and road salt (Forman and Alexander 1998). Roads can also be a cornucopia for opportunistic scavengers, especially ones that consume invertebrates, herpetiles, small mammals, or birds. Roadkill is easy prey, albeit coming with a high risk of the scavenger becoming the scavenged. The risk is accentuated on roads on which drivers can travel at high speeds, when it is difficult to react quickly.

Researchers have been concerned with the impact of roads on animals since the mid-1920s. Casual observations of roadkill throughout the United States were published by Stoner (1925, 1935), Sprague (1939), and Knobloch (1939). These early accounts related the concern that cars were having a major negative impact on native animal populations. Later studies were more systematic in their mortality counts, and they began to relate the casualties to biological factors such as dispersal (Davis 1940; Haugen 1944) and to human factors such as resource competition from livestock grazing that forced some animals to feed on roadside vegetation (Davis 1940). Many modern studies have focused on factors such as traffic volume, speed rates, road treatment, road width, or right-of-way (verge) width to explain roadkill rates for a variety of taxa, including mammals, birds, herpetiles, and insects (e.g., Alexander and others 2005; Baker and others 2004; Caro and others 2000; Case 1978; Lodé 2000; Oxley and others 1974; Spellerberg 2002). Most studies have focused on a given species of concern, such as the nine-banded armadillo (*Dasypus novemcinctus*; Inbar and Mayer 1999) or white-tailed deer (*Odocoileus virginianus*; Puglisi and others 1974). Only a few studies — Wilkins and Schmidly's (1980) in southeastern Texas is an example — recorded multiple species and attempted to tie their deaths to physical features. None of these studies have been conducted in the southern Great Plains.

Our study arose from our casual observations of roadkills while driving throughout the southern Great Plains. We noticed apparent seasonal peaks in numbers of certain medium-sized mammals dead along roads, so we began to collect data systematically to test our suspicion that these peaks were related to the specific reproductive cycles of the species roadkilled, such as mate seeking, foraging with young, and dispersal of subadults. We also assessed to what extent factors such as road treatment, width, and division played roles in roadkill rates. Our research indicates patterns of mesopredator roadkills specific to the southern plains as well as highlighting factors and conservation efforts that apply generally.

Methods

Surveys

Between March 2004 and March 2007 we conducted surveys along roads within the southern Great Plains (southern Kansas, Oklahoma, and north-central Texas) for native medium-sized mammals killed by collisions with vehicles (we recorded nothing smaller than a *Sciurus* squirrel). Surveys were opportunistic: they were conducted while driving to and from study sites for other projects or during recreational outings. No pattern of surveys was established, as some roads were driven multiple times, others were not. We recorded all data systematically on standard sheets we designed for this study. All surveys were conducted by car during daylight hours and were spaced at least one week apart if the same road was traversed. We did not survey at night or in inclement weather due to poor visibility. We tallied identifiable carcasses on or directly adjacent to the road but not those hidden in roadside vegetation. We recorded road type, habitat type, and mileage. Roads had 2 to 4 lanes, with and without central dividers/barriers (e.g., vegetation or concrete), and were either paved or dirt/gravel. We distinguished among four broad habitats: rural/agricultural, crosstimbers, bottomland, and prairie. Habitats were classified by the prevailing vegetation on both sides of the road, as visible from our vehicle. Right-of-way areas were not considered in these assessments as they did not affect general habitat structure any more than the roads did. We did not survey urban and high-density suburban areas. Mileage zeroed upon entering a specific road type or habitat and re-zeroed whenever road type or habitat changed.

Biases

A number of biases likely skewed our totals downward, in some cases significantly. For example, Slater (2002) described a large difference between roadkills counted by car and on foot. We bypassed many carcasses we could not identify. We could have tallied such carcasses as “dead animal,” but that did not suit our objective, and stopping for identification was inconsistent with our study design (besides being frequently unsafe, sometimes illegal, and logistically infeasible). Other factors leading to under-counting included intense scavenging and rapid decomposition when warm and humid. Furthermore, critically injured animals could crawl off roads into nearby vegetation, and road clean-up crews sometimes remove carcasses (e.g., Tulsa County crews regularly clear U.S. Route 75 of large mammals, such as deer; R. Jordan *in litt.*). One factor that may have artificially elevated our counts was recounting of carcasses that remained in good condition on a re-surveyed road for longer than a week. Despite these biases our data allow relative comparisons and provide a representative sample of roadkills in the southern Great Plains.

Analyses

We calculated roadkill rates by road type or habitat, which corrected for random coverage and varying sample sizes, and we standardized rates per 100 km traveled. Such rates behave like proportions: so long as sample size was adequate, a biological difference in, say, number of roadkills by road type or season would reveal itself as a difference in their respective rates. But, as with a proportion, calculating separate ones for each survey would have been problematic because on any given day the distance traveled would likely vary; moreover, there could be a high incidence of zeros in the data. Either problem mitigates against use of standard inferential statistics based on the comparisons of central tendency (e.g., means). To alleviate this problem, we calculated a single rate for all data that fell into a particular category of interest: (a) road width (2 or 4 lane), (b) road type (paved or unpaved), (c) whether a road was divided, (d) season, and (e) habitat. Seasons were defined as winter (December, January, February), spring (March, April, May), summer (June, July, August), and autumn (September, October, November). Statistical differences between rates — e.g., between 2-lane and 4-lane roads — is a matter of calculating the 95% confidence intervals (CI) for each and then assessing if the CIs overlap. Calculation of CIs can be accomplished accurately, taking into account sample size and boundary issues (i.e., that rates cannot fall below zero, so neither can the lower CI). We determined CIs with the uncorrected score method, which is suitable for rates and proportions (Newcombe 1998). This method yields unequal CIs — the lower is not automatically equal to the upper — and takes differing sample sizes into account.

Results

We recorded 1412 roadkills of 18 mammal species (size ranged from *Sciurus* squirrels to the white-tailed deer) during our 239 surveys of >16,500 km traveled. The overall rate was 8.5 roadkills / 100 km (Table 1). Four species were prone to collisions: the Virginia opossum (*Didelphis virginiana*), nine-banded armadillo, striped skunk (*Mephitis mephitis*), and northern raccoon (*Procyon lotor*). Together these four species accounted for 84.8% (1198) of all roadkills.

Mortality rate differed significantly between 2-lane (8.39 [8.11, 8.63] / 100 km) and 4-lane (7.79 [7.49, 8.07] / 100 km) roads if we excluded the last two weeks of our surveys (Fig. 1a), but a sharp upsurge in skunks during that two weeks made the difference evaporate (Fig. 1b; 8.40 [8.13, 8.63] versus 8.56 [8.30, 8.78], respectively). The morality rate was also significantly higher on paved roads versus unpaved ones: 8.60 [8.43, 8.76] / 100 km versus 3.65 [2.27, 5.29] / 100 km, but did not depend on whether a road was divided (Fig. 1c, d).

Roadkills were higher in spring than in fall (1.5×), winter (1.4×), or summer (1.3×). The spring peak (kills / 100 km) was driven chiefly by the armadillo (2.76 in spring/summer versus 0.73 in autumn/winter) and opossum (2.65 versus 1.47). On a month-to-month basis (Fig. 2), there was a sharp peak in August for the armadillo (0.69) and distinct peak in April for the opossum (0.47), although that species had secondary peaks in March (0.30) and August (0.32). By contrast, seasonality was dampened by a late winter/early spring peak in skunk mortalities, for which 41% occurred in the 6-week period of mid-February through March (Fig. 2). The raccoon did not exhibit a

Table 1 Rank order of species recorded as roadkills in the southern Great Plains during >16,500 km of surveys, March 2004–March 2007

Scientific name	English name	Total roadkills
Mephitis mephitis	Striped Skunk	355
Didelphis virginiana	Virginia Opossum	339
Dasypus novemcinctus	Nine-banded Armadillo	284
Procyon lotor	Northern Raccoon	220
Sylvilagus spp.	cottontail species	59
Odocoileus virginianus	White-tailed Deer	45
Canis latrans	Coyote	44
Sciurus niger	Eastern Fox Squirrel	28
Sciurus carolinensis	Eastern Gray Squirrel	11
Vulpes vulpes	Red Fox	10
Taxidea taxus	American Badger	5
Erethizon dorsatum	North American Porcupine	3
Marmota monax	Woodchuck	2
Castor canadensis	American Beaver	2
Urocyon cinereoargenteus	Gray Fox	2
Felis rufa	Bobcat	1
Spirogale putorius	Eastern Spotted Skunk	1
Mustela vison	American Mink	1

Nomenclature follows Duff and Larson (2004)

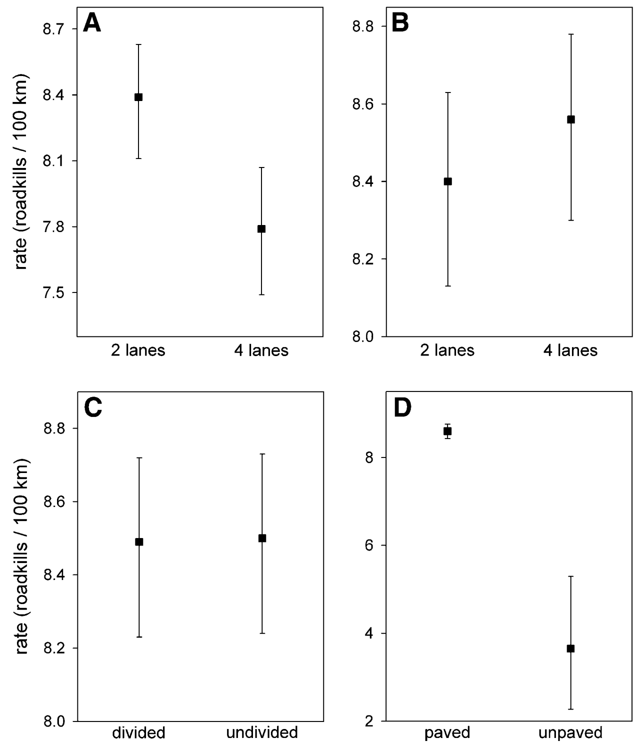


Fig. 1 Total roadkills by road type. Road width (**a**) had a significant effect on roadkill rate when the last two weeks of data were excluded, but disappeared when the upsurge of dead skunks within those last two weeks were added (**b**). Whether a road is divided (**c**) had no effect on roadkill rate, but paved roads had a significantly higher rate than unpaved roads (**d**). Plotted values are the rate 95% confidence intervals

strong seasonal pattern but rather had multiple minor peaks throughout the year.

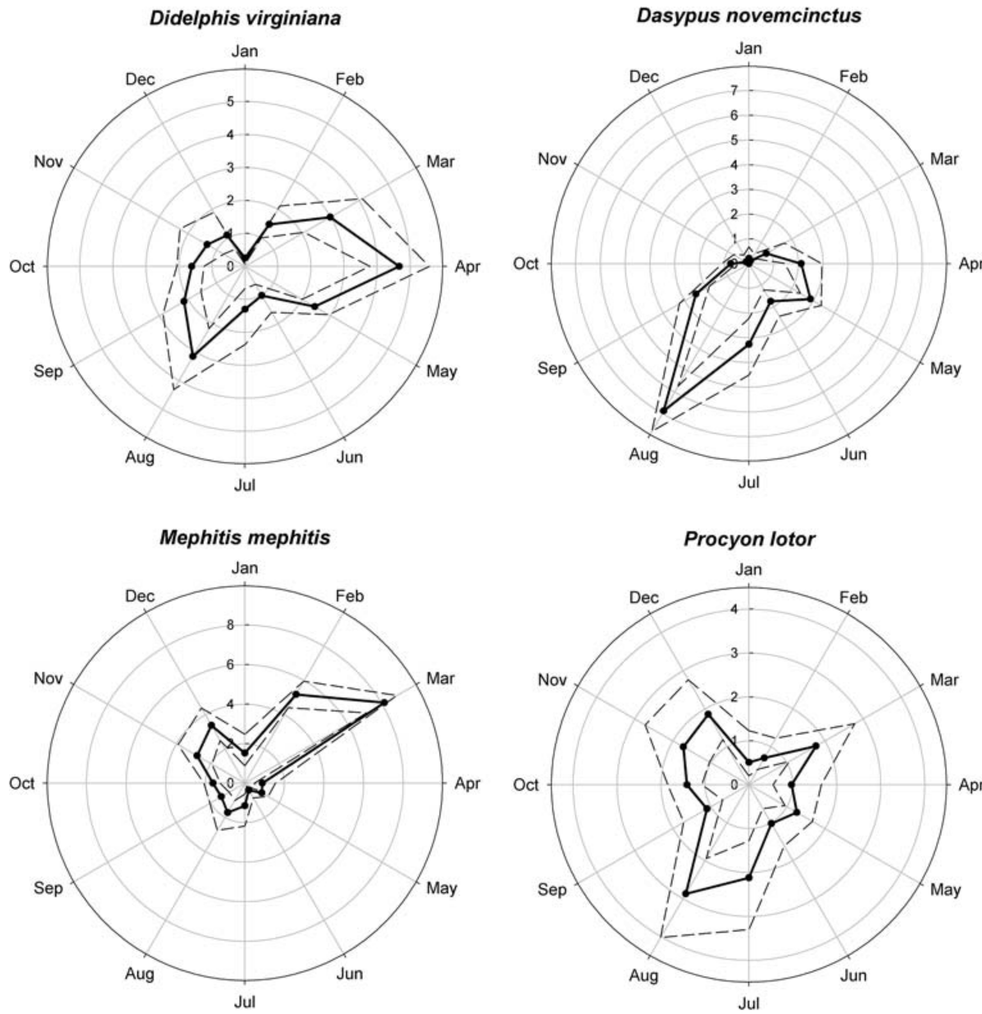
Habitat association did not exhibit as clear a pattern as seasonality (Fig. 3). Total roadkills (/ 100 km) tended to be higher in bottomland (11.1 [8.4, 14.4]), but otherwise differed little among the other habitats (7.4 [6.6, 8.3] for prairie; 8.3 [7.6, 9.1] for crosstimbers; 9.0 [8.4, 9.7] for rural). Individual species overlapped greatly in which type of habitat carcasses tended to occur (Fig. 3). Striped skunks were the only species that affiliated with a particular habitat: many more occurred in prairie (Fig. 3). By contrast, armadillos were the least likely to be found in prairie. Akin to their aseasonality, raccoons showed no habitat association, although relative to other species they were the least likely to be found in rural areas. Opossums were more likely to be in rural areas than the other three species, but their numbers were highest in bottomland (Fig. 3). Roadkills were relatively equal in crosstimbers.

Discussion

Road Features

Principles of physics dictate that the faster an object is approaching an animal the less time that animal has to get out of the way. Given that animals have not evolved at the same rate as vehicle technology it is no wonder that animals often lose the battle. We did not specifically look at rates of speed, but other studies have indicated it has a significant effect (Allen and McCullough 1976; Case 1978). We did, however, include contributing factors to high speed: road width and whether a road was paved. Throughout our study, the road treatment (i.e, pavement or gravel/dirt) remained a key component of the roadkill equation, likely because of a difference in vehicle speed. Oxley and others (1974) determined that “road surface was not a critical inhibiting factor” but “surface (asphalt versus gravel) does affect traffic volume and speed and thus influences road mortality.” We concur. Case (1978) found that speed “accounted for nearly 85 percent of the variation in road-kills” for species he studied in Nebraska. He did not report an effect of traffic volume, although he admitted that his statistics were “unrefined,” yet Conard and Gipson (2006) likewise detected minimal correlation to traffic volume in northeastern Kansas. Clevenger and others (2003) suggest that this minimal association is due to the “alienating effect” of highways acting as deterrents to highway crossing. Other research has shown traffic volume

Fig. 2 Seasonality of roadkill rates (solid lines) for the four most commonly recorded species. Note distinct seasonal peaks for all species except for the raccoon. Dashed lines are the 95% confidence intervals



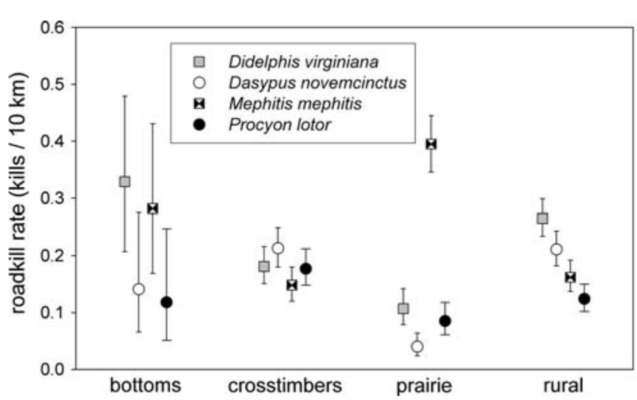


Fig. 3 Total roadkills by habitat type. Skunks had a much higher rate in prairie. Note the mesic to xeric gradient for opossums from bottomland to rural to crosstimbers to prairie. Plotted values are the rate 95% confidence intervals

to be related to road mortality of vertebrates (Alexander and others 2005; Langevelde and Jaarsma 2004; Mazerolle 2004). This aspect requires further study in the southern Great Plains, as traffic volume could conceivably have opposing effects: more cars mean more opportunities for casualties, but they also mean more noise, which could keep animals away from the roads.

Road width had a significant effect on mortality rate, being higher on 2-lane roads when we analyzed all but the last two weeks of our data. The effect disappeared, however, when we added the last two weeks, during which we recorded a spike of dead skunks on 4-lane roads. We reasoned that the wider the road, the lower the connectivity. We thus hypothesized 4-lane roads would present greater hurdles and thus fewer animals would attempt to cross them; furthermore, prior research has pointed to a higher incidence of collisions on 2-lane roads (Hughes and others 1996). Oxley and others' (1974) data indicated the inverse, namely "medium-sized mammals ... showed increasing mortality rates with increasing road clearance." Their definition of road clearance ("distance an animal had to move between forest margins to cross the roadway") does not correspond perfectly to road width, but the idea of crossing a large unnatural area is analogous. They further suggested that mesopredators will continue to cross such spaces and that their likelihood of crossing depends on whether the animal is strongly associated with forest.

We were surprised to find little difference in roadkill rates depending on whether a road was divided, although we recognize that arguments can be made for advantages and disadvantages of a divider. The type of barrier (concrete or vegetative) may play a role, but we did not differentiate between barrier types. Perhaps concrete barriers trap animals in traffic — and we noted many carcasses along such barriers — but a concrete barrier may prevent an animal from seeing habitat across the road and thus discourage it from crossing. Vegetative barriers, depending on their width and extent of cover, may encourage crossing because animals may use them as safety zones. Our study was not designed to account for animals that may have been obscured by these vegetative barriers, but additional studies could tease apart potential differences in barrier type. Another aspect for future study could be effects of road level on roadkill rate, as Clevenger and others (2003) found "that raised roads resulted in fewer road-kills relative to level roads." We did not examine this factor, but roads in the southern Plains are predominantly level or slightly raised, which may contribute to the high rates of roadkills in this region.

Seasonality

Some studies have attempted to associate roadkill mortalities with season (e.g., Caro and others 2000), whereas others have extended the seasonality concept to look specifically at periods such as mating (Davies and others 1987; Davis 1946) or juvenile dispersal (Conard and Gipson 2006; Davis 1940; Wilkins and Schmidly 1980). We hypothesized that roadkill patterns would correlate, within species, with three spurts in movement: mating season(s), post-weaning when young forage with their mother, and dispersal of juveniles. Given our methodology, we could not identify every carcass to species (see Biases, above) nor mammals smaller than a *Sciurus* squirrel, nonetheless we obtained sample sizes sufficiently high to explore patterns in key victims.

Armadillos are killed at a high rate in spring/summer (Fig. 2), a pattern related to their reproductive cycle. Young armadillos become motile in late spring and continue to forage with their mothers into mid-summer (Caire and others 1989; Whitaker and Hamilton 1998). This motility is consistent with Merriam's (2002) observation of a mid-summer peak in roadkills in Kansas. The August peak in our data implies much movement on and near roads during reproductive periods, coinciding with subadult dispersal and the end of the mating period. Loughry and McDonald (1998) noted similar timing in a Florida study, in which they determined that littermates had separated by early autumn either through death or dispersal. They found that although juvenile mortality tends to be high, young are less likely than adults to be roadkill victims, presumably because juveniles have smaller home ranges (Loughry and McDonald 1996, 1998). They also hypothesized that given similar home range sizes in adult males and females, there would be no discernable difference in roadkill by sex. But a study conducted in south Texas riparian woodland (McDonough 2000) reported males to be polygynous, meaning their movement could differ by habitat and locality that in turn could affect their likelihood of becoming roadkill. We did not look at age and sex of roadkilled armadillos, but these other studies point to movement of mating adults as the likely cause of the August spike; however, juvenile dispersal should not be discounted without further research. We found virtually no armadillos during winter months, a result documented elsewhere (Wilkins and Schmidly 1980). Despite this seasonal drop, Layne (2003) noted that armadillos are often cited as the most roadkilled animal where they occur. Their odd behavior of "jumping straight upward like a bucking horse" (Talmage and Buchanan 1954) when startled is implicated, and the prevalence of damaged carapaces in roadkilled specimens attests to its validity (Layne 2003).

Opossum roadkills have a bimodal distribution (Fig. 2). The breeding season can start as early as December and extend to late summer/early fall (Gardner and Sunquist 2003; Hartman 1928; Lay 1942). With such a long breeding season and two litters per year, mating, post-wean foraging, and dispersal all occur during spring and summer (Caire and others 1989; Whitaker and Hamilton 1998), providing an explanation for roadkill peaks. Nevertheless, using mating as a explanatory factor is problematic because there is not a spike in winter, during the first mating. Thus, peak movements of juveniles and subadults, with or without the mother's accompaniment, may be a more likely explanation.

Striped skunks exhibit a high rate of roadkills in late February and March (Caire and others 1989), with an abrupt drop by April (Fig. 2). A minor peak in November and December is followed by a steeper drop in January. These peaks correspond well with breeding behavior. Striped skunks enter winter dens in November or December, with vagility likely increasing prior to denning, when they are seeking a suitable den and "fattening up" for their long torpor, from which they emerge in February or March (Caire and others 1989). After emergence adult males, known polygamists, move up to 8 km / night in search of receptive females (Hansen and others 2004; Schwartz and Schwartz 2001). This period is also when the previous year's litter disperses (Caire and others 1989). Thus, not only is the entire skunk population emerging from hibernation, but some individuals are moving considerably, including near or across roads, which can lead to high roadkill rates. For instance, on 25 February 2007 we tallied 47 dead skunks in a 223 km drive (>21 / 100 km). This rate drops drastically during summer, when mating season is over and females and their young are in natal dens. Lastly, like armadillos, skunks have a specific behavior contributing to their deaths: skunks usually run from an approaching vehicle, but when they cannot outrun it they will strike a defensive posture, resulting in the animal's death (Wade-Smith and Verts 1982).

Raccoons were the only of the four common roadkills that did not exhibit a marked seasonality pattern (Fig. 2), an expected result when considering the species' reproductive cycle, a cycle predicated on individual temperament. Although mating tends to commence in February or March, it occurs as early as December and as late as June (Lotze and Anderson 1979). Accordingly, dispersal is unpredictable (Gehrt and Fritzell 1998), making movements appear random with respect to season. Cubs begin foraging by themselves after weaning, with some, particularly males, dispersing by autumn (Gehrt and Fritzell 1998) and others denning through the winter with their mother (Gehrt 2003). Families may part ways in spring, although female offspring-biased philopatry occurs (Gehrt 2003) and dispersal partially depends on sexual maturity of offspring. Our data indicated only a shallow peak in roadkill rate starting in July and peaking in August. Perhaps dispersal in southern Plains populations is early relative to the more typical fall dispersal (Gehrt 2003).

Species-specific behaviors, like those we discussed, may exhibit different age and sex ratios of roadkills (Baker and others 2007; Loughry and McDonough 1996). These issues need to be explored further given the possible detrimental effects on breeding behavior and population size that, for example, skewing the operational sex ratio can cause, which could have far-reaching conservation implications.

Habitat Associations

Habitat proved to be a difficult variable to account for fully because we made assessments quickly (see Methods), and habitat sometimes differed on either side of the road. Other studies have encountered this last obstacle (Caro and others 2000; Malo and others 2004). We attempted to circumvent the problem by classifying habitat into four broad types typical of the southern Great Plains (bottomland, crosstimbers, rural, and prairie), but doing so may have obscured patterns. Future research would benefit from plotting individual roadkills and taking advantage of spatial analysis in GIS to detect specific landscape patterns.

We detected little covariation between species and habitat, although we did detect a slight tendency for roadkills to be in bottomland, which is likely consistent with the peak in "riparian" reported by Conard and Gipson (2006). Each of the four species used woodlands, as indicated by the relatively even distributions in bottomland and crosstimbers. Bottomland habitat is prone to flooding, so it contains fewer roads, which greatly reduced our sample size there (<50 roadkills versus >300 in crosstimbers). Small sample size may account for the extensive overlap of species found in bottomland. Still, the opossum followed a mesic gradient from wet bottomland through intermediate crosstimbers and rural areas to dry prairie (Fig. 3), a pattern consistent with their preference for wetter environs, especially deciduous woodlands with active streams (Gardner and Sunquist 2003; McManus 1974).

The only distinct habitat association we detected was between skunks and prairie (Fig. 3). This pattern was evident even within a day; for example, during the aforementioned high count of roadkills, 46 of the 47 dead skunks were in prairie. This species occupies a variety of habitats in the plains but is "most abundant in agricultural areas, grassy fields, brushy areas, ravines, drainage ditches, hedgerows, and mixed crop lands" (Whitaker and Hamilton 1998).

Conservation Implications

The four species we recorded most commonly, representing approximately 85% of all roadkills, are human commensals that are more abundant or widespread on the Great Plains now than they were a century ago (Caire and others 1989; Gardner and Sunquist 2003; Gehrt 2003; Layne 2003; Merriam 2002; Rosatte and Larivière 2003). The same could be said of the next two most numerous species in our census, the white-tailed deer and coyote (*Canis latrans*), even though each accounted for small percentages of the total number of roadkills (3.2% and 3.1%, respectively). Conversely, species that may be of conservation concern we recorded only a few times (Table 1); however, assuming roadkills occur in direct proportion to a species' population size, if a species is rare, every unnatural mortality matters. Nevertheless, one could argue that the high incidence of roadkills in the southern plains is not a pertinent conservation issue: the numerous human commensals are the ones paying the price.

But such an argument fails to get at the heart of the Leopoldian ethic. Regardless of whether most roadkills are common species, human commensals, or "pests," their deaths represent the value humans place on wildlife. Put another way, a society that tolerates a large number of roadkills places too little value on wildlife. This point is particularly evinced by people who intentionally injure or kill animals by swerving to hit those in or near roads (personal observation). With heightened public awareness of the intrinsic value of wildlife, no matter how common, negative impacts will be lessened. Infrastructural changes needed to facilitate safe movement for animals are well known (e.g., Clevenger and others 2001; Dodd and others 2004; Foster and Humphrey 1995; Spellerberg 2002). Every serious environmental manager and conservation biologist ought to work for their implementation.

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