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Intrinsic and extrinsic drivers of home range size in owned domestic cats *Felis catus*: Insights from a French suburban study

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Abstract

Domestic cats' varying home range sizes are connected to their impact on wildlife. Most of the previous studies suffered from lacking causality or small sample sizes. To overcome these limitations, we conducted a comprehensive study involving 55 owned domestic cats in a French suburban area where each cat was monitored during one or nine sessions over 5 years and all four seasons. We tracked the cats using GPS technology while controlling for the device used for monitoring, climatic conditions, environmental changes, and their degree of roaming. Using linear mixed-effect models, we found that age and sex significantly predict home range size. Younger cats tend to have larger home ranges and male cats have larger home ranges compared to females. We also found that the device used during the monitoring influenced the size of the home range. Surprisingly, climatic conditions, surrounding environment and degree of roaming had no significant impact. When considering our models, most of the variability in home range size was due to random effects that accounted for the identity of cats which were monitored one or more times. Therefore, a deeper understanding of intrinsic and extrinsic factors influencing home range size in domestic cats is crucial. This includes investigating individual behavior, breed-specific traits, and the role of owner care but also reassessing management solutions for reducing cat roaming and not only focusing on restrictive ones. Identifying these factors will enable the development of more effective management.

KEYWORDS

domestic cats, GPS, home range, predation, tracking, welfare, wildlife

1 | INTRODUCTION

The domestic cat, *Felis catus*, has shared a deep-rooted history with humans for over 9500 years, marking its estimated time of domestication (Vigne et al., 2004). This enduring companionship still profoundly impacts human society, shaping popular culture (Myrick, 2015) and even influencing aspects of human health (Brooks et al., 2018; Endo et al., 2020). In contrast to many other domesticated species, cats display significant variability in their

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degree of independence from humans, particularly in terms of feeding, movement, and reproduction. This divergence leads to a spectrum of domestic cat populations, ranging from those under human ownership to completely feral ones (Crowley et al., 2020a). This distinction is pivotal due to its implications for the interaction between wildlife and domestic cats, a connection strongly mediated by the extent of human control, especially in relation to predation (Loss et al., 2013).

All domestic cats are obligate carnivores, and a multitude of studies has concentrated on quantifying their impact on wildlife through predation (Loss et al., 2022). A major concern arises from their introduction to islands, where feral populations can proliferate and become invasive alien species, leading to at least 26% of global bird, mammal, and reptile extinctions (Bellard et al., 2017; Doherty et al., 2016; Medina et al., 2011).

In continental regions, the direct impact of domestic cats on prey populations through predation has raised concerns among local wildlife communities. Numerous studies have documented significant numbers of prey killed by domestic cats (Blancher, 2013; Dauphine & Cooper, 2009; Li et al., 2021; Loss et al., 2013; Murphy et al., 2019; J. C. Z. Woinarski et al., 2017; Woinarski et al., 2018, 2020) and some quantified potential ecological impacts of domestic cats (Belaire et al., 2014; Grayson et al., 2007; Kosicki, 2021; Marzluff et al., 2016; Parsons et al., 2006; Perkins et al., 2021; van Heezik et al., 2010).

The specific effect of owned or semi-owned domestic cats is less known (compared to feral cats) but there is growing interest in quantifying their effect on mainland wildlife (Assis et al., 2023; Brickner-Braun et al., 2007; Loss & Marra, 2017; Mella-Mendez et al., 2022; Mori et al., 2019; Woods et al., 2003). Based on the precautionary principle (Calver et al., 2011), many researchers call for better management of domestic cats to limit their effects on wildlife (Crowley et al., 2019) especially because owners can directly implement them. Some management options, such as brightly colored collars (Cecchetti et al., 2020; Geiger et al., 2022; Willson et al., 2015), sonic warning collars (Nelson et al., 2005), bells (Ruxton et al., 2002), pounce protectors (Calver et al., 2007), providing high-meat-content food, or object play, have been shown to have a significant effect on reducing cat predation on birds (Cecchetti et al., 2020). However, concerns about the impact of domestic animals on wildlife vary from country to country and the application of restrictive measures to owned domestic cats really depends on the country and can be very unwelcome by cat owners (e.g., in the United Kingdom, see Hall, Adams, et al. (2016) for more details), particularly when it comes to restricting their cat's movements (Crowley et al., 2019; Foreman-Worsley et al., 2021).

While the spatial behavior of cats and their ecological impact on wildlife lack a clear definition, emerging results suggest that differences in home range size may not directly influence the number of prey captured (Cecchetti, Crowley, Wilson-Aggarwal, et al., 2022; van Heezik et al., 2010). However, cat roaming is implicated in various ecological consequences, including (i) an increase in the diversity of prey brought home (Morgan et al., 2009), (ii) elevated chances of crossing protected areas housing vulnerable species (López-Jara et al., 2021; Wierzbowska et al., 2012), and/or (iii) a higher probability of killing native species (Herrera et al., 2022). The presence of cats also induces fear and heightened vigilance in prey, so domestic cat roaming would influence the number of individuals affected by sublethal effects (Bonnington et al., 2013). Additionally, domestic cat roaming can have health implications for the cats themselves, increasing the risk of transmitting zoonotic parasites or encountering vehicle collisions (Chalkowski et al., 2019; Egenvall et al., 2009; Moreau et al., 2003; Rochlitz, 2004). The observed influence of domestic cat roaming on wildlife, as revealed by these results, raises significant concerns. Just as with predation, the need for effective management solutions to mitigate these impacts is evident. Implementing suitable measures, particularly for domestic animals where emotional considerations play a crucial role (Crowley et al., 2020b; Hall, Adams, et al., 2016), requires a robust scientific foundation. Clear guidance should be provided to owners, emphasizing the importance of informed and responsible management strategies to address the potential ecological implications of domestic cat roaming on wildlife.

In 2016, Hall et al. conducted a meta-analysis revealing factors influencing domestic cats' home range size. They found male sex, rural location, and age impacted home range size, with males and rural cats having larger ranges, and adult cats (2–8 years) displaying greater ranges than mature cats (>8 years). Contrary to expectations, desexed cats did not exhibit smaller ranges. In a recent study, Cecchetti, Crowley, Wilson-Aggarwal, et al. (2022) examined how owner strategies influence the home ranges of owned domestic cats. Their findings demonstrated, for the first time, that cats subjected to outdoor restrictions exhibited significantly smaller home ranges compared to those with more unrestricted access. Despite the growing interest in domestic cat behavior, numerous predictors influencing home range remain elusive, often attributed to inadequately defined models that overlook confounding predictors. Additionally, the noteworthy effect of outdoor restriction identified by Cecchetti, Crowley, Wilson-Aggarwal, et al. (2022) has yet to be replicated, highlighting the need for further research. To enhance understanding, this study aimed to (i) establish a causal-based empirical model (see Section 2) and (ii) ensure statistical robustness through a substantial sample size.

This study sought to validate prior findings by conducting extensive monitoring of 55 individual cats across multiple sessions throughout all four seasons (winter, spring, summer, and fall) from 2016 to 2021. Building upon previous research that explored the influence of outdoor access (Cecchetti, Crowley, Wilson-Aggarwal, et al., 2022), sex, and age (Hall, Bryant, et al., 2016) on home range size, we incorporated considerations for climate, vegetation proportion in the surrounding environments, and monitoring devices. Our hypothesis posited a positive correlation between the proportion of vegetation and home range size, based on its potential to facilitate movement, increase prey availability, and reduce competition among conspecifics. Concerning climatic factors, we anticipated a positive correlation with temperature and a negative correlation with rainfall, indicating more favorable conditions for pets to venture outdoors. To test these hypotheses, we constructed linear mixed-effect models to establish the most causal relationships possible between home range and the identified variables. Utilizing 95% and 50% autocorrelated kernel density estimates (aKDE 95% and aKDE 50%) as proxies for full and core home range size, we conducted analyses across 155 monitoring sessions involving 55 domestic cats. This study had a dual objective: firstly, to improve our understanding of the internal and external factors linked to significant variations in the home range size of domestic cats, and secondly, to provide insights for assessing the suitability of management strategies aimed at mitigating potential impacts on wildlife. In doing so, we emphasize the central role of owner involvement in developing effective and responsible management approaches.

2 | METHODS

2.1 | Ethics statement

The entire study complied with legal requirements in France, and ethics approval was not mandatory for the study. All participants voluntarily participated in the study by attaching a GPS to their own cats, provided informed consent, and the recovered position data was anonymized.

2.2 | Study site

All cats monitored for this study were located around the agricultural area of Saclay (hereafter referred to as "agricultural land") (48°42′32.18″ N, 2°10′33.00″ E), which is located between the north of the Essonne department and the southeast of the Yvelines department, close to Paris metropole, France. This fertile agricultural land, extending over an area of around 30 km^2, has a long agricultural history with colza, wheat, barley, and maize being the dominant crops. The study site corresponds to a suburban area dominated by single-family homes, small forest patches, and agricultural fields.

2.3 | Sample set building

The monitoring process encompassed two distinct phases: from autumn 2016 to summer 2017 and autumn 2020 to summer 2021. Within each of these phases, a monitoring was conducted for each season, namely winter, spring, summer, and fall. This design enabled each domestic cat to have up to 12 monitoring sessions—4 sessions between autumn 2016 and summer 2017, and 8 sessions between autumn 2020 and summer 2021.

For owner recruitment, we focused on urban residents in proximity to the agricultural Saclay Plateau. Our approach involved diverse strategies, including direct door-to-door visits, distributing notes in mailboxes, disseminating flyers through local veterinarians, and collaborating with the TERRE ET CITE association. Once recruited, participants were provided with a GPS device (either a CatLog/CatTrack1, referred to as blue GPS, or a CatLog Gen2 GPS/GNSS Data Logger, referred to as gray GPS) for each session. They were required to outfit their cats with the devices for a minimum of 3 days, and a maximum determined by GPS battery longevity.

While the initial phase (2016–2017) encountered recruitment difficulties, we successfully reengaged these owners in the subsequent phase (2020–2021), while also recruiting new participants. The objective for the latter phase was to monitor the same 30 cats across all four seasons. Nonetheless, challenges emerged, including owner availability, collar acceptability by cats, and some owners' hesitation to replicate the protocol multiple times. Consequently, each domestic cat underwent monitoring 1 to 9 times out of the 12 potential ones. Our efforts yielded a collection of 184 GPS monitoring from 62 distinct domestic cats across the 12 sessions.

2.4 | Home range computation

Before the analysis, we removed all erroneous locations identified based on improbable travel distances given the time between locations (Hanmer et al., 2017; Kays et al., 2020; Morris & Conner, 2017). Home range size was calculated using the R software (R Core Team, 2021) as 95% and 50% autocorrelated Kernel Density Estimation (aKDE) (Fleming et al., 2015), using the *akde* function of the ctmm R package (Calabrese et al., 2016) as a proxy for the domestic home range. aKDE95% corresponds to the full home range of the cat, and aKDE50% corresponds to the core home range. We plotted the correlogram of all individuals to evaluate if they had established a home range or if they were monitored long enough, using the *variogram* function of the ctmm R package. We removed all home ranges that did not display convergence through their variogram.

2.5 | Variables

To construct the most causal model linking variables with the home range of domestic cats, we identified both established predictors of home range variation and potential confounding variables. Across 184 monitoring sessions of the 62 domestic cats, we recorded diverse intrinsic and extrinsic factors. Two established predictors, cat age (in years) and sex (male/female), were noted. Additionally, we introduced three underexplored extrinsic predictors: the cat's outdoor access (restricted/unrestricted), season (spring, summer, fall, winter), and the proportion of vegetation surrounding the cat owner's home. Vegetation proportion was computed within 100 m and 500 m buffers using 2021 land use data from INSTITUT PARIS REGION, encompassing forests, shrublands, agriculture, parks, sports fields, and cemeteries. These buffer distances are aligned with mean (~0.03 km^2) and extreme (~0.8 km^2) home range sizes from literature (Hall, Bryant, et al., 2016; Kays et al., 2020). Three control variables were included: mean daily temperature (°C) and rainfall (mm/day), sourced from METEOFRANCE, reflecting encountered climatic variability during GPS monitoring; and GPS device used during monitoring (blue/gray) to assess potential device impact. We used these multiple predictors and controls to mitigate confounding influences. Of these 62 cats, all were desexed and only 4 were purebred, 2 Siamese and 2 British shorthair. Considering the low number of purebred cats, we did not take this variable into account in the rest of our study.

2.6 | Data processing

Of the initial 184 GPS monitoring data, 20 were removed due to an absence of convergence of the corresponding variogram, 3 were removed due to a problem during the session (e.g., owners removed the GPS during the monitoring session), 4 were removed because they were too young (<1 year) and finally, 2 were removed because at least one variable (described "Variables" section) was missing for the monitoring. We consequently analyzed 155 GPS monitoring of 55 cats (summarized in Table 1).

2.7 | Statistical analyses

To mitigate potential bias stemming from uneven monitoring session counts per cat, we computed mean aKDE95% and aKDE50% values per cat by utilizing all accessible monitoring data for each cat, ranging from 1 to 9 values based on individual circumstances.

For evaluating the impact of sex, age, outdoor access, climatic conditions, and vegetation proportion on cat home range size, we developed two linear mixed-effect models using aKDE95% and aKDE50% as responses. Prior to constructing the models, we log-transformed home range sizes (aKDE95% and aKDE50%), cat ages, and daily rainfall data to achieve distribution normalization. Non-categorical variables mentioned in the cat characteristics section (refer to Table 1) were centered by mean and scaled by two standard deviations to facilitate comparison (Gelman, 2008). Due to a robust correlation between daily mean temperature and season (as depicted in Figure S1), we opted to exclude season from our models, as both variables conveyed similar information. Subsequently, we employed the *lmer* function from the lme4 R package (Bates et al., 2011) to compute the linear mixed-effect models. All variables were employed as fixed effects but we added the cat identity as a random effect because most of the cats were monitored multiple times (Figure 1):

$$\begin{aligned}\log(\text{aKDE}) \sim\ & \text{sex} + \text{age} + \text{outdoor access} \\ & + \text{proportion of vegetation in a 100 m buffer} \\ & + \text{proportion of vegetation in a 500 m buffer} \\ & + \text{mean daily temperature} \\ & + \text{mean daily rainfall} + \text{type of GPS} \\ & + (1|\text{cat identity})\end{aligned}$$

For categorical variables, female, restricted access to outdoor and blue GPS were used as reference for model computation. We provided the confidence interval at 95% (95% CI) and 90% (90% CI) of the different estimates using the *confint* R function of the R Stats Package. We computed the conditional and marginal R-squared of this model using the *r2_nakagawa* function (see Nakagawa & Schielzeth, 2013) of the performance R package (Lüdecke et al., 2021) to assess the part of the model explained by our predictors. The assumptions of the residuals were

TABLE 1 Summary of the full (aKDE 95%) and core (aKDE 50%) home range computed in our study using 155 GPS monitoring sessions of 55 cats in a suburban area of France and seven associated predictors.

Predictors	Category	Number	Mean	Standard deviation	Min	Max
AKDE 95% (m^2)		155	32,737	44,475	6452	414,347
AKDE 50% (m^2)			4079	5736	597	50,587
Age (years)			6.9	4.6	1	18
GPS type	Blue	86	55%			
	Gray	69	45%			
Mean temperature (°C)		155	11	5.2	−1.6	25
Proportion of vegetation 100 m			0.48	0.37	0.0032	1
Proportion of vegetation 500 m			0.57	0.27	0.08	0.99
Outdoor access	Restricted	85	55%			
	Unrestricted	70	45%			
Daily rainfall (mm per day)		155	2.1	1.9	0.057	9.1
Season	Fall	54	35%			
	Winter	37	24%			
	Spring	30	19%			
	Summer	34	22%			
Sex	Female	91	59%			
	Male	64	41%			

Note: The categorical predictors are in italics and the others are continuous. For continuous variables, units are in parentheses. The category column is only valid for categorical predictors and the standard deviation, min and max columns for continuous predictors.

verified using the DHARMa R package (Hartig, 2022). Additionally, we calculated the statistical power (i.e., 1–Type II error probability) for the significant predictors using the *powerSim* function of the simr R package (Green & MacLeod, 2016).

3 | RESULTS

3.1 | Overview of the study

We observed an asymmetrical distribution of aKDE 95%, computed on 55 different domestic cats, with a range from 0.0065 km^2 to 0.41 km^2, a mean of 0.041 ± 0.061 km^2, and a median of 0.022 km^2 (Figure 2a). We observed a similar distribution for aKDE 50%, with a range from 0.00060 km^2 to 0.051 km^2, a mean of 0.0051 ± 0.0079 km^2, and a median of 0.0028 km^2 (Figure 2b).

3.2 | Variables influencing cat home range size

We tested eight different predictors (sex, age, outdoor access, daily temperature, daily rainfall, type of GPS and proportion of vegetation in a 100 m and 500 m buffer) of the aKDE 95% and aKDE 50% variability through 155 GPS monitoring (Figure 3; Figures S2 and S3). We first found that age had a strong negative effect on aKDE95% (estimate = −0.51, 95%CI = [−0.85;−0.17]) and aKDE 50% (estimate = −0.53, 95%CI = [−0.88;−0.17]). We then observed, with a weaker evidence, that male had an higher aKDE 95% (estimate = 0.39, 95%CI = [0.028;0.76]) and aKDE 50% (estimate = 0.37, 95%CI = [−0.016;0.75] and 90%CI = [0.048;0.69]). We also found an important effect of the type of GPS used during the study with a lower aKDE95% (estimate = −0.53, 95%CI = [−0.78;−0.26]) and aKDE50% (estimate = −0.71, 95% CI = [−0.98;−0.43]) for cats monitoring with gray GPS. The statistical power, with $\alpha = 0.05$, of the age effect was 79.60% (95%CI = [76.97, 82.06]) for aKDE 95% and of 78.30% (95%CI = [75.61, 80.82]) for aKDE 50%. Additionally, the statistical power, of the sex effect was 52.10% (95% CI = [48.95, 55.24]) for aKDE 95% with $\alpha = 0.05$ and of 59.40% (95%CI = [56.28, 62.46]) for aKDE 50% with $\alpha = 0.1$. The type of GPS had a statistical power with $\alpha = 0.05$ of 97.90% (95%CI = [96.81, 98.70]) for aKDE95% and of 99.90% (95%CI = [99.44, 100.00]) for aKDE50%. None of the five remaining predictors showed a significant effect in predicting aDK95% or aDK50% (Figure 3).

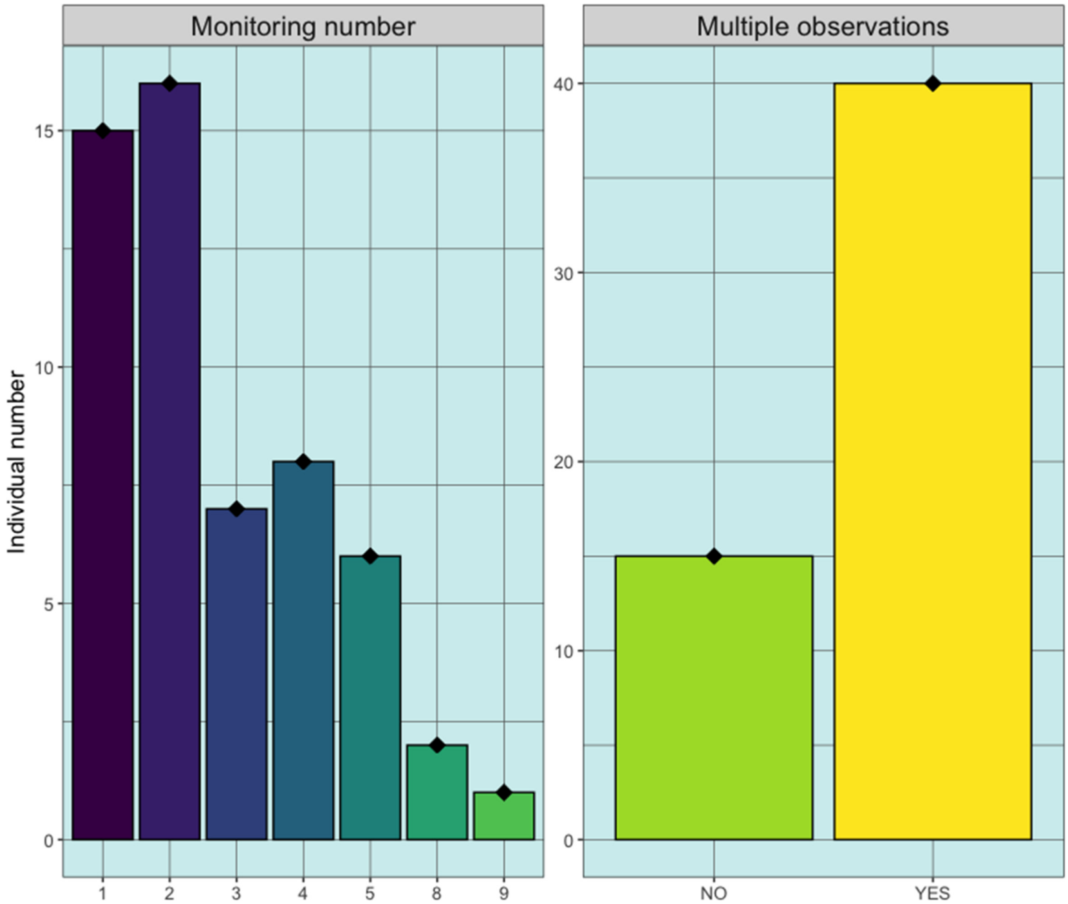

FIGURE 1 Monitoring sessions distribution across 55 domestic cats in our cross-longitudinal study of home range size estimation. The 55 domestic cats were tracked from 2016 to 2021 over four seasons. On the left-hand panel, the columns topped by a black diamond represent the number of domestic cats by monitoring numbers. On the right-hand panel, the green column with a black diamond represents the total number of domestic cats tracked once, and the yellow column the total number of domestic cats tracked twice or more.

The eight predictors only explained a small part of the variation of the aKDE 95% (marginal R-squared = 0.20), but the random effect, corresponding to the cat identity, had a better power of explanation (conditional R-squared = 0.72). We observed similar values for the aKDE 50% (marginal R-squared = 0.22 and conditional R-squared = 0.71).

4 | DISCUSSION

We found that domestic cats in a suburban area had a relatively small home range (mean aKDE 95% =0.041 ± 0.061 km^2 and mean aKDE50% = 0.0051 ± 0.0079 km^2) compared to other wild carnivores, except for two outliers (cat n°9 and n°8) for aKDE 95% reaching a mean of 0.41 km^2 and 0.26 km^2, and three outliers (cat n°9, n°8 and 71) for aKDE 50% reaching a mean of 0.051 km^2, 0.031 km^2 and 0.030 km^2. Among the different predictors, we showed that the age of domestic cats and the sex (male or female) had an effect on aKDE 95% and aKDE 50%. Specifically, we demonstrated that the home range size of domestic cats decreases with their age and we showed a higher home range for male than females for aKDE 95% and aKDE 50%. We were able to reach the 80% statistical power threshold for the impact of sex on aKDE 95% and aKDE 50%, but not for age, which limits the strength of our conclusions for the second variable. We also found that the type of GPS used during monitoring significantly influenced the results. Cats monitored with blue and gray GPS showed differences in both aKDE 95% and aKDE 50%, with a lower home range for cats tracked by gray GPS, with statistical robustness above 80%. None of the other variables showed any evidence of an impact (positive or negative) on the home range size.

These results were consistent with previous findings on domestic cat home ranges. We confirmed that in a French suburban area, the home ranges were only a few hectares (4.2 ± 6.2). Kays et al. (2020) found similar results with home ranges of 3.6 ± 5.6 ha using 875 cat

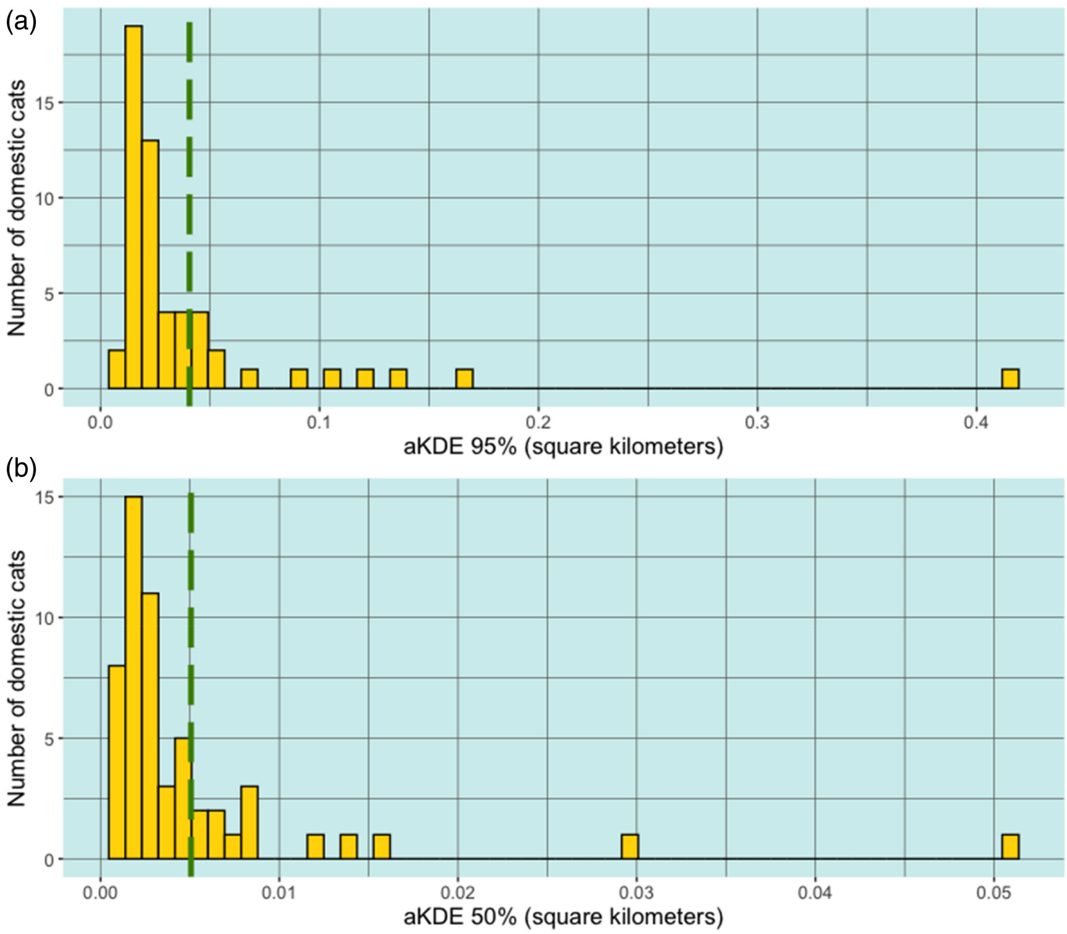

FIGURE 2 Distribution of the aKDE calculated from the monitoring of 55 domestic cats. (a) panel, showing the results for aKDE95% and (b) panel for aKDE50%. The green dashed line represents the mean value of aKDE.

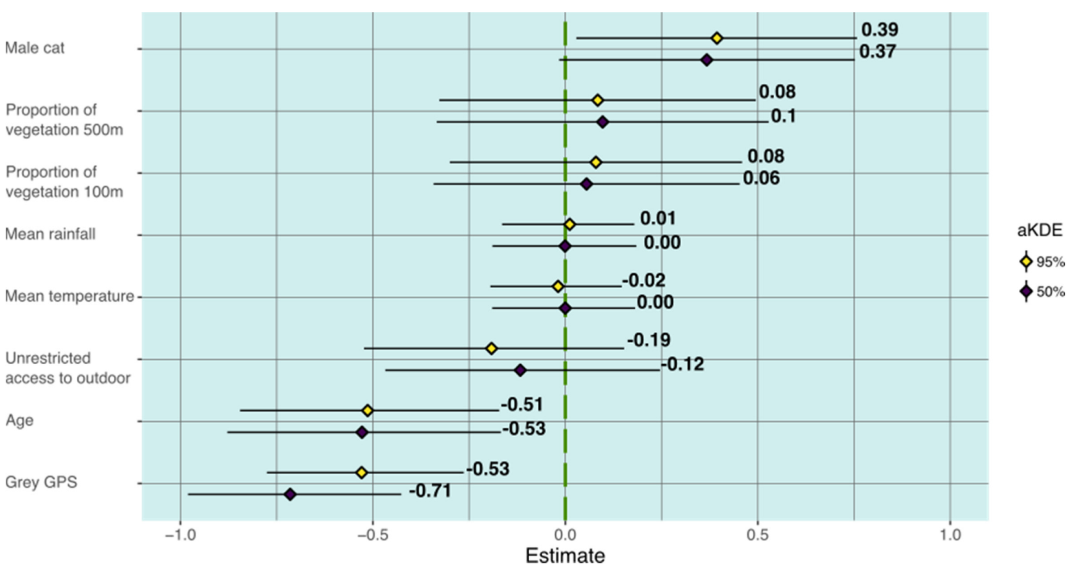

FIGURE 3 Estimates of predictors influencing aKDE for 55 domestic cats. We computed two linear mixed-effects models to predict aKDE95% (full home range size) and aKDE50% (core home range size) based on seven predictors with potential a priori effects. The number in bold and the diamonds show the estimate of each predictor for aKDE95%, in yellow, and for aKDE50%, in purple. The two associated black lines correspond to the 95% confidence interval of the estimates.

tracking data across six continents. Through these results, the home range size appears to be a highly conserved trait of owned domestic cats, regardless of the geographical location of the study. We also found a similar result to the meta-analysis by Hall, Bryant, et al. (2016), with evidence of a sex effect on home range size, where males had larger home ranges than females. This effect of sex was also found in Kays et al. (2020). However, in contrast to Cecchetti, Crowley, Wilson-Aggarwal, et al. (2022), we found that the age of cats had a negative impact on home range size but we used age as a linear predictor since we did not find strong evidence of ecological basis for dividing domestic cats into different age categories as previously done (see e.g., Cecchetti, Crowley, Wilson-Aggarwal, et al., 2022). This way of considering age makes our findings less data consuming and without any need of creating artificial age classes.

Similar to the work of Cecchetti, Crowley, Wilson-Aggarwal, et al. (2022), our study investigated the impact of owner strategies in providing outdoor access on the home range of domestic cats. However, in contrast to their findings, our study did not reveal any significant effect on home range size based on whether outdoor access was restricted or unrestricted for owned domestic cats. More specifically, efforts to reduce the roaming behavior of domestic cats did not result in a statistically significant decrease in home range size.

Contrary to most studies, we also examined the impact of climatic conditions and the proportion of vegetation in the areas surrounding cat owners' homes on domestic cat home range size. Whereas we expected a negative effect of daily rainfall and a positive effect of daily temperature on home range size, we found no evidence of an effect of climatic conditions on home range size for domestic cats, and therefore no temporal variation in home range size according to the season (mainly due to the high correlation between season and daily temperature, see Figure S1). As a result, we found no support for our hypothesis that home range size would increase in spring and summer when climatic conditions are more favorable and prey availability is higher. The degree of urbanization in the surrounding environment also had no effect on the home range size of domestic cats. Herrera et al. (2022) found that domestic cats' prey ranges from highly urbanized to more natural environments and from non-native to native prey species. Therefore, if domestic cats roam more in natural and semi-natural areas, they could have a more negative impact on local biodiversity through direct and indirect effects (e.g., sublethal effects). Fortunately, wildlife, especially birds, appear to exhibit adaptive behavior in the presence of cats in highly urbanized environments, which may mitigate their impact through both lethal and sublethal effects (Díaz et al., 2022). Moreover, the significant impact of the type of GPS on domestic cat home range size highlights the necessity for studies using different monitoring devices to consider and account for these variations in their models, to avoid potential confounding effects.

Although the climatic, environmental and methodological predictors presented mostly non-significant effects on home range size of domestic cats, their inclusion in the models was essential to address potential confounding factors, which could affect the conclusion regarding other predictors in our models. This necessity is particularly emphasized given the study's multi-seasonal span over 5 years and the inherent landscape heterogeneity, intensified by significant artificialization at our study site. Consequently, our research is the first to establish more causal links between classical predictors and cat home range size, offering robust and precise insights into the factors influencing cat behavior in this specific context.

In addition, our study provided the opportunity to observe the effect of cat identity (i.e., which individual) on home range size variations by incorporating the cat identity as a random factor in our models. We thus found that the classical predictors of home range sizes, corresponding to the fixed effect of our models, explained less the variation of home range size than the cat identity random factor. Our findings suggest that the observed variation in home range size is primarily attributed to intrinsic differences among domestic cats. In line with this, recent studies (Cecchetti, Crowley, McDonald, & McDonald, 2022; Cordonnier, Ferry, et al., 2022; Cordonnier, Perrot, et al., 2022) have investigated the potential of using cat personality to predict predatory behavior, indicating that cat personality could serve as a valuable predictor of cat home range. Therefore, exploring the integration of cat personality and other potentially explanatory factors, including how cats are cared for at home (e.g., type of food or playtime, as explored by Cecchetti et al., 2021), presents a promising avenue for further research. This exploration aims to enhance our understanding and prediction of cat home range behavior, potentially paving the way for the implementation of management solutions that can influence these behaviors and, consequently, reduce cat roaming.

Our study is not without limitations, and it is crucial to acknowledge them. One primary limitation lies in the categorization of outdoor access as either restricted or unrestricted, which may be considered vague and lacking detailed information. This binary classification could potentially influence our results, and further research incorporating more comprehensive data on outdoor access would be advantageous for a clearer understanding of its impact. Recognizing that owners employ various methods in letting their cats outside, each with potentially distinct effects on home range size, we acknowledge the need for a more nuanced quantitative approach in future studies. For instance, some owners may permit outdoor access only at night, a factor that could significantly influence home range size, while others may allow outdoor access during the day or when they are present. Despite these variations, the specific behavior of owners toward their cats during monitoring sessions was not consistently categorized to maintain the causal nature of our findings. Consequently, we opted to retain the binary classification to avoid introducing ambiguity. We acknowledge and recommend that future studies should employ a more quantitative approach to encode outdoor access, thereby enhancing ecological understanding and unraveling the consequences of owner routines. This aspect is particularly important for a more precise evaluation of whether restrictive management measures for domestic cats are genuinely effective in reducing home range size and mitigating their consequent negative effects on wildlife.

Additionally, our dataset suffers from attrition, resulting in heterogeneity in the number of monitoring sessions per cat and a lack of unique cats to achieve sufficient statistical power to draw significant conclusions on the effect of sex on home range size. Despite monitoring a relatively large number of domestic cats and considering many confounding effects in our model, this limitation highlights the importance of larger sample sizes and balanced representation of different studied groups.

We observed that the existing literature could benefit from more causal and longitudinal datasets (see, e.g., Hall, Bryant, et al., 2016; Kays et al., 2020; or Cecchetti, Crowley, Wilson-Aggarwal, et al., 2022). We strongly advocate for a reconsideration of methodologies employed to measure predictors, whether intrinsic or extrinsic, that influence domestic cat home ranges. The utilization of structural equation models emerges as an interesting and robust method for understanding these predictors' impact on cat home range size, but its application demands a substantial number of individuals monitored across multiple surveys. By better understanding the factors that influence cat home range size and their interaction with wildlife, we can design more targeted management strategies to mitigate the impact of cats on local wildlife, while considering owner considerations. Our results challenge the assumption that reducing the roaming behavior of domestic cats necessarily leads to a reduction in home range size. This calls for a reassessment of management solutions, suggesting that other approaches than just restrictive ones, which are not always well received by owners (Crowley et al., 2019; Foreman-Worsley et al., 2021), should be considered, as well as finer-grained restrictive strategies that go beyond a binary classification such as restricted versus unrestricted.

Given recent advancements in understanding domestic cat behavior, especially regarding their notably small home range sizes, and the heightened vulnerability of native prey in more 'natural' areas (see Herrera et al., 2022), the implementation of management policies for roaming cats becomes increasingly crucial. Owners residing in proximity to 'natural' or 'semi-natural' zones, where domestic cats have the potential to roam, may need to adopt proactive measures to mitigate potential negative impacts, both lethal and sublethal, on native wildlife especially because we showed that the proportion of natural area surrounding domestic cats did not affect their spatial behavior. These measures, such as complete restricting outdoor access during critical periods like bird migration or threatened species' reproductive phases (e.g., certain reptiles or bats), employing bell collars, or adjusting protein ratios in pet food, warrant further examination to formulate effective management strategies for preserving local biodiversity and maintaining ecological balance in these sensitive environments (Cecchetti et al., 2021).

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DATA AVAILABILITY STATEMENT

The data and code that support our analyses are available from Zenodo and GitHub: https://doi.org/10.5281/zenodo.8276774 and https://github.com/MartPhilip/Intrinsic-and-extrinsic-drivers-of-home-range-size-in-owned-domestic-cats-Felis-catus-Insights-from. The raw GPS data, the raw climatic data and raw land use data are not accessible for privacy policies.

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SUPPORTING INFORMATION

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