Seasonal Activity Patterns of Mesocarnivores in Southcentral Oklahoma

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Abstract:- The primary goal of this study was to identify temporal activity patterns of mesocarnivores, and to identify activity overlap and seasonal variations in activity overlap at Oka' Yanahli Preserve (OYP), located in southcentral Oklahoma. We used camera traps to collect photographs of mesocarnivores in the preserve during winter (November 2016 – February 2017) and summer (May 2017 – August 2017). We deployed six remotely-triggered infra-red cameras, moving cameras to different, random locations every 4 weeks. Twenty-five camera locations in winter resulted in 1531 mesocarnivore pictures, and 18 camera locations during the summer resulted in 1455 mesocarnivore pictures. We identified coyote (*Canis latrans),* raccoon *(Procyon lotor),* bobcat (*Lynx rufus)*, Virginia opossum (*Didelphis virginiana)*, and striped skunk (*Mephitis mephitis)* during both seasons. All species were more active in winter than in summer, as they were detected more frequently in winter (Kernel Density Estimates). Temporal activities, measured by the coefficient of overlap (Δ), showed substantial overlap among all species in winter ($\Delta > 0.7$). The summer did not yield sufficient detections of bobcats, opossums, and skunks to assess their activity patterns. Moderate activity overlaps between coyotes and raccoons ($0.4<\Delta<0.7$) were recorded in summer. The data show that mesocarnivore species do not necessarily avoid each other, rather they co-exist through resource partitioning, as supported by large temporal overlap between the species, specifically in the winter season.

Introduction

Animal activity encompasses the time spent on essential processes crucial for survival (Clapham 2017; Cid et al., 2020; Caetano et al., 2020). This includes foraging, mating, resting, and other behaviors vital for energy acquisition, reproduction, and avoiding predators (Zhang et al., 2017). Studies suggest that the level of activity plays a significant role in determining an animal's resilience to environmental stressors. For instance, more active marine invertebrates were found to be more likely to survive during global change extinctions (Clapham 2017). Additionally, wildlife activity patterns are influenced by internal states (e.g., pregnancy) and external factors (e.g., seasonal resource availability and weather conditions) (Cid et al., 2020).

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Engaging in any activity requires energy. To survive, animals must undertake various activities to manage their energy budgets while navigating their habitats (Bu et al. 2016). The activities they perform could expose them to elevated predation risk or thermal stress, thus they need to perform these activities in a way that is as energetically beneficial as possible (Rowcliffe et al. 2014). However, due to environmental pressures such as habitat fragmentation and other human influences, the realized niches of numerous species worldwide have been altered. To survive, animals have to utilize the resources available by niche partitioning, and most importantly, by co-existing with minimal conflicts (Monterroso et al. 2013). Therefore, time has become a niche dimension that animals could use to segregate from each other to prevent agonistic encounters (Carothers and Jaksić 1984). Daily routines of animals within the time structure are inherited through evolution but adapted according to the environment in which they live (Carothers and Jaksić 1984, Monterroso et al. 2013,). That is, the adaptive significance of diel activity and circadian rhythms are intrinsic and their plasticity for local environmental adaptations is rather restricted (Kavanau and Ramos 1975). For example, nocturnal animals have physical and physiological adaptations that could maximize their energetical expenditures when they behave nocturnally whereas diurnal animals have different types of adaptations. Using all of these adaptations, animals utilize niche dimensions with low energetic demand that avoid mortality (Brown et al. 1999; Monterroso et al. 2013).

Ecological niche partitioning in spatial and temporal scales is important when studying predator-prey relationships and intraguild predation. According to optimal foraging theory, predators have to utilize energy budgets in a way to maximize the energy gain during foraging that could ultimately increase fitness (Porfirio et al. 2016). Alternatively, prey species should avoid potentially risky areas by either using their behavioral adaptations or physical characteristics to avoid predators. Prey species try to minimize activity overlap with predators while predators try to maximize and synchronize their temporal overlap with prey species. Therefore, animals are in an arms race when they partition their niche (Brown et al. 1999; Lima 2002; Monterroso et al. 2013).

In ecosystems without large carnivores, mesocarnivores assume the role of the apex predator (Roemer et al. 2009). Like other species, mesocarnivores divide their time performing several behaviors such as resting, hunting, defending their territories, and protecting themselves. Mesocarnivores can feed on a variety of prey species (Porfirio et al. 2016; Rowcliffe et al. 2014). Simultaneously, they are a very diverse group of mammals, that could experience intraguild predation (Prugh and Sivy 2020; Thompson and Gese 2007). Mesocarnivores occur across a large geographic distribution and how they utilize their resources, their activity patterns, and diet will vary across that distribution. It is therefore important to understand mesocarnivore ecology throughout their range.

Mesocarnivores are a diverse group of mammals ranging from elusive, nocturnal behaviors to dietary specialists, or sometimes generalists (Roemer et al. 2009). Hence, monitoring their temporal activity patterns can be challenging. The use of camera traps is convenient in this situation because they can provide a large set of data that could be analyzed by using modern robust methods like habitat use modeling, Bayesian modeling, and even in machine learning and computer vision. The degree of spatial overlap between sympatric species would help to understand intraguild predation or avoidance.

We used detection data of mesocarnivores at Oka' Yanahli Preserve (OYP) in south-central Oklahoma. We fitted them in circular density estimates to identify temporal activity patterns of individual mesocarnivore species in the winter and summer seasons. We then analyzed temporal activity overlap between sympatric mesocarnivore species to identify any activity avoidance among mesocarnivore guild. Circular density estimates are designed for data with a cyclical nature, such as time-of-day activity patterns, where there is no true beginning or end (e.g., midnight connects seamlessly to the next midnight). Kernel density estimation (KDE), on the other hand, is a more general method for estimating the probability density function of data. When applied to circular data, KDE must be adapted to handle the continuous nature of the circle, ensuring that density estimates wrap around smoothly. In the context of animal activity studies, KDE for circular data allows researchers to understand and visualize patterns of activity throughout a 24-hour cycle, providing insights that account for the biological rhythms influenced by sunrise and sunset.

We expected that coyotes (*Canis latrans)* and bobcats (*Lynx rufus)* should avoid each other temporally, hence they should have minimal activity overlap because bobcats are more elusive than coyotes and bobcat kittens could be eaten by coyotes (Knick 1990; Koehler and Hornocker 1991; Palomares and Caro 1999). We also expect that Virginia opossum (*Didelphis virginiana)*, raccoons (*Procyon lotor)*, and skunks (*Mephitis mephitis)* should also avoid coyotes because of their larger body size and the potential for conflict (Gehring and Swihart 2003; Prange and Gehrt 2007). Finally, we expected a significant difference in the coefficient of activity overlap among mesocarnivores between winter and summer seasons, due to more abundant resources during summer months that can affect the activity levels.

Methods

Field-Site Description.

We conducted our study during winter (November 2016-February 2017) and summer (May-August 2017) at Oka' Yanahli Nature Preserve (OYP) located in Johnston County, southcentral Oklahoma (34°26'14.7"N 96°38'09.9" W) and managed by The Nature Conservancy. It is located about 40 km south of Ada and about 24 km north of Tishomingo, on the Arbuckle Mountain Plains (Fig. 1). The preserve consists of 1457 hectares along 3.2 km of the Blue River. OYP is at the intersection of the Cross Timbers Forest and mixed grass prairies of the Great Plains (Woods et al. 2005). Apart from limestone prairie grassland, oak/hickory bottomland forests occurred on the eastern side of OYP and by the Blue River (Diamond and Elliott 2015).

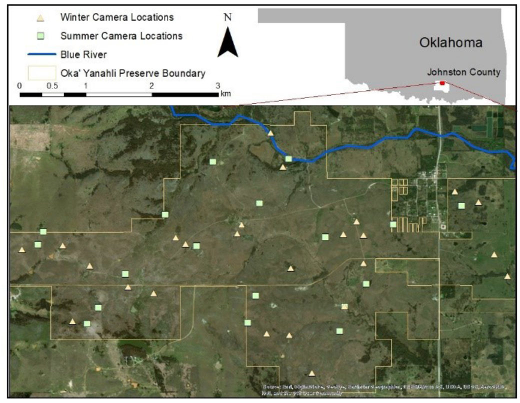


Figure 1. Location of study area, Oka' Yanahli Preserve in Arbuckle Mountain Plains, Johnston County, Oklahoma. Camera survey locations at Oka' Yanahli Preserve are triangles for winter (November 2016-Februry 2017) and squares for summer (May-August 2017).

The prairie is dominated by silver bluestem (*Andropogon saccharoides*), little bluestem (*Andropogon scoparius*), broomsedge bluestem (*Andropogon virginicus*), oldfield threeawn (*Aristida oligantha*), and buffalograss (*Bouteloua dactyloides*). Some other grasses and forbs include prairie dropseed (*Sporobolus hetrolepis*), sideoats grama (*Bouteloua curtipendula*), compass plant (*Silphium laciniatum*), leadplant (*Amorpha canescens*), wild alfalfa/scurf pea (*Psoralea tenuifolia*), Illinois bundleflower (*Desmanthus illinoensis*), blazing star (*Liatris sp*.), goldenrod (*Solidago sp*.), Indian paintbrush (*Castillega coccinea*), and Maximillian sunflower (*Helianthus maximilliani*) (Diamond and Elliott 2015).

Before purchase by The Nature Conservancy, OYP was used primarily as rangeland. We identified the following habitats: hardwood tree patches, aquatic habitats consisting of abandoned ponds and spring water accumulations, riparian corridors, bottomland forests, and prairie. There are some man-made and natural trails and roads that run through the preserve. The Nature Conservancy limits human use of the property; however, they allow limited deer hunting during winter and cattle grazing during summer as part of their land management plan.

The average annual precipitation of the study area ranged from 99–120 cm, with most precipitation occurring from midsummer to fall (Oklahoma Climatological Survey 2018). Snowfall during the winter months averaged 2 cm. In summer the temperature was as high as 35 ^{0}C, in winter it was as low as -1.6 ^{0}C, and the annual average temperature was 17 ^{0}C. Average frost-free days ranged between 224 –231 and the average growing season was 212 days. Wind speed was on average 12 km/hr. and relative humidity was 42 % –96 %. The highest humidity was in May and the lowest in August. On average there are 45 thunderstorms per year in the area (Oklahoma Climatological Survey 2018).

Camera trapping

We conducted camera trap sampling during the winter (November 2016 – February 2017) and summer (May – August 2017) seasons. We used Reconyx HC 500 Hyper Fire Semi-Covert Cameras, which use an infra-red, motion trigger function (Reconyx Inc., 3828 Creekside Ln, Site 2, Holmen, WI 54636). We programmed cameras to take 3 pictures every time the camera was triggered, record the date, time, and temperature, and rest for 5 minutes between bursts. The delay between each photo in the 3-photo burst was 1 second.

We used the ArcGIS 10.4 computer program (Environmental Systems Research Institute, Redlands, CA) to generate 100 random camera trap locations with 1.5 km between each camera location. Locations were selected from random locations in areas that were accessible and maintained a distance of at least 1.5 km between each camera in winter and 1.4 km in summer. In November 2016, 8 camera traps were used. Afterward, 6 camera traps were set each month in new, random locations. Cameras were set at random locations and moved every 3-4 weeks, to different random locations based on accessibility (Cove et al. 2013). Cameras were placed about 0.5 –1 m above the ground, angled downwards. Usually, cameras were attached to trees, bushes, or fence posts, but when not available wooden posts with stable stands (Christmas tree stands) were used. Winter season had 25 camera locations and summer season had 18 camera locations.

Data analysis

For each mesocarnivore detection, we recorded the species, number of animals per picture, location, camera ID, date the trap was set, date detected, time of the first picture, time of the last picture, number of pictures recorded during that detection, and temperature. Consecutive pictures of the same species and multiple animals in pictures were considered as single detection.

We analyzed mesocarnivore activity periods using nonparametric circular density functions (Frey et al. 2017; Linkie and Ridout 2011; Ridout and Linkie 2009). Since animal behavior patterns tend to change according to the daylight changes and the position of the sun: the time of sunrise, zenith, or sunset, analyzing the activity according to the clock time of sunrises and sunsets has no biological meaning (Azevedo et al. 2018; Caravaggi et al. 2018; Haswell et al. 2020; Noor et al. 2017; Nouvellet et al. 2012). The clock time of sunrises and sunsets changes according to the latitudes and the longitudes of the study location. Therefore, we adjusted each record to a specific day sunrise and sunset time. We standardized each clock time activity detection to sun time using "sunTime" and "overlap" packages in R version 4.0.3 (Meredith and Ridout, 2020). We estimated the activity pattern of each species during each season using Kernel Density Estimation (KDE) for circular data and activity overlap using the coefficient of overlap (Δ) (Porfirio et al.2016; Ridout and Linkie 2009). The coefficient of overlap varies from zero to one, where zero is no overlap and one is complete overlap (Penido et al. 2017). According to Ridout and Linkie (2009), KDE considers camera trap pictures as random samples with an underlying continuous distribution, therefore, they are not categorized into discrete time variables. We used the Δ_1 estimator which is recommended when the smallest sample size is below 50 records for all mesocarnivore pairs except for coyote-raccoon. With more than 50 records for coyote-raccoon, we used Δ_4 estimators. Confidence intervals of Δ_1

and Δ_4 were calculated as a percentile of intervals from 10,000 bootstraps (Frey et al. 2017; Linkie and Ridout 2011; Ridout and Linkie 2009). If $\Delta > 0.7$, it was considered a higher activity overlap, and $\Delta<0.4$ was considered a lower activity overlap (Bu et al. 2016). To minimize pseudo replication, we pooled detections of the same species at the same trap location that occurred within two hours. Also, if there were more than one animal in one picture, it was considered as a single detection (Bu et al. 2016). All statistical analyses were performed using R software (R Software Core team 2020 version 4.0.3) using packages Overlap, Circular, Boot, SunTime, Suncalc, and Maptool (Meredith and Ridout 2014). All figures were made using ggplot2 package.

Results

We had 844 camera nights in winter and 600 camera nights in summer for a total of 1444 camera nights (Table 1). More than 100,000 pictures were recorded; among them, 4233 pictures were obtained of mesocarnivores. The winter season had a higher number of pictures (2778) than the summer season (1455). Mesocarnivore species recorded were coyote, bobcat, Virginia opossum, raccoon, and striped skunk. Camera malfunctions were very rarely identified and did not affect the survey during either season.

Table 1. Camera days and numbers of independent detections of each mesocarnivore species; coyote, bobcat, raccoon, Virginia opossum, and striped skunk during the camera trap survey in winter 2016-2017 and summer 2017 at Oka' Yanahli Preserve, southcentral Oklahoma.

	Winter season	Summer season	Totals
Camera days	844	600	1444
Species			
coyote	80	24	104
bobcat	22	3	25
raccoon	138	31	169
opossum	60	1	61
skunk	19	4	22

KDE for single species during the winter season showed that all species were highly crepuscular and peak activities were seen at sunrise and sunset (Fig. 2). The graphs overall show that all mesocarnivore species recorded were highly nocturnal during the winter season. While coyotes had higher activity density during both sunrise and sunset; bobcats, opossums, and skunks had higher activity density during sunset and thus nocturnal. Raccoons had a higher activity peak during sunrise than sunset.

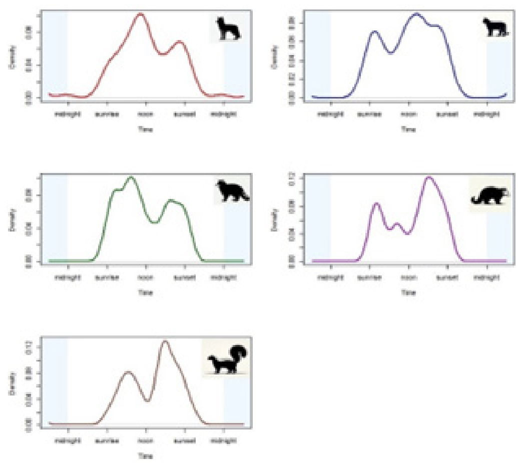


Figure 2. Winter Activity patterns of five species of mesocarnivores; coyote, bobcat, raccoon, Virginia opossum, and striped skunk at Oka' Yanahli Preserve, southcentral Oklahoma, as captured by camera trap records. Curves are fitted with circular kernel density distributions along with the time of the day during the winter season of 2016-2017.

In summer, only coyotes and raccoons had enough data to analyze activity patterns. bobcats, opossums, and skunks were removed from the analysis due to low detection rates. Raccoons were active slightly after sunset while coyotes were active throughout the day with a slightly higher peak between noon and sunset (Fig. 3).

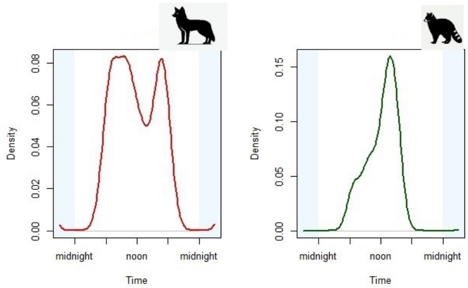
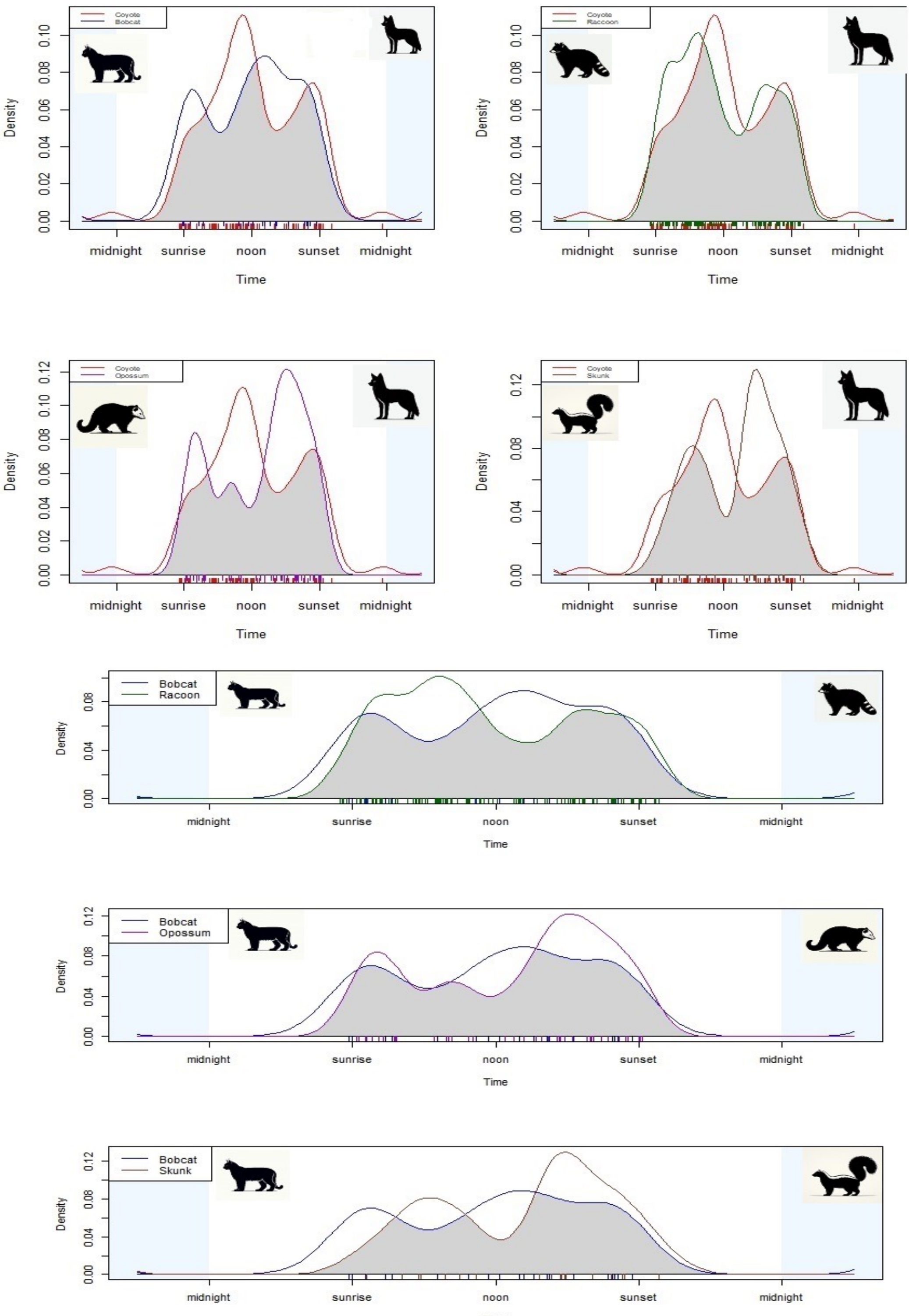


Figure 3. Summer activity patterns of four species of mesocarnivores; coyote and raccoon at Oka' Yanahli Preserve, southcentral Oklahoma, as captured by camera trap records. Curves are fitted with circular kernel density distributions along with the time of the day during the summer season of 2017.

During the winter season, almost all mesocarnivore pairs had a high coefficient of activity overlap (Δ > 0.7) (Table 2, Fig. 4). The highest activity overlap was recorded between skunk-opossum Δ_1=0.87 (95% CI,0.52 to 0.89), while the lowest occurred between coyote and opossum Δ_1=0.74 (95% CI,0.67 to 0.98) (Table 2, Fig. 4). The coyote-opossum activity overlap plot shows higher activity peaks from opossum when coyote had low activity peaks, especially in sunset and sunrise (Fig. 4). Skunk and opossum both had higher activity peaks during sunset, where there were low activity peaks with bobcats and raccoons respectively (Fig. 4).

Table 2. Estimated activity level overlap of five mesocarnivore species, coyote, bobcat, raccoon Virginia opossum, and striped skunk at Oka' Yanahli Preserve southcentral Oklahoma, during winter 2016-2017 obtained from camera trap data. Values were obtained from circular density functions and the coefficient of Overlap (Δ) and 95% Confidence intervals Δ are shown.

Species	The coefficient of Overlap (Δ)			
	Type	Lowest Value	Overlap Estimate	95% CI
coyote-bobcat	Δ_1	22	0.822	0.997—0.676
coyote-raccoon	Δ_4	76	0.856	0.813—0.420
coyote-opossum	Δ_1	42	0.741	0.977—0.674
coyote- skunk	Δ_1	18	0.762	0.975—0.616
bobcat-raccoon	Δ_1	22	0.827	0.889—0.549
bobcat-skunk	Δ_1	18	0.765	0.935—0.594
bobcat-opossum	Δ_1	22	0.842	0.985—0.699
raccoon-opossum	Δ_1	42	0.804	0.842—0.542
raccoon-skunk	Δ_1	18	0.798	0.892—0.528
skunk- opossum	Δ_1	19	0.874	0.895—0.526


Coyote
Bobcat
Density
Time
midnight
sunrise
noon
sunset
midnight
Coyote
Raccoon
Coyote
Opossum
Coyote
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Opossum
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Skunk

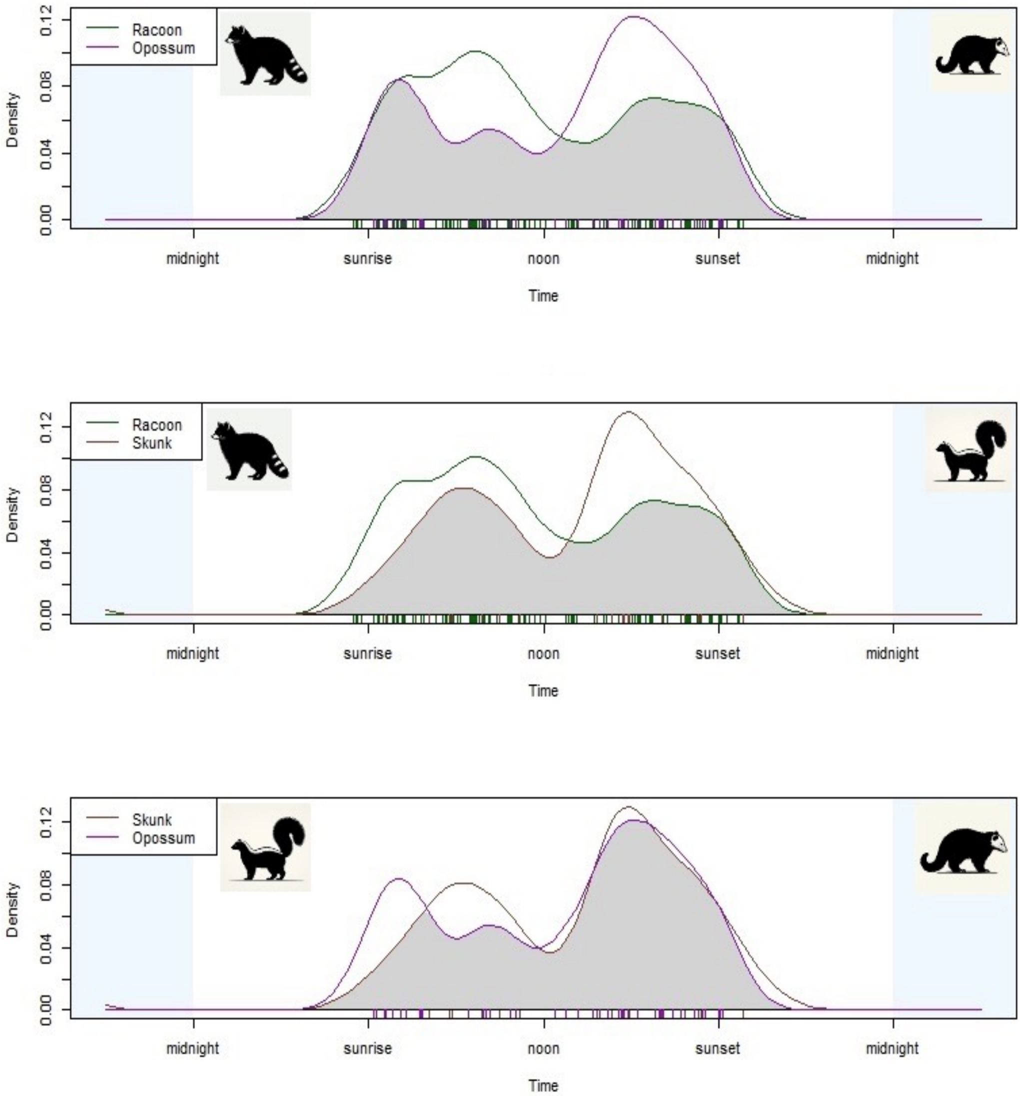

Figure 4. Temporal overlap of activity patterns of mesocarnivores; coyote, bobcat, raccoon, Virginia opossum, and striped skunk during the winter season (November to February 2016-2017) in Oka' Yanahli Preserve at southcentral Oklahoma. The y-axis represents the kernel density estimate. The overlap area was denoted in grey. Species names are given in the legend of each graph.

During summer, moderate activity overlap (0.4 < Δ < 0.7) was recorded between coyote and raccoon Δ_1=0.63 (95% CI,0.45 to 0.81) (Table 3, Fig. 5). However, activity overlap patterns were dissimilar from winter activity patterns. In summer, both raccoons and coyotes had activity peaks during sunset, but raccoons were more active than coyotes during this time (Fig. 5).

Table 3. Estimated activity level overlap of Coyote and striped skunk at Oka'Yanahli Preserve south-central Oklahoma, during summer 2017 obtained from camera trap data. Values were obtained from circular density functions the coefficient of Overlap (Δ) and 95% Confidence intervals Δ are shown.

Species	The coefficient of Overlap (Δ)			
	Type	Lowest Value	Overlap Estimate	95% CI
coyote-raccoon	Δ_1	24	0.628	0.448—0.808

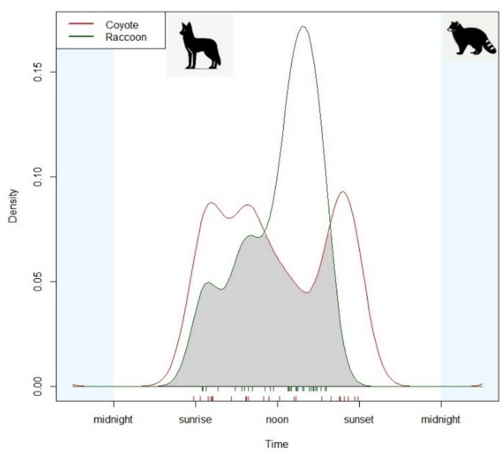

Figure 5. Temporal overlap of activity patterns of mesocarnivores; coyotes and raccoons during summer season (May to July 2017) in Oka' Yanahli Preserve southcentral Oklahoma. The y-axis represents the Kernel Density Estimates. The overlap area was denoted in grey. Species names are given in the legend of each graph.

Discussion

Our study revealed that during winter, there was a high degree of temporal activity overlap among all pairs of mesocarnivore species. The interplay of factors such as increased scavenging opportunities, reduced competition, behavioral adaptations, physiological needs, and changes in habitat use explains why mesocarnivores in North America tend to be more active in winter than in summer (Bell et al., 2023). This adaptability is crucial for their survival as they face seasonal challenges, and our study provides additional support for these findings. In contrast, during summer, we observed a moderate level of activity overlap between coyotes and raccoons, as anticipated. However, we could not identify seasonal variations in individual activity patterns or the activity overlap of bobcats, opossums, and skunks due to low detections in summer. Several similar studies have reported that there was a reduction in mesocarnivore detections in summer (O'Connell et al. 2006, Hackett et al. 2007, Crimmins et al. 2012). Additionally, our summer season was from May to August, which was a comparatively shorter survey period for particularly elusive species like mesocarnivores. Therefore, longer study periods along with repeated surveys are required (Gompper et al. 2006).

Even though coyotes were ubiquitous, their activity peaked during sunrise and sunset in both seasons. Mammals are known to change their daily rhythmic activity according to their thermoregulatory energetic requirements (Pavey et al. 2016). In winter, homoeothermic animals will alter their foraging and other related activities in a way that they will maximize their foraging activities. Therefore, all detected mesocarnivore species had high activity peaks during sunset and hence are nocturnal, as the potential for finding prey at night is higher in winter (Symmank et al. 2014). This is specifically true for Coyotes because they travel significantly higher distances at night in winter when they are not breeding or rearing pups (Andelt and Gipson 1979). Therefore, higher nocturnal activity during winter can be expected. Our results agree with other related studies about winter activity patterns of mesocarnivore species that are mostly nocturnal (Lesmeister et al. 2015; Tigasa et al. 2002). The activity patterns of raccoons in winter showed high-density peaks at sunrise and lower activity during the daytime. Raccoons' breeding season starts in March leading to an increase in movement as much as twice normal movement, both diurnally and nocturnally (Greenwood 1982). Therefore, less activity during the daytime in winter could be expected. Opossums were highly nocturnal with comparatively low activity peaks during sunrise in winter.

In contrast, coyotes and raccoons had increased diurnal activity patterns in summer than in winter. Coyotes and raccoons have their breeding season during spring; therefore, they should be active throughout the day while nurturing their pups (Ozoga and Harger 1966). This is specifically true for coyotes as the lactating coyote females tend to travel as far as males during summer (Ozoga and Harger 1966). Our results of coyotes' activity patterns during summer supported the results of previous studies.

Bobcat males and females usually live separately with wider home ranges, but they live nearby during the breeding season (Lawhead 1984). The breeding season of the bobcat typically spans from February to March, immediately following our winter sampling period. Therefore, it is plausible that bobcats exhibit elevated activity levels in preparation for breeding, aligning with the increased activity observed during winter (Lawhead, 1984). During the kitten-rearing season, male and female bobcats do not demonstrate significant separation; instead, they adapt their movements within their respective home ranges. Male bobcats typically have larger seasonal home ranges than females, with males' territories approximately three times larger than those of females (McNitt et al., 2020; Janečka et al., 2007). Despite variations in reproductive investments, both sexes maintain relatively consistent seasonal home ranges, indicating constraints imposed by territorial behavior (Janečka et al., 2007). Female bobcats increase their movements during the kitten-rearing period, engaging in intensive foraging and frequent returns to den sites (Plowman et al., 2006). In contrast, male bobcats exhibit increased movements during the dispersal period, potentially reflecting heightened territorial behavior before breeding. These findings suggest that seasonal fluctuations in home range selection and movements are influenced by reproductive activities and prey availability.

Contradictory to what we expected, coyotes and bobcat activity patterns largely overlapped during winter. Since bobcats and coyotes are sympatric across their distribution range, we expected that they would coexist by partitioning resources either by selecting different prey species or being active at different times of the day (Flores-Morales et. al 2019). However, coyotes and bobcats had activity overlap throughout the day. Similar studies have found that bobcats do not avoid coyotes, and they largely coexist (Fedriani et al. 2000; Lesmeister et al. 2015; Melville et al., 2020; Lombardi et al., 2020). Bobcats are solely carnivorous, and their diet mainly consists of rodents and lagomorphs (Lesmeister et al. 2015; Neale et al. 2001; Wilson et al. 2010). Coyotes are mostly carnivorous, but their diet has seasonal variations (Andelt and Gipson 1979; Turner et al. 2011). Coyotes mainly depend upon deer carcasses and in some cases invertebrates. Therefore, these two mesocarnivores could co-exist by separating their resource use. Consequently, this type of resource use could result in realized niche partitioning other than competition-driven niche partitioning (Lesmeister et al. 2015; Neale et al. 2001; Wilson et al. 2010).

Due to the ubiquitous nature of coyotes, we expected that their activity would overlap with all the other small mesocarnivores. According to the Mesopredator Release Theory (MRH), large mesocarnivores have a profound impact on smaller mesocarnivores. The intensity of the impact may depend upon the defensive mechanisms coupled with the intensity of competition between smaller mesocarnivores and coyotes

(Prange and Gehrt 2007). According to MRH coyotes can significantly reduce the population numbers of skunks, opossums, and raccoons; but a considerable amount of research around the United States has still failed to identify skunks or raccoons in the coyotes' diet (Prange and Gehrt 2007). Therefore, predation could not be the major reason for skunks, raccoons, and opossums to avoid coyotes. Indeed, there is evidence that they do not temporally avoid coyotes (Crooks and Soulè 1999; Prange and Gehrt 2007; Sovada et al. 2000).

Coyotes and bobcats are more carnivorous than raccoons who are more generalized in their diet. Raccoons have larger body sizes than all the other potential prey species of coyotes and bobcats. Also, there are observations that a raccoon can successfully defend deer carcasses from coyotes (Lesmeister et al. 2015), because of that there should be less resource competition between coyotes, bobcats, and raccoons allowing them to co-exist and have high temporal activity overlap. These findings could be further strengthened by our findings of activity overlap between these three species.

The activity of opossum highly overlaps with coyotes and bobcats. According to similar studies, there is evidence that coyotes and bobcats are not major predators of opossums (Cove et al. 2012; Prange and Gehrt 2007; (Troyer et al. 2014). Our results of opossums with coyotes and bobcats observed here support strongly the current findings on mesocarnivore resource partitioning and co-existence.

Skunks' activity overlaps with both coyotes and bobcats are slightly higher than opossums. Skunks are predominantly nocturnal in winter with low activity during the daytime. A possible reason would be to avoid sympatric large mesocarnivores. However, similar research has shown skunks and coyotes can co-exist with slight interspecific avoidance due to conspicuous coloration in the pelage of skunks and their defensive noxiousness (Aleksiuk and Stewart 1977; Lesmeister et al. 2015; Prange and Gehrt 2007).

Contradictory to the winter season, summer had minimal detections from bobcats, opossums, and skunks (Plowman et al. 2006). Our results with low detections support similar studies, however, there are no adequate references specifically from different regions of Oklahoma to compare our results obtained from the southcentral region. During the summer season, the most influential event that happened in the preserve was cattle grazing. Abundant cattle may not have had a significant influence on coyote behavior. According to our data, which had increased diurnal activity in summer than winter, coyotes may not have been affected by the presence of cattle to the same degree as other mesocarnivores. Coyotes can be a predator of calves, but not an adult cow (Danner and Smith 1980; Bradley and Fagre 1988). Similar studies have found that coyotes can overlap home ranges with cattle ranches, but they aggregate more around carcasses of cattle than live cattle (Bradley and Fagre 1988, Danner and Smith 1980). Therefore, the presence of cattle may not have affected the activity of coyotes during summer. Southcentral Oklahoma summer weather could be another possibility for low activity detections because most species prefer cover and the preserve mostly consists of open grassland with less cover. At the same time, there was abundant rainfall in summertime causing more vegetation growth in the preserve which could lead to a considerable number of false detections and low detection of small species like opossums and skunks (Gompper et al. 2006).

In conclusion, this study supported the fact that strong interference competition may not always happen within carnivore communities; rather species tend to coexist and structure the community in a way that allows co-existence. The mesocarnivore species identified in this study did not exhibit significant dietary overlap or inferred competition with one another. Consequently, they are capable of coexisting within their shared habitat. We recognize that we were unable to detect any seasonal variations in the activity patterns of mesocarnivores within this preserve. However, our findings mark the first of their kind reported in southcentral Oklahoma. Looking ahead, it's essential to conduct additional research to delve into the implications of this intraguild co-existence among mesocarnivores, particularly concerning the management and conservation plans for Oka' Yanahli Preserve.

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