ACTIVITY PATTERNS OF TWO SYMPATRIC SPECIES OF SKUNKS (*MEPHITIS MEPHITIS* AND *SPILOGALE GRACILIS*) IN TEXAS

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ABSTRACT—We used radiotelemetry to document and compare activity and movement between the western spotted skunk *Spilogale gracilis*, and the striped skunk *Mephitis mephitis* in Texas. *Mephitis mephitis* had a higher rate of movement than *S. gracilis*. Both species had highest rates of movement during autumn, coinciding with dispersal of young. With the exception of summer, *M. mephitis* was significantly more active than *S. gracilis* and generally took shorter breaks during nightly activity. We documented statistical differences in activity between species for all seasons. Highest activity of one species occurred during lowest activity of the other species, which may indicate avoidance of the larger more-dominant species, *M. mephitis*, by *S. gracilis*.

RESUMEN—Utilizamos datos de telemetría para documentar y comparar la actividad y el movimiento entre el zorrillo manchado occidental *Spilogale gracilis* y el zorrillo rayado *Mephitis mephitis* en Texas, USA. *Mephitis mephitis* tuvo un índice de movimiento más alto que *S. gracilis*. Ambas especies tuvieron la taza de movimiento más alta durante el otoño, coincidiendo con la dispersión de crías. Con la excepción del verano, *M. mephitis* estuvo significativamente más activo que *S. gracilis* y generalmente tomó descansos más cortos durante la actividad nocturna. Documentamos diferencias estadísticas en la actividad entre las especies en todas las estaciones del año. La alta actividad de una especie ocurrió durante la baja actividad de la otra especie, lo que puede indicar que *S. gracilis* evita a la especie más grande y dominante, *M. mephitis*.

The western spotted skunk *Spilogale gracilis* and the striped skunk *Mephitis mephitis* occur sympatrically throughout much of western North America (Rosatte and Larivière, 2003). *Mephitis mephitis* is the larger of the two species (on average 2–5 kg) and may be one of the most common carnivores in North America (Verts, 1967; Rosatte and Larivière, 2003). *Spilogale gracilis* is about one-half the size of *M. mephitis* (0.5–1.8 kg) and is considered to be more specialized in habitat selection (Doty and Dowler, 2006; Neiswenter and Dowler, 2007). While *M. mephitis*, like most carnivores, breeds in spring, *S. gracilis* breeds during September–October, and then after a period of delayed implantation, parturition typically occurs in May (Rosatte and Larivière, 2003). Both species primarily are insectivorous and, therefore, there is a seasonal component to their availability of prey. Furthermore, both species exhibit overlap in food habits in Texas; however, *S. gracilis* consumes a higher proportion of mammalian prey than *M. mephitis* during winter (W. P. Taylor, in litt.).

Previous studies of activity patterns of skunks generally have focused on only one of the species. For example, activity and movements of western spotted skunks have been conducted in the western extent of their geographic range (Carroll, 2000) and on islands where striped skunks do not occur (Crooks and Van Vuren, 1995). Activity of striped skunks varies daily and seasonally at the northern edge of its range (Larivière and Messier, 1997). No study to date has addressed activity and movement of sympatric striped and spotted skunks.

Activity patterns in animals are related directly to a variety of ecological factors, including activity of prey, risk of predation, and competition (Zielinski et al., 1983; Larivière and Messier, 1997). Activity of prey may be the underlying cause of activity of predators (Zielinski et al., 1983). Similarity in food habits of the two skunks may be reflected in similar patterns of activity. While both species are predators, they also are potential prey, which may further affect activity. Skunks exhibit aposematic coloration and behavior (Larivière and Messner, 1996) and enlarged scent glands that may make predation by larger carnivores less likely (Walton and Lariviere, 1994). Furthermore, species may alter their activity to avoid interference competition with other species (Carothers and Jaksic, 1984). Patton (1974) observed temporal differences in success of trapping efforts between western spotted skunks and striped skunks in western Texas, which led him to hypothesize that spotted skunks limited activity to later parts of the night when in sympatry with striped skunks.

Our objectives were to document and compare patterns of activity and rates of movement for two sympatric species of skunks in Texas and to examine influence of season on both species. We hypothesized that activity and rates of movement will differ between *S. gracilis* and *M. mephitis*. Specifically, we predicted that *S. gracilis* would exhibit lower rates of movement and reduced activity compared to *M. mephitis*, that *S. gracilis* will limit activity to later portions of the night based on observations by Patton (1974), and that highest seasonal activity and movement will be in autumn and spring, coinciding with dispersal and breeding seasons for both species.

Materials and Methods—This study was conducted 15 km N San Angelo, Tom Green County, Texas. The study area consisted of ca. 2,000 ha of the Angelo State University Management, Instruction, and Research Center and the surrounding San Angelo State Park. Dominant vegetation is a mix of honey mesquite (*Prosopis glandulosa*) and prickly pear cactus (*Opuntia*). This study was conducted 15 May 2003–14 May 2004. Rainfall during this period totaled 67.6 cm and was slightly higher than the 30-year average of 59.7 cm. Soils in this area include clay loams and Tulia loams with 13% slope (Wiedenfeld and Flores, 1976).

We followed appropriate procedures for trapping, anesthetizing, and handling animals (Animal Care and Use Committee, 1998). Skunks were live trapped using various-sized Tomahawk live traps (Tomahawk Live Trap Company, Tomahawk, Wisconsin) or hand-captured during spotlighting surveys. Captured skunks were anesthetized using a 2:1:1 ratio of ketamine hydrochloride (10 mg/kg), xylazine (5 mg/kg), and acepromazine (1 mg/kg), and fitted with a radiocollar weighing either 24 g (for *S. gracilis*) or 30 g (for *M. mephitis*) that featured an activity monitor and mortality sensor (Telemetry Solutions, Concord, California).

Skunks were located weekly via triangulation from permanent stations using a 4-element, null-peak system (AVM Instrument Co., Colfax, California) mounted on a truck. Tracking efforts included only crepuscular and nocturnal hours (1800-0900 h). A focal animal was located hourly by collecting 2–3 bearings within 7 min to determine hourly rates of movement of each species across the landscape. In addition, we scored activity for three or four nearby individuals every 15 min by way of a reset monitor incorporated into the radiocollar. Upon movement, the radiotransmitter emitted a pulse of 40 pulses/min, and after movement had ceased for 1 min, the radiocollar defaulted to 30 pulses/min. To confirm activity, we rechecked signals twice, each >1 min apart (Garshelis et al., 1982). Activity was defined as percentage of active fixes per hour. All locations of radiomonitored animals were used in the analysis and they were assessed seasonally. We estimated locations using LOCATE II (Nams, 1990) and calculated hourly rates of movement as straight-line distance between successive hourly locations (m/h) in ArcGIS 9 (Environmental Systems Research Institute, Redlands, California) for focal animals during times of activity. An attempt was made to evenly distribute sampling effort across all radiocollared individuals and all times of the night.

To determine accuracy of radiotelemetry, we placed five radiocollars within known home ranges of skunks throughout the study area. The observer, not knowing where the radiocollars were placed, triangulated them 20 times employing the same method used to track skunks. We determined accuracy for triangulation data from linear error of estimates of location (Withey et al., 2001) to be 34.7 ± 24.6 m (range, 2.8–92.4 m).

Data were pooled into seasons representing basic environmental and biological changes throughout the year. These four seasons were spring or breeding season for *M. mephitis* and implantation for both (1 February–14 May), summer or post-parturition and rearing of young (15 May–31 August), autumn or dispersal for both and breeding season for *S. gracilis* (1 September–14 November), winter (15 November–31 January). Small samples, particularly the number of female *S. gracilis*, precluded testing for differences between sexes, so sexes were pooled within species. We compared activity between species and among seasons with chi-squared analyses by testing whether number of active signals observed for *S. gracilis* differed from number of active signals expected based on the percentage of activity of *M. mephitis* at that time. We used a Student's *t*-test to determine if the mean hourly difference between *M. mephitis* and *S. gracilis* differed significantly from zero for each season, an indication that one species was more active than the other. Movement was analyzed using an analysis of variance (ANOVA) to determine if there were significant differences among seasons and between species. Because only one hourly measurement was obtained for *S. gracilis* during winter, we omitted that season from the analysis. We corrected for multiple tests using Bonferroni adjustments.

Results—There was a significant interaction between species and among seasons ($F = 6.41$, df

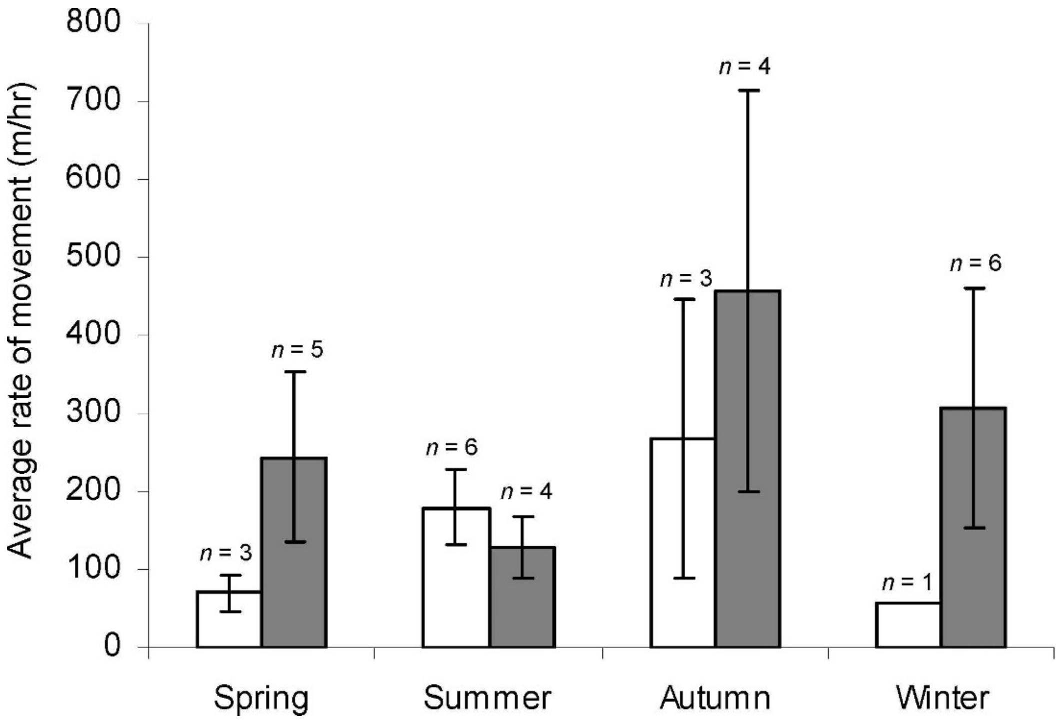

FIG. 1—Average rate of movement (m/h) during each season for the western spotted skunk *Spilogale gracilis* (white bars) and striped skunk *Mephitis mephitis* (gray bars) in Tom Green County, Texas. Error bars indicate 95% *CI* for the mean. Number of individuals (*n*) used in the analysis for each season is shown above the bar.

= 2, $P = 0.003$). Average hourly movements with 95% *CI* are reported in Fig. 1. *Spilogale gracilis* had a lower rate of movement than *M. mephitis* during spring and both species had the highest rate of movement in autumn (Fig. 1).

For activity, 15 *M. mephitis* (9 males, 6 females), and 12 *S. gracilis* (10 males, 2 females) were used in analyses. There were significant differences in activity of both species during each of the 4 seasons after correcting for multiple tests (spring, $\chi^2 = 40.23$, $df = 1$, $P < 0.001$; summer, $\chi^2 = 19.60$, $df = 1$, $P < 0.001$; autumn, $\chi^2 = 22.13$, $df = 1$, $P < 0.001$; winter, $\chi^2 = 13.63$, $df = 1$, $P < 0.001$). *Mephitis mephitis* had a longer peak in activity near the earlier part of the night, while peak activity of *S. gracilis* occurred later at night in both spring (Fig. 2A) and summer (Fig. 2B). *Mephitis mephitis* had two equally high peaks in autumn, while *S. gracilis* showed the least-defined pattern of activity during this time (Fig. 2C). In winter, *M. mephitis* peaked early in the night followed by a slow decline of activity while activity of *S. gracilis* showed two peaks; one between 2000 and 2100 h and again at 0200 and 0400 h (Fig. 2D).

The *t*-tests revealed that species differed in amount of activity during spring ($t = 2.834$, $df = 13$, $P < 0.001$), autumn ($t = 3.076$, $df = 14$, $P = 0.008$), and winter ($t = 2.964$, $df = 14$, $P = 0.010$), but not summer ($t = 1.363$, $df = 13$, $P = 0.196$). There was less activity for both species during winter than other seasons, and on cold nights, skunks would limit most activity to the early part of the night (Fig. 2D).

DISCUSSION—Many of the spotted skunks were not followed through winter; only one spotted skunk was followed from autumn to spring. It is not known whether the skunks died or simply lost their radiocollars, because in many cases a carcass was never recovered with the radiocollar. Only one successful hourly movement was collected from spotted skunks for use in analysis for winter and, therefore, the data should be considered with caution.

Both species of skunks had highest rates of movement during autumn, which corresponds to dispersal time for both species and the breeding season for *S. gracilis*. Males may make large

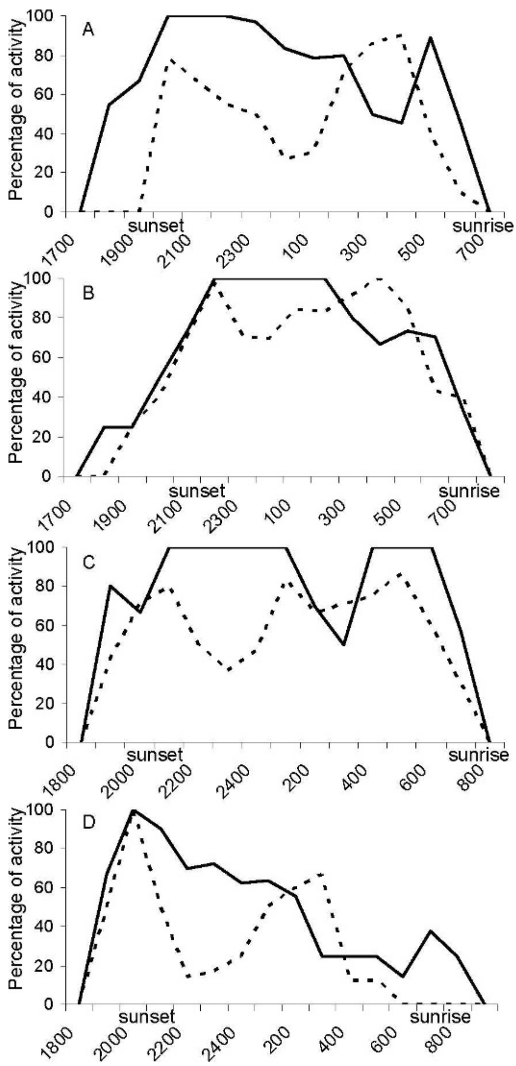

FIG. 2—Percentage activity for the western spotted skunk *Spilogale gracilis* (dashed line) and striped skunk *Mephitis mephitis* (solid line) in Tom Green County, Texas, in each season: A) spring, B) summer, C) autumn, and D) winter.

movements to gain access to females during the breeding season, but if breeding was driving the increased rates of movement seen in our data, we would expect a comparable increase in spring when *M. mephitis* breeds. Lack of an increase in rate of movement for *M. mephitis* in spring suggests dispersal is the primary cause of the increase in rate of movement in autumn.

Average rates of movement in our assessment were comparable to previously published data from different portions of the range of each species of skunk (Shirer and Fitch, 1970; Storm, 1972; Phillips et al., 2004). The highest rate of movement for *M. mephitis* in the Great Plains region was through the agricultural matrix at 8.6 m/min and the lowest rate was in planted cover at 5.2 m/min (Phillips et al., 2004). We did not compare rates of movement within various habitats; however, we detected a comparable overall average rate of movement in our study of 4.6 ± 2.0 m/min. As expected, *S. gracilis* moved at an overall lower average of 2.4 ± 1.7 m/min versus the larger *M. mephitis*. Carroll (2000) reported a similar average rate of movement for *S. gracilis* at 2.75 m/min in the Sierra Nevada of California.

We detected similar seasonal patterns of activity for *M. mephitis* in Texas as were reported in other parts of the geographic range of this species. Larivière and Messier (1997) reported activity for striped skunks on Canadian prairies. While similar biological seasons were defined in their study, skunks in Canada hibernate during winter and, therefore, the actual dates of seasons differ markedly. Skunks in our study showed no evidence of hibernation. Nevertheless, highest activity for male striped skunks in Canada, as in our study, was during the dispersal season. Verts (1967) suggested that average ambient temperature did not affect activity of striped skunks based on observations during February and March, although he did mention that on cold nights during October skunks were active only for a few hours early in the night. Similarly, in our study, skunks limited activity to earlier parts of the night on the coldest nights of the year. Whereas Verts (1963) noted that no true peak of activity was detected in juvenile skunks, the study was limited to only 3 months; August, September, and October. During these months in our study, adult *M. mephitis* exhibited a sharply bimodal pattern of activity (Fig 2C).

Spilogale gracilis exhibited a bimodal pattern of activity and, as predicted, showed a generally lower activity throughout all seasons. During summer and autumnl in the Sierra Nevada of northern California, *S. gracilis* ($n = 6$) showed a bimodal pattern of activity similar to that in our study, with an early peak near 2000 h, a dip in activity at 2400 h, and a second peak at 0100 h. Maximum nightly activity, reported as percentage of active locations per hour, was only 7.5% (occurring at 2000 h) for both sexes, and the highest hourly activity was by males at 10.7%

(2100 h) for *S. gracilis* in California (Carroll, 2000). This is extremely low compared to our study, which showed maximum activity as high as 100% at its peak (0400 h) during summer, and consistently >30% throughout most of the year (Fig. 2). Crooks and Van Vuren (1995) described percentage of activity per hour for the western spotted skunk on the Channel Islands of California, which peaked at ca. 90% at 2200 h, and slowly declined throughout the course of the night until it ceased at 0900 h.

Both species appear to constrain activity to nocturnal hours. No animal was recorded as active during daylight hours, 1000–1700 h, although few fixes were obtained during this time ($n = 20$). Activity generally began at dusk and ceased just after dawn. Skunks are likely nocturnal due to diet and their avoidance of predators (Larivière and Messier, 1997). There are minor differences in diet between the two species of skunks (W. P. Taylor, in litt.) and, although activity for carnivores is related to activity of prey, differences in prey and activity of prey for these species are probably too minimal to explain the difference in peak of activity.

An alternative hypothesis for the consistent short-term alternation of peaks in activity, as well as the lower total percentage of activity between species, is that *S. gracilis* is altering patterns of activity to reduce direct interactions with *M. mephitis*. Patton (1974) noted *S. gracilis* was never trapped before midnight while *M. mephitis* was trapped throughout the night. *Mephitis mephitis* was also the dominant species in interference interactions, which led Patton (1974) to suggest that *S. gracilis* limited its activity when in sympatry with *M. mephitis*. Our study demonstrates that during spring and summer, *S. gracilis* was more active after midnight than *M. mephitis*, supporting, in part, the findings of Patton (1974). Additionally, the only data available on activity of *S. gracilis* not in sympatry with *M. mephitis* (Crooks and Van Vuren, 1995) document a unimodal pattern of activity with a peak prior to midnight (2200 h), further supporting the hypothesis that spotted skunks alter activity when in sympatry with striped skunks. The difference in patterns of activity for *S. gracilis* may be avoidance of direct interactions with the larger, *M. mephitis*, when in sympatry. Summer may provide the greatest abundance of resources reducing competition and allowing both species to maintain similar activity. Clearly, more data are needed to better understand temporal partitioning in these species.

These data add to the growing literature on behavior and natural history of skunks. Understanding movements and activity patterns is an important step toward developing a proper management plan for these species. These data may also be useful in understanding temporal cycles of disease transmission, specifically rabies, in skunks. For example, in autumn, skunks generally are more active and move farther each night, which may make them more prone to transmission of disease through direct contact. In turn, increased activity may increase the likelihood of humans and domestic animals being exposed to diseased skunks. Finally, we hypothesize that subtle changes in temporal activity in conjunction with different microhabitats allow these two similar species to co-exist. In west-central Texas, there are three species of skunks, as well as several other mesocarnivores, including raccoons (*Procyon lotor*), ringtails (*Bassariscus astutus*), and Virginia opossums (*Didelphis virginiana*), that occur sympatrically. This area offers future opportunities to examine how patterns of temporal activity and use of space differ among organisms with different feeding ecologies and different levels of phylogenetic relatedness.

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