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A nocturnal guild with a diurnal exception: Diel activity and temporal overlap among riparian mesocarnivores and their small mammal prey in southern Africa

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Abstract

Temporal partitioning of activity is a key mechanism facilitating coexistence among ecologically similar species and structuring interactions between predators and prey. Yet, within Africa this has been examined almost exclusively among competing mesocarnivores, rarely extending to their small mammal prey. This study used camera-trap data collected across ten riparian sites spanning multiple biomes in South Africa and Namibia (2017–2024) to characterise diel activity patterns of eight mesocarnivore and small mammal taxa, quantify temporal overlap both among co-occurring mesocarnivores and between mesocarnivores and their small mammal prey, and assess whether activity timing within each taxon was spatially consistent across sites. Seven of eight taxa were classified as nocturnal; only Slender mongoose was strongly diurnal. Pairings involving Slender mongoose consistently showed low overlap with other mesocarnivores ($\hat{\Delta}$ = 0.18–0.38), while overlap among the remaining nocturnal mesocarnivores was moderate to high ($\hat{\Delta}$ = 0.70–0.84). Overlap between mesocarnivores and murids ranged from low (Slender mongoose, $\hat{\Delta}$ = 0.23) to high (Serval, $\hat{\Delta}$ = 0.86), broadly reflecting differences in dietary reliance on this prey group among predator species. Activity timing was spatially consistent across sites for three of four taxa assessed, with Water mongoose showing comparatively lower consistency. These findings indicate that temporal partitioning operates unevenly within this mesocarnivore guild, it is shaped in part by species-specific dietary relationships with prey, and, for most taxa, appears resistant to variation in local site conditions. This study extends existing understanding of African mesocarnivore temporal ecology to include predator–prey dynamics within riparian systems, a habitat and interaction type that has received limited prior attention in the region.

Introduction

Understanding how ecologically similar species coexist within shared landscapes is a central question in community ecology. Where species overlap in space and diet, temporal partitioning through the differential use of the diel cycle, can reduce direct interspecific encounters and is considered one mechanism facilitating coexistence among competitors (Caravaggi et al. 2018). The same temporal dimension also structures interactions between predators and their prey, where the degree of activity synchrony can influence the frequency of encounters between them (Augugliaro et al. 2022).

Mesocarnivores are typically small to medium-sized carnivores occupying intermediate trophic levels (McKaughan et al. 2023) and form a diverse and ecologically important guild across African landscapes (Smith et al. 2023). Species within this guild frequently overlap in habitat use and diet, and are subject to interference competition by larger or more dominant carnivores (Webster et al. 2021). Under these conditions, temporal partitioning provides one route by which subordinate or ecologically similar species can reduce direct encounters with competitors while continuing to exploit shared resources. Quantifying the degree of temporal overlap among co-occurring mesocarnivores therefore offers insight into the mechanisms structuring coexistence within this guild.

Independently of these competitive dynamics, sympatric mesocarnivores also often overlap in terms of prey species targeted, meaning the timing of prey activity can directly shape the temporal opportunities available to predators for foraging (Botts et al. 2020; Augugliaro et al. 2022). High temporal overlap between a predator and its prey increases the window during which the two are simultaneously active and therefore more likely to encounter one another (Porfirio et al. 2016; Puls et al. 2021). Temporal segregation may reduce this probability, potentially reflecting active avoidance by prey, or predators adapting their own timing to periods of peak prey availability (Monterroso et al. 2014). Temporal overlap alone does not demonstrate predation, and elevated overlap may also arise from shared responses to environmental conditions rather than a direct behavioural interaction between the species involved (Seveque et al. 2022). Nonetheless, quantifying temporal overlap provides a non-invasive means of generating knowledge into both predator–predator and predator–prey dynamics even when interactions are rarely observed directly (Frey et al. 2017).

Camera trapping provides a practical, non-invasive method for simultaneously recording the timing of animal activity across multiple co-occurring species (Bridges and Noss 2011). Timestamped detections from camera-trap data can be used to construct kernel density estimates of diel activity for individual species, and the degree of overlap between two such distributions can be quantified using the coefficient of overlap ($\hat{\Delta}$). This is a framework developed by Ridout and Linkie (2009) that has since become widely used for comparing activity distributions between species pairs, whether among competitors or between predators and prey.

Riparian ecosystems represent a habitat type in which both of these temporal relationships, among mesocarnivores, and between mesocarnivores and prey, may be particularly pronounced. By concentrating water, structurally complex vegetation, and food resources within otherwise heterogeneous landscapes, riparian zones can function as refugia for small mammals (Hamilton et al. 2015). It may also function as movement corridors for mesocarnivores, potentially increasing the spatial and temporal likelihood of encounter both among competing mesocarnivores and between mesocarnivores and their prey (Santos et al. 2011; Santos et al. 2016). Despite this, only few studies have examined mesocarnivore activity patterns specifically within riparian habitat in southern Africa (Webster et al. 2021; Carvalho et al. 2024), and none have extended this to include prey.

A further, largely unaddressed question concerns whether activity patterns within a given mesocarnivore or its small mammal prey taxon remain consistent when that taxon is monitored at multiple, geographically separated sites. Existing multi-site studies, including Smith et al. (2023), have compared activity patterns between different species at a given location, but none have formally tested whether a single species' own activity pattern is temporally stable across sites. Given that activity timing can be shaped by local factors such as predation risk, resource availability, and the composition of the surrounding community (Caravaggi et al. 2018), a species' activity pattern observed at one site cannot necessarily be assumed representative of its behaviour elsewhere.

This study addresses these gaps using camera-trap data collected across ten riparian sites spanning multiple biomes in South Africa and Namibia between 2017 and 2024. Eight focal taxa were examined: six mesocarnivores (African clawless otter – *Aonyx capensis*, Water mongoose – *Atilax paludinosus*, Black-backed jackal – *Canis mesomelas*, Slender mongoose – *Galerella sanguinea*, Genets – *Genetta*, Serval – *Leptailurus serval*) and animals belonging to two of their small mammal prey taxa: the Lagomorphs (Order Lagomorpha, Family Leporidae) and Murids (Order Rodentia, Family Muridae). Specifically, this study aimed to: (1) characterise the diel activity patterns of these taxa; (2) quantify temporal overlap both among co-occurring mesocarnivores and between mesocarnivores and their small mammal prey; and (3) assess the spatial consistency of activity patterns within each taxon across geographically separated riparian sites.

Based on the ecological considerations outlined above, mesocarnivore activity was expected to be predominantly nocturnal or crepuscular. Temporal overlap among co-occurring mesocarnivores was expected to vary according to relative body size and dominance status, with subordinate or smaller-bodied species predicted to show lower overlap with potential competitors than similarly sized or ecologically distinct species. Temporal overlap between mesocarnivores and murids was likewise expected to vary among predator species, reflecting differences in the extent to which each relies on small mammal prey, rather than following a single uniform pattern. Finally, given that riparian sites in this study differed in vegetation structure, biome, and surrounding land use, activity patterns within a given taxon were expected to show some degree of variation across sites, reflecting the influence of local environmental and community context on activity timing.

Methods

Study area

This study used existing camera-trap data collected at 10 riparian study sites across southern Africa (Fig. 1) as part of several projects. Sites were located within eight nature reserves or national parks in South Africa and two in Namibia, spanning multiple biomes including savanna, thicket, grassland, and arid systems. Data were collected across all seasons but mostly in winter between 2017 and 2024. All sites were situated along riverbanks or in close proximity to rivers, where mesocarnivores and small mammal prey were expected to occur.

Field deployment

A total of 187 camera traps, comprising Primos ProofCam3, SpyPoint Solar Dark, SpyPoint Force, Browning Dark Ops, and Panthera Poachercam units, were deployed across 10 study sites: Spekboom (n = 21), Sandfontein (n = 20), Telperion Nature Reserve (n = 48), Bulolo (n = 9), Izolwane (n = 9), Golden Gate Highlands National Park (n = 9), Millstream (n = 14), Verloren Valei (n = 18), Cobham (n = 20), and Bwabwata National Park (n = 19). Cameras were deployed systematically at 100–250 m intervals within

areas considered accessible to riparian mesocarnivores, generally within 10 m of the water's edge and near access points. Cameras were not placed near animal latrines, to avoid distorting detection data, but did include areas of evident pathways. Traps were mounted on trees, or on wooden poles where trees were unavailable, at heights of 50 – 100 cm from the ground and were triggered by animal movement to record bursts of four images with a 10-second delay between trigger events. All cameras had a minimum detection range of 15 m.

Data recording

Camera-trap images were uploaded per deployment for each study site to Agouti (https://agouti.eu/). Animals that could not be confidently identified were annotated as "unknown," and images with no visible animal were annotated as "blank." Birds and reptiles appearing as bycatch were annotated to Class (Aves and Reptilia, respectively) but not identified further, as they fell outside the scope of this study. Mammals were identified to species level wherever possible, with the exception of three taxa: the murids (Order Rodentia, Family Muridae), lagomorphs (Order Lagomorpha, Family Leporidae), and Genus *Genetta* (Order Carnivora, Family Viverridae)- which could not be reliably distinguished to species level from camera-trap images. Following identification, the finalised dataset was exported from Agouti as a CSV file for analysis in R.

Data analysis

Each camera-trap detection of a mammal was treated as an activity event, using the embedded image timestamp. To avoid pseudoreplication from repeated triggers of the same individual, only one independent event per species was recorded within a 30-minute window, following established convention in activity pattern studies (Botts et al. 2020; Kasozi et al. 2022). Timestamps were validated by cross-checking image-embedded times against exported metadata, and only deployments with consistent temporal information (n = 181) were retained. Consistent with recommendations for minimum sample sizes in activity pattern analyses (Kasozi et al. 2022; Park & Lim, 2023), only taxa with a minimum of 30 total detections across the study were retained for analysis; taxa below this threshold were excluded.

Records were filtered to mesocarnivores and restricted to observations with a valid taxonomic assignment and detection timestamp. Detection timestamps were converted from ISO 8601 format to local time (Africa/Johannesburg, UTC + 2) and expressed as radians (0 to 2π) to represent time of day on a circular scale, following standard practice for camera-trap activity pattern analysis (Ridout and Linkie 2009). All analyses were conducted in R version 4.4.3 (R Core Team 2025) using RStudio (Posit Team 2025).

Eight focal taxa were selected for analysis, comprising six mesocarnivores and two small mammal prey taxa: African clawless otter, Water mongoose, Black-backed jackal, Slender mongoose, Genets, Serval, Lagomorphs and Murids.

Activity pattern classification

For each focal taxon, the proportion of detections occurring within three time-of-day categories was calculated: diurnal (06:00–18:00), nocturnal (19:00–05:00), and crepuscular (05:00–06:00 and 18:00–19:00). In alignment with van der Hoek et al. (2023), fixed clock-time windows were applied uniformly across all sites for consistency and comparability in addition to the fact that surveys were generally restricted to winter months and all study sites were in the same time zone. Each taxon was classified according to whichever category accounted for the largest proportion of its detections; taxa without a single dominant category were to be classified as cathemeral.

Temporal overlap between co-occurring mesocarnivores and their small mammal prey

Pairwise temporal overlap in activity patterns was estimated for taxon pairs detected sympatrically, using the kernel density overlap coefficient ($\hat{\Delta}$; Ridout and Linkie, 2009) implemented in the R package overlap (Meredith et al. 2024). Overlap was calculated only using detections from the specific study site(s) at which both taxa in a pair had ≥ 30 independent detections; taxon pairs not meeting this threshold at any shared site were excluded. Where the smaller of the two sample sizes in a pair was < 50, the $\hat{\Delta}_1$ estimator was used; where both were ≥ 50, $\hat{\Delta}_4$ was used, following the sample-size-based recommendations of Ridout and Linkie (2009). Ninety-five percent confidence intervals were generated for each $\hat{\Delta}$ estimate using the basic bootstrap method with 1,000 resamples. Following Monterroso et al. (2014), overlap was interpreted as low ($\hat{\Delta} < 0.5$), moderate ($0.5 \leq \hat{\Delta} \leq 0.75$), or high ($\hat{\Delta} > 0.75$).

Intraspecific consistency in activity patterns across sites

To assess whether activity patterns for a given taxon were temporally consistent across its study sites, pairwise temporal overlap was calculated between every pair of sites at which that taxon had ≥ 30 independent detections, using the same estimator-selection rule and bootstrap procedure described above. For taxa recorded at more than two qualifying sites, overall spatial consistency in activity timing was summarised as the mean of all pairwise $\hat{\Delta}$ values. A separate 95% confidence interval was calculated around this mean by resampling (with replacement) the set of pairwise $\hat{\Delta}$ estimates for each taxon 1,000 times, recalculating the mean on each resample, and taking the 2.5th and 97.5th percentiles of the resulting distribution (percentile bootstrap). This interval reflects uncertainty in the mean overlap value itself and is distinct from the confidence intervals calculated for each underlying pairwise comparison. Taxa with fewer than two qualifying sites were excluded from this analysis. As above, mean overlap across sites were interpreted as low ($\hat{\Delta} < 0.5$), moderate ($0.5 \leq \hat{\Delta} \leq 0.75$), or high ($\hat{\Delta} > 0.75$).

Results

Activity pattern classification

Detection frequencies ranged from 66 (lagomorphs) to 542 (Water mongoose) independent records (Table 1). Proportion of detections data for diel activity classification showed that the majority of taxa (87.5%) exhibited predominantly nocturnal activity.

Among the mesocarnivores, nocturnal activity was most pronounced for Genets, with a nocturnal proportion of 0.85, a diurnal proportion of 0.03, and the remaining 0.12 of activity falling within crepuscular periods. African clawless otter, Water mongoose, Black-backed jackal, and Serval similarly showed nocturnal-dominant activity, with nocturnal proportions ranging from 0.55 to 0.64, and diurnal proportions ranging from 0.19 to 0.37 (Table 1). Crepuscular proportions were comparatively low across all nocturnal species, ranging from 0.07 to 0.17. Slender mongoose was the only species to depart from this pattern, with activity almost entirely restricted to daylight hours (diurnal proportion = 0.96), and negligible nocturnal (0.03) and crepuscular (0.01) activity.

Among the small mammal prey taxa, both murids and lagomorphs were classified as nocturnal, with nocturnal proportions of 0.75 and 0.82 respectively. Diurnal proportions for these taxa were low (0.13 and 0.05), while crepuscular proportions ranged from 0.12 to 0.14.

Table 1

Activity pattern classification of the eight focal mesocarnivores and prey taxa detected across riparian study sites in southern Africa. Proportions represent the proportion of activity occurring during diurnal (06:00–18:00), nocturnal (18:00–06:00), and crepuscular (05:00–06:00 and 18:00–19:00) periods. Activity patterns were classified according to the dominant activity period(s), with the number of detections included for reference.

Species/ Taxon	**Common name**	**No. of Detections**	**Diurnal**	**Nocturnal**	**Crepuscular**	**Classified Activity Pattern**
Aonyx capensis	African clawless otter	344	0.19	0.64	0.16	Nocturnal
Atilax paludinosus	Water mongoose	542	0.23	0.61	0.16	Nocturnal
Canis mesomelas	Black-backed jackal	88	0.22	0.6	0.17	Nocturnal
Galerella sanguinea	Slender mongoose	151	0.96	0.03	0.01	Diurnal
Genetta spp.	Genets	395	0.03	0.85	0.12	Nocturnal
Lagomorpha	Rabbits & hares (lagomorphs)	66	0.05	0.82	0.14	Nocturnal
Leptailurus serval	Serval	67	0.37	0.55	0.07	Nocturnal
Muridae	Rats & mice (murids)	277	0.13	0.75	0.12	Nocturnal

Temporal overlap between co-occuring mesocarnivores and their small mammal prey

Temporal overlap between mesocarnivore pairs varied according to whether the pairing included Slender mongoose, the only taxon classified as diurnal in this study (Table 1). Pairings involving Slender mongoose consistently showed low overlap with other mesocarnivores: with Water mongoose ($\hat{\Delta}_4$ = 0.38, Fig. 1b), Serval ($\hat{\Delta}_1$ = 0.38, Fig. 1g), African clawless otter ($\hat{\Delta}_1$ = 0.18, Fig. 1d), and Genets ($\hat{\Delta}_1$ = 0.18, Fig. 1f).

In contrast, overlap among the remaining, exclusively nocturnal mesocarnivore pairings was moderate to high. The highest overlap recorded among any mesocarnivore pairing was between Water mongoose and Serval ($\hat{\Delta}_1$ = 0.84, Fig. 1e), followed closely by Water mongoose and Genets ($\hat{\Delta}_4$ = 0.83, Fig. 1a). Overlap between Water mongoose and African clawless otter was comparatively lower but still moderate ($\hat{\Delta}_4$ = 0.70, Fig. 1c).

Temporal overlap between mesocarnivores and their small mammal prey was assessed only for murids, as this was the only prey taxon with sufficient detections at co-occurring sites to permit overlap estimation. Overlap between murids and mesocarnivores ranged from low to high. Overlap was low between murids and Slender mongoose ($\hat{\Delta}_4$ = 0.23, Fig. 2b); moderate between murids and Water mongoose ($\hat{\Delta}_4$ = 0.69, Fig. 2a), African clawless otter ($\hat{\Delta}_1$ = 0.70, Fig. 2c), and Genets ($\hat{\Delta}_1$ = 0.74, Fig. 2d); and high between murids and Serval ($\hat{\Delta}_1$ = 0.86, Fig. 2e).

Intraspecific consistency in activity patterns across sites

Of the eight focal taxa, four species had sufficient detections (≥ 30) at two or more sites to permit an assessment of intraspecific temporal consistency across space. Mean pairwise temporal overlap across sites was moderate for Water mongoose ($\hat{\Delta}$ = 0.70) and high for Slender mongoose ($\hat{\Delta}_1$ = 0.84), murids ($\hat{\Delta}_1$ = 0.77), and Genets ($\hat{\Delta}$ = 0.76) (Fig. 4). With the exception of Water mongoose, activity patterns were therefore highly consistent across sites within each taxon.

Discussion

This study provides one of the more comprehensive assessments to date of temporal niche structure within a southern African mesocarnivore guild, extending beyond the predator-predator focus of prior regional work to explicitly incorporate a small mammal prey taxon, and introducing a novel test of whether activity timing within a species is spatially conserved across geographically separated sites. Taken together, the three objectives offer a more complete account of how temporal behaviour structures both competitive and trophic relationships within this riparian mammal community than has previously been available for the region.

Activity pattern classification

Seven of the eight focal taxa were classified as nocturnal, consistent with the broadly nocturnal tendency reported across mesocarnivore guilds generally (Cox and Gaston 2024). Nocturnality in mesocarnivores is commonly interpreted as a strategy to avoid activity overlap with larger, potentially dangerous apex predators (Haswell et al. 2020) and with humans (Mills and Harris 2020). In most of our study areas, the apex predator present was the leopard, which is not predominantly diurnal and exhibits substantial nocturnal activity (Martins and Harris 2013) with crepuscular peaks (Smyth et al. 2025). Therefore, although nocturnal activity in mesocarnivores may reduce encounter risk with humans and potentially apex predators, predator avoidance in isolation is unlikely to explain the nocturnal activity of the mesocarnivore guild across our study areas.

Slender mongoose was the clear exception, with activity almost entirely restricted to daylight hours. This pronounced diurnality is consistent with the species' documented ecology as a strictly diurnal, solitary and opportunistic forager that consumes a diverse range of vertebrate and invertebrate prey (Graw and Manser 2017; Cronk and Pillay 2020). This complete temporal separation from the rest of the mesocarnivore guild positions Slender mongoose as occupying a fundamentally distinct temporal niche, a pattern that carries through consistently into the pairwise overlap results discussed below.

Temporal overlap among mesocarnivores

The clearest structural pattern in the pairwise overlap results was the sharp divide between pairings involving Slender mongoose and pairings among the remaining, exclusively nocturnal mesocarnivores. This pattern is broadly consistent with classical resource-partitioning theory, which predicts that ecologically similar species competing for shared resources will diverge along at least one niche axis - here, time - to reduce the intensity of interspecific competition (Barros et al. 2024). Under this theory, Slender mongoose's strong diurnality may function less as a deliberate avoidance response to any single competitor and more as a fixed, foraging-driven temporal niche (Graw and Manser 2017) that incidentally reduces overlap with the remainder of an otherwise nocturnal guild.

By contrast, the consistently high overlap among the remaining nocturnal species suggests that temporal partitioning is not the dominant coexistence mechanism operating among this majority subset of the guild. This is not unusual: where nocturnality itself is constrained by shared physiological or ecological pressures (e.g., thermoregulation in warm riparian environments, or shared predation-risk avoidance), species may be unable to diverge temporally (Cong et al. 2024). Even where interspecific competition exists, coexistence may instead be maintained through spatial or dietary partitioning rather than temporal separation (Wu et al. 2025). The present study did not assess spatial or dietary niche overlap directly; therefore, it cannot determine whether these nocturnal mesocarnivores are in fact partitioning resources along other axes; this represents a natural extension for future work at these sites.

Body size and dominance hierarchies may also help explain the pattern of high overlap among nocturnal species. Where a size or dominance asymmetry exists between two mesocarnivores, the subordinate species is sometimes expected to shift its activity away from the dominant species to reduce encounter risk (Smith et al. 2023). This was not observed among the nocturnal mesocarnivores studied here which

may suggest that interspecific risk among these particular species is comparatively low, or that other factors like diverging diets or spatial use override any avoidance signal (Grabowski et al. 2024).

Temporal overlap between mesocarnivores and their small mammal prey

Overlap between mesocarnivores and murids varied considerably, from low (Slender mongoose) to high (Serval). This range sits within two competing conceptual frameworks for predator–prey temporal relationships. Under an activity-synchrony hypothesis, predators are expected to align their activity with that of their prey to maximise encounter and capture opportunities, particularly where a predator relies heavily on a given prey type (Augugliaro et al. 2022). By contrast, under a predator-avoidance hypothesis, prey species are expected to shift their activity away from that of their principal predators to reduce predation risk. This is a phenomenon closely related to the "landscape of fear" concept describing how perceived predation risk shapes prey behaviour across space and time (Palmer et al. 2022).

The high overlap between Serval and murids is consistent with the synchrony hypothesis and aligns with this species' recognised specialisation on small rodent prey (Ravhuanzwo et al. 2024). This suggests that where a mesocarnivore is more dietarily dependent on a given prey taxon, its activity timing may track that of the prey more closely. Conversely, the low overlap between Slender mongoose and murids is a direct reflection of the fact that the Slender mongoose have a broad diet in which this prey group make up only small proportion of their diet (Graw and Manser 2017). Thus, differences in dietary dependence may help explain variation in temporal overlap between mesocarnivores and their potential prey (Botts et al. 2020).

The moderate overlap observed for Water mongoose, African clawless otter, and Genets may also reflect differences in their dietary relationships with murids rather than a direct response to rodent prey availability. Genets are more likely to exhibit temporal overlap with murids because rodents do constitute an important component of their diet (Plaatjie et al. 2024). In contrast, the moderate overlap observed for Water mongoose and African clawless otter is less readily explained by direct dietary dependence on rodents, as both species typically rely heavily on aquatic prey, particularly crustaceans (Somers et al. 2026).

Spatial consistency in activity patterns

Contrary to an expectation that activity timing would vary meaningfully across sites differing in vegetation structure, biome, and land use, three of the four taxa assessed (Genets, Slender mongoose, and murids) showed high intraspecific consistency in activity timing across sites, with only Water mongoose showing moderate rather than high consistency. This pattern suggests that, for most of the taxa examined, diel activity timing may be regulated more strongly by relatively fixed, possibly endogenous circadian mechanisms than by plastic behavioural responses to local site conditions (Webster et al. 2021). This temporal niche conservatism is consistent with activity timing functioning as a relatively stable species-level trait, shaped over evolutionary rather than local ecological timescales

(Anderson and Wiens 2017). Another possible explanation could be that although geographically separated, the species here may have been exposed to relatively similar biotic pressures (Smith et al. 2023)

The comparatively lower spatial consistency in Water mongoose is noteworthy, particularly given this species' strong association with riverine and wetland habitats (Haring et al. 2023; Somers et al. 2026). However, the apparent inconsistency may be driven largely by the Millstream site, where the water mongoose exhibited a pronounced increase in activity around sunset (Fig. 4). Millstream is a fly-fishing estate characterised by an unusually high density of otters, including African clawless otters, as documented by Majelantle et al. (2021), as well as spotted-necked otters (McIntyre, pers. obs.). The high density of these otters and the year-round anthropogenic presence may influence the activity patterns of Water mongoose at this site, potentially contributing to the observed site-specific departure from its activity patterns elsewhere. Thus, the lower spatial consistency observed for Water mongoose reflects local interspecific interactions at Millstream rather than an inherent departure from their conserved activity rhythm regulated by an endogenous circadian clock.

Taken together, these findings indicate that temporal partitioning operates unevenly within this mesocarnivore guild. It was pronounced where it coincides with a fundamentally distinct foraging strategy, as in the slender mongoose, but largely absent among the remaining, exclusively nocturnal species, where coexistence likely depends on spatial or dietary partitioning not assessed here. This study contributes to the existing regional literature on mesocarnivore temporal ecology (Webster et al. 2021; Smith et al. 2023; Sievert et al. 2023) by explicitly incorporating a small mammal prey taxon, which in turn broadens current understanding of temporal relationships within riparian mammal communities in southern Africa. The multi-site assessment also provides evidence for generally consistent intraspecific activity patterns across sites. Ultimately, these findings contribute to understanding how temporal behaviour shapes both competitive and trophic relationships within these communities. Future work will benefit by incorporating spatial co-occurrence, dietary data, and finer taxonomic resolution for small mammal prey taxa.

Declarations

Conflict of Interests

The authors have no competing interests to declare that are relevant to the content of this article.

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Data Availability

The data and code supporting the findings of this study are archived in the Zenodo repository (DOI: 10.5281/zenodo.23272394).

Ethics approval

This study employed non-invasive methods only (field surveys and camera trapping); no animals were captured, handled, or harmed at any stage of this research. All applicable national and institutional guidelines for animal research were followed throughout the study.

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Author Contributions

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Seth J. Eiseb – Methodology, Resources, Validation, Writing – review & editing

Tshepiso L. Majelantle – Methodology, Validation, Writing – review & editing

Trevor McIntyre – Conceptualization, Methodology, Project Administration, Resources, Supervision, Validation, Writing – review & editing

All authors have approved the manuscript.

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Figures

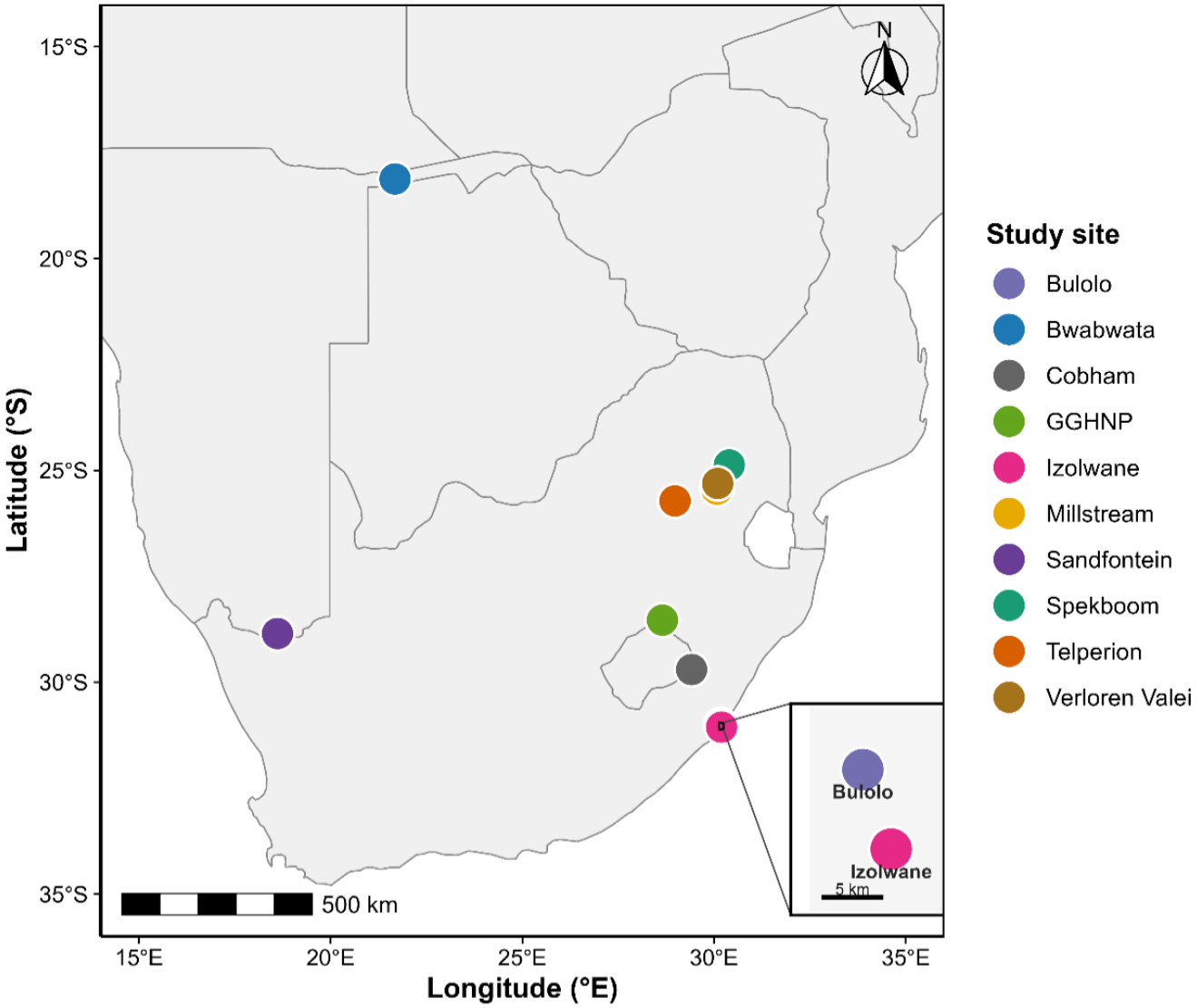


Figure 1

Geographic distribution of camera-trapping study sites across southern Africa. GGHNP refers to Golden Gate Highlands National Park.

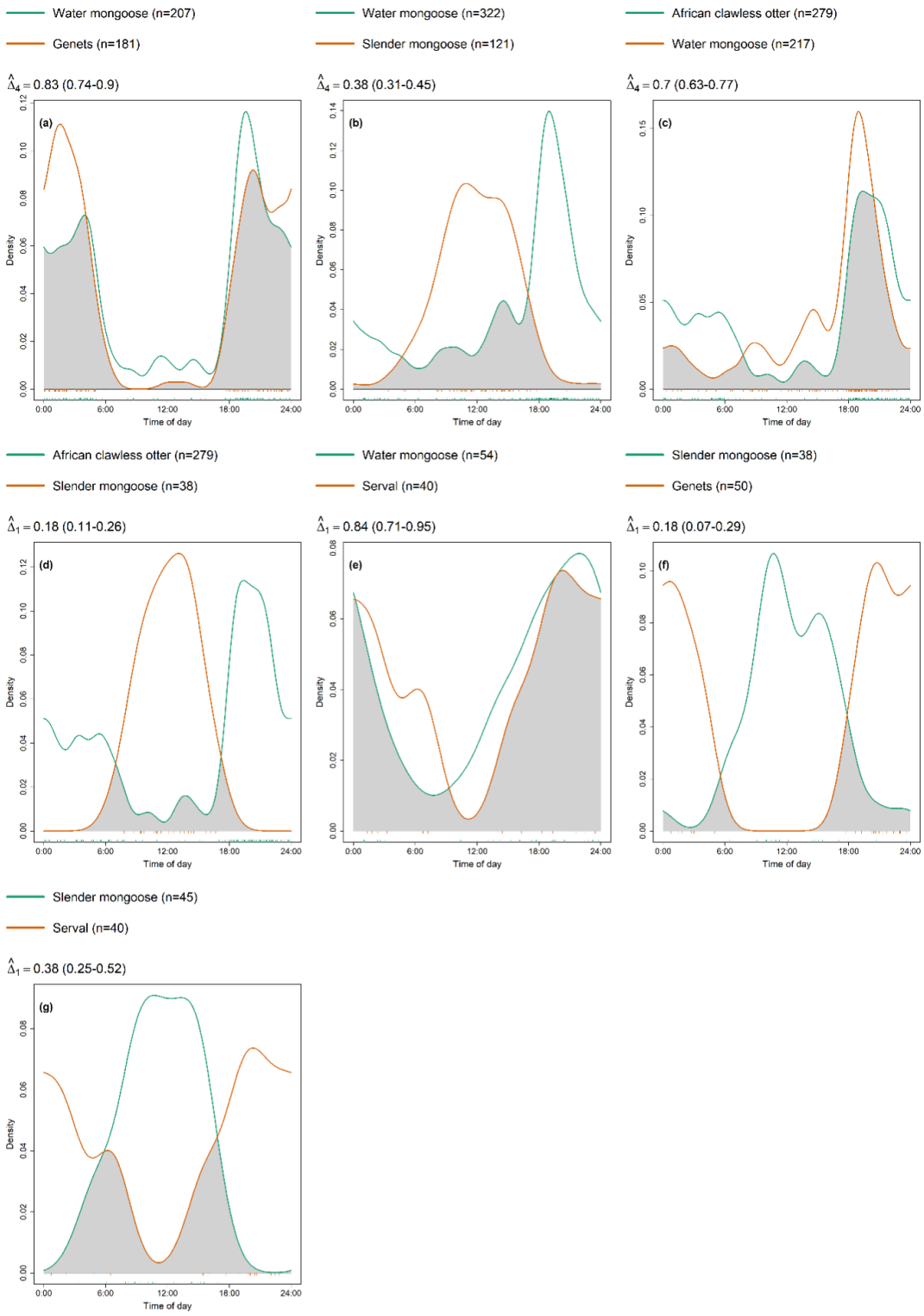


Figure 2

Diel activity overlap between co-occurring mesocarnivore pairs in riparian areas of southern Africa. Sample sizes (n) indicate the number of independent detections per species used to construct each density curve. Panel labels correspond to the following species pairs: a.) Water mongoose – Genets; b.) Water mongoose – Slender mongoose; c.) African clawless otter – Water mongoose; d.) African

clawless otter – Slender mongoose; e.) Water mongoose – Serval; f.) Slender mongoose – Genets; and g.) Slender mongoose – Serval.

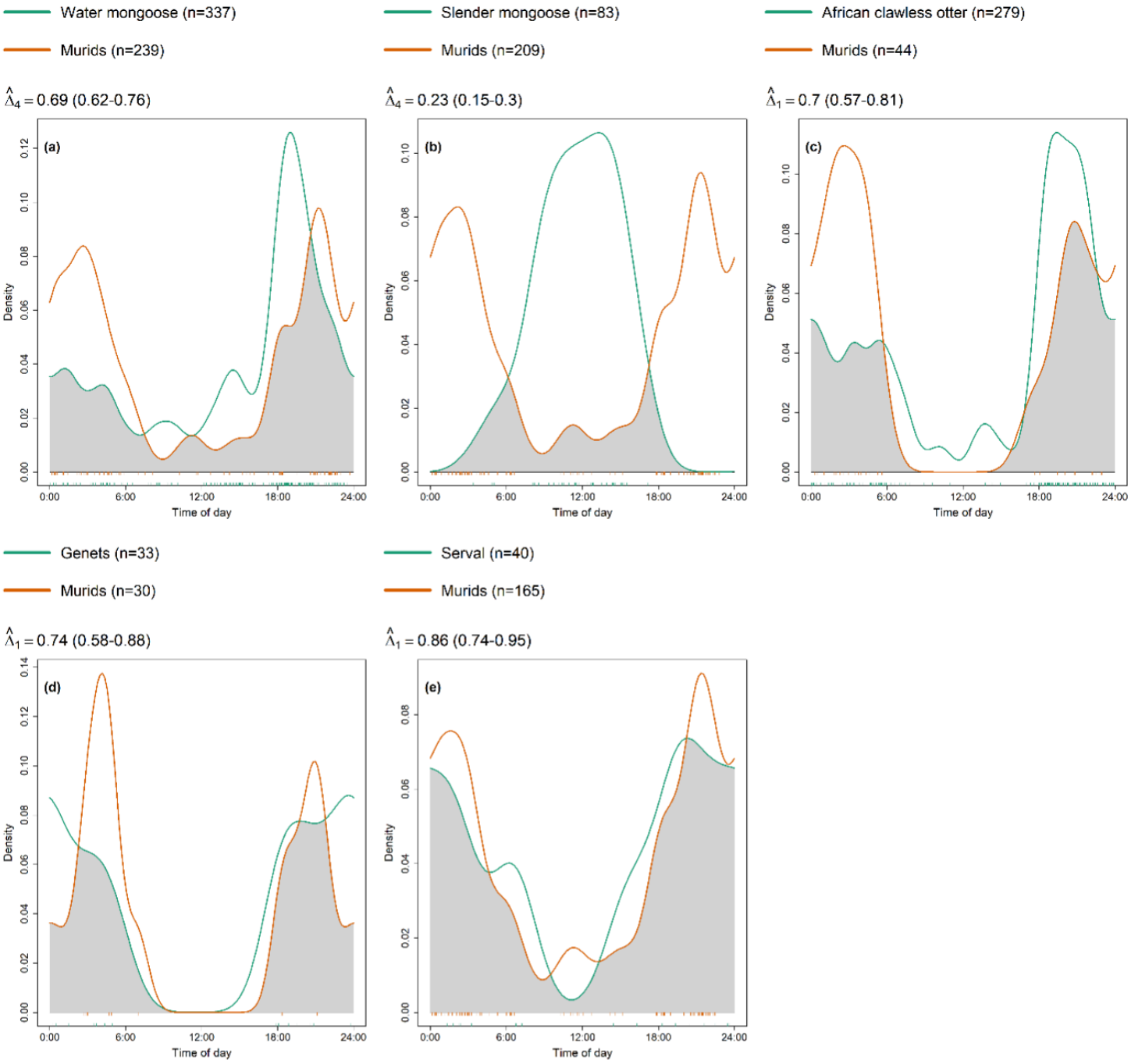


Figure 3

Diel activity overlap between mesocarnivores and their small-mammal prey (murids) in co-occuring riparian areas of southern Africa. Sample sizes (n) indicate the number of independent detections per species used to construct each density curve. Panel labels correspond to the species pairs Murids and: a.) Water mongoose; b.) Slender mongoose; c.) African clawless otter; d.) Genets; e.) Serval.

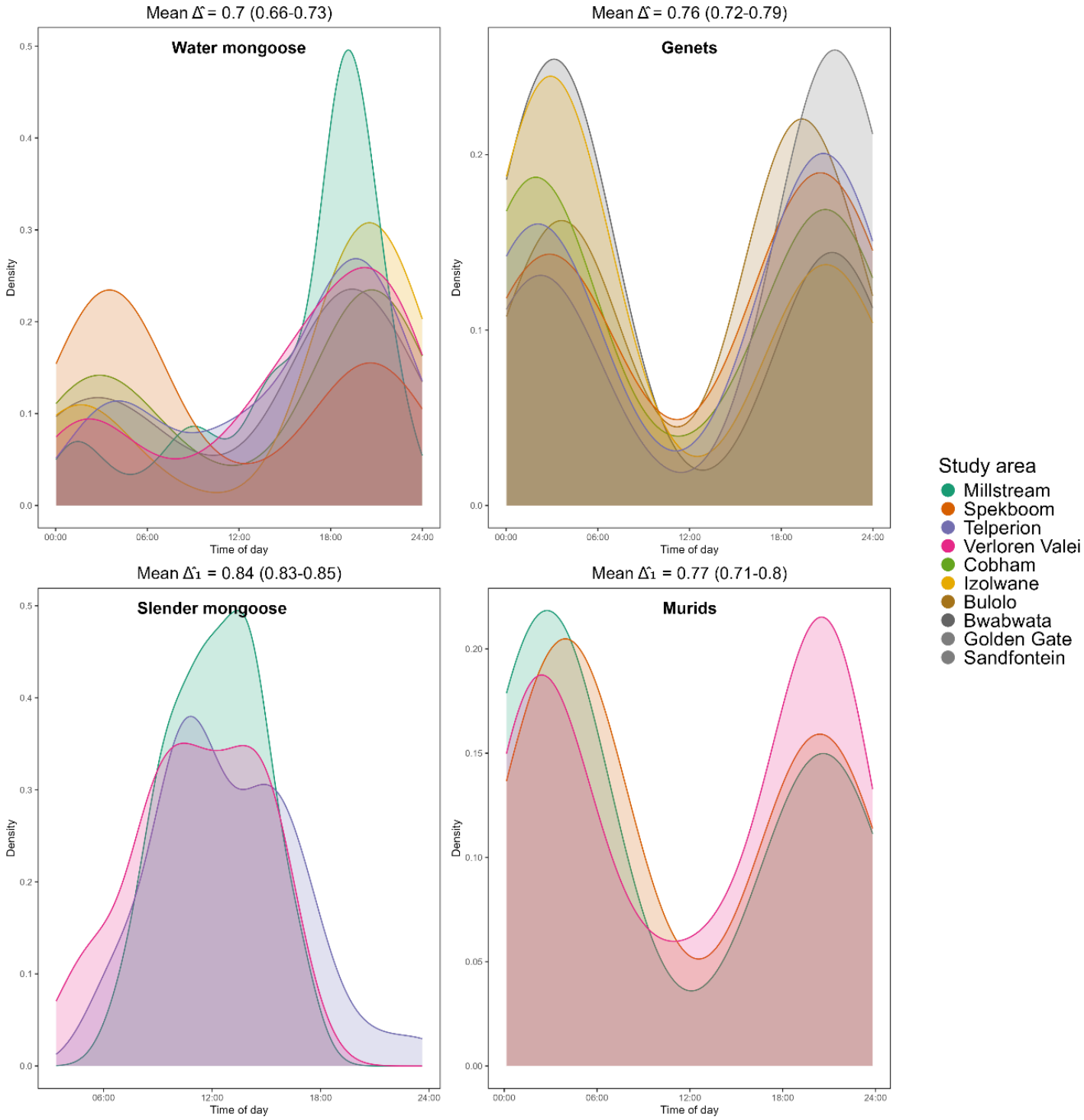


Figure 4

Inter-site variation in diel activity patterns and intraspecific temporal overlap ($\hat{\Delta}$) for mesocarnivores and their small mammal prey across different riparian study areas in southern Africa. Panels without an overlap coefficient subscript indicate that the underlying site-pairs for those species used a combination of both estimators.