Wild and feral mammals in a natural area in Mexico City, Mexico

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Abstract

Mexico City, one of the largest urban areas in the world, continues to expand into natural landscapes, threatening native biodiversity. The Sierra de Guadalupe (SG), a protected mountainous area in the city's northern region, represents a critical refuge for wildlife. However, the presence of feral mammals—particularly domestic species exhibiting wild behavior—poses serious ecological and public health risks. From February 2020 to August 2021, we conducted 20 survey walks and 255 camera-trap days across SG to assess the composition and relative abundance of medium-sized mammals. We identified nine species, with dog (*Canis lupus familiaris)* (24 %) emerging as the most frequently detected. Behavioral indicators—such as gregariousness, robust body condition, and lack of human proximity—suggested that many dogs exhibited feral characteristics. In contrast, species such as gray fox (*Urocyon cinereoargenteus)* and cacomixtle (*Bassariscus astutus)* showed lower relative abundances, suggesting potential displacement. Species richness estimation (Chao2) confirmed that all predicted species were recorded. No significant seasonal variation in domestic animal presence was found, but spatial analysis revealed higher abundances near urban-adjacent entrances. Testimonies from local residents corroborated the presence of dog packs and reported incidents of aggression toward people, livestock, and wildlife. Our findings highlight the urgent need for ethical and ecologically informed management strategies to control feral mammal populations. Reducing their abundance will help mitigate zoonotic disease risks and support long-term conservation efforts in urban natural areas.

Keywords: Feral mammals; Urban protected area; Camera trap monitoring; Species displacement; Zoonotic risk; Sierra de Guadalupe.

Study contribution

While the ecological impacts of domestic animals in natural areas are broadly recognized, specific and systematic data remain scarce—particularly in highly urbanized regions such as Mexico City. This study provides quantitative and behavioral evidence of the presence, activity, and relative abundance of feral dogs and cats in the Sierra de Guadalupe, a protected natural area under intense urban pressure. Through camera-trap monitoring and field observations, we identified patterns of territorial behavior, social grouping, and possible predatory activity in feral individuals. Additionally, we integrated local testimonies and ethological analyses to contextualize their ecological roles. Our findings underscore the need to incorporate feral fauna management into urban conservation strategies to mitigate impacts on native wildlife and reduce zoonotic and public health risks.

Introduction

Mexico City is one of the largest and most populated cities in the world. The Metropolitan Zone of Mexico City which includes the 16 boroughs of Mexico City, 59 municipalities in the State of Mexico, and one in Hidalgo, had an estimated population of approximately 21.4 million people in 2020.[1] Urban expansion in this region has dramatically transformed ecological dynamics, driving land-use change and habitat fragmentation. Mexico City has undergone profound environmental alterations due to accelerated human settlement growth and infrastructural development,[2, 3] which has led to the ecological isolation of surrounding green areas such as the Sierra de Guadalupe.

The Sierra de Guadalupe is a volcanic mountain range located in the northern part of the Mexico Basin, covering approximately 15 000 hectares across areas of Mexico City

and the State of Mexico. The region includes multiple protected zones under different jurisdictions: around 1 500 hectares are federally designated as El Tepeyac National Park, managed by Comisión Nacional de Áreas Naturales Protegidas, since 1937; and approximately 5 293 hectares are protected at the state level by the Government of the State of Mexico. Within Mexico City, about 633 hectares are managed by Secretaría del Medio Ambiente under the local designation of Zone Subject to Ecological Conservation (ZSEC).[4–6] It is crucial to highlight that neither the state-protected nor the ZSEC sections benefit from federal-level protection,[4] making them especially vulnerable to anthropogenic pressures. Their conservation and management rely solely on state or municipal regulations, which may lead to inconsistencies in the implementation and effectiveness of protective measures.

The portion of Sierra de Guadalupe located within Mexico City, corresponding to the ZSEC, is a remnant natural area where ecosystems persist despite fragmentation and remain under constant pressure from urban encroachment.[7] In such ecosystems, biodiversity loss is often closely linked to the introduction of exotic species, particularly domestic animals that have become feral. These animals—introduced through abandonment, loss, or uncontrolled reproduction—are not part of the original fauna and disrupt native communities through predation, competition for resources, and disease transmission. Dog (*Canis lupus familiaris*) and cat (*Felis catus*) are among the most common feral species found in the area.[8, 9]

According to operational definitions used in this study, feral dogs and cats are free-ranging domestic species that survive and reproduce independently of direct human control, often forming groups or populations in urban or peri-urban natural areas.[9, 10]

Dogs may also exist in peridomestic conditions, accessing natural spaces regularly while maintaining some degree of dependence on human settlements. These classifications represent a continuum of domestication and are essential for understanding their ecological impact. Cats, in particular, possess behavioral traits that enable them to survive and reproduce without direct human interaction, facilitating their establishment as feral populations in urban natural areas.[11, 12] Feral dogs may form self-sustaining packs that hunt cooperatively, while cats are typically solitary, territorial, and difficult to manage.[10, 13]

The overpopulation of feral animals poses significant ecological and public health risks. In addition to threatening native biodiversity, they serve as vectors and reservoirs of zoonotic diseases such as rabies, toxoplasmosis, tularemia, and murine typhus, among others.[14–16] In ecosystems where large native carnivores are absent, such as Sierra de Guadalupe, feral dogs may assume the ecological role of apex predators—species at the top of the food chain that influence community structure through top-down regulation. These combined ecological and sanitary pressures highlight the urgent need for systematic monitoring and management of feral animal populations.

Despite the presence of documented wildlife in Sierra de Guadalupe, there are no current population estimates for feral species or systematic data on their interactions with native mammals. Therefore, the aim of this study was to survey wild and feral mammals within the ZSEC of the Sierra de Guadalupe using camera traps between February 2020 and August 2021. This survey provides a descriptive characterization of mammalian species composition and relative abundance, with an emphasis on the role of feral and peridomestic animals in shaping community dynamics.

Materials and methods

Ethical statement

No animals were handled in this study. Permits for camera trap placement and specimen collection were obtained from Secretaría del Medio Ambiente y Recursos Naturales (SEMARNAT) and the Sierra de Guadalupe Protected Natural Area authorities

Study area

Sierra de Guadalupe is located in the northern part of the Mexico Basin, between 19°37' and 19°29' N latitude and 99°12' and 99°02' W longitude. The study was primarily conducted in the Ecological Conservation Area (Zone Subject to Ecological Conservation-ZSEC), located within the Mexico City portion of Sierra de Guadalupe, where natural ecosystems persist despite fragmentation and face constant pressure from surrounding urbanization. Additional sampling points were placed in adjacent areas of the State of Mexico for comparative purposes. The region has a temperate-subhumid climate (C(wo) and C(wi')), with an average annual temperature of 16.7 °C. Annual precipitation ranges between 600 and 700 mm, primarily occurring from May to October, peaking in July and August. The dry season spans from November to April, with minimal rainfall between December and February.[17]

Field survey

To survey feral and wild mammals, passive sampling methods were used, specifically the placement of camera traps along pre-established traversed routes within Sierra de Guadalupe. For this study, feral animals were defined as free-ranging domestic species

that survive and reproduce independently of direct human control, while peridomestic individuals referred to those with regular access to natural spaces but partial dependence on human-associated resources.[9, 10]

Eighteen motion- and infrared-activated camera traps (Bushnell Trophy Cam HD, Moultrie M-990i, and Cuddeback IR) were installed across four designated sampling regions in both the State of Mexico and Mexico City during. These regions were (**Figure 1**):

1) Arboledas entrance (Calle del Árbol and La Casilda) and adjacent areas (Feb–Mar and Aug–Sep 2020),
2) Joya de Nieves entrance (Feb–Mar and Aug–Sep 2020),
3) La Armella Ecological Conservation Area (Vinguineros, Jun–Jul 2020),
4) El Panal and Sierra de Guadalupe State Park (Jul 2020–Mar 2021).

Figure 1. Sierra de Guadalupe North of Basin of México, Gustavo A. Madero (Mexico City), Ecatepec, Coacalco, Tultitlán and Tlalnepantla (State of Mexico). Ecological

Conservation Area of Sierra de Guadalupe 1) Arboledas entrances through Calle del Árbol and La Casilda and the State of Mexico (February–March and August–September 2020), 2) Entrance through Joya de Nieves (February–March and August–September 2020), 3) Ecological Conservation Area La Armella, entrance Vinguineros (June–July 2020); and 4) El Panal and Sierra de Guadalupe State Park. https://www.google.com/maps/@19.5863497,-99.1338258,11240m/data=!3m1!1e3?entry=ttu Cameras were placed at an average distance of 397.45 m apart (S.D. ± 241.63 m), with a minimum spacing of 200–500 m, based on established recommendations to reduce spatial redundancy.[18, 19] Camera locations were determined along routes showing mammal signs (e.g., hair, tracks, scat, burrows), and were installed approximately 40 cm above ground. Bait included tuna, sardines, and peanut butter.[20, 21] Placement accounted for terrain complexity, vegetation cover, and safety concerns. All cameras operated 24 hours per day, set to capture three consecutive images per trigger with one-minute intervals. Geographic coordinates (latitude, longitude) were recorded for each camera site.[22–26]

Data analysis

Species were identified using field guides and regional records.[27, 28] Only records identified to the species level were used; most rodents, except Sciuridae, were excluded due to image resolution limitations and their small, nocturnal nature. Independent events were defined as observations of the same species occurring more than 24 hours apart at the same camera location.[18, 19] Signs found during transects also guided initial species identification.

Medium-sized mammals were defined as those weighing more than 500 g,[26, 29] and were used for species richness estimation to reduce detection bias. Dominance was established based on the number of independent events; *Canis lupus familiaris* showed the highest frequency across all sampling zones and was the most dominant species throughout the 2020–2021 period, as reflected in the rank-abundance curve. Given the absence of native apex predators in the area, particular attention was given to the role of domestic dogs as potential top predators within the mammal community.

Relative abundance was calculated using the capture proportion from independent events.[29] A rank-abundance curve was generated to assess community richness, structure, and composition.[30, 31]

Species richness was estimated using the Chao2 estimator in EstimateS v9.1.0,[32] excluding rodents due to their low detectability and to avoid violating the assumptions of this class of estimators by obtaining low proportions of rodent species, compared to the actual number.[26, 29, 33–35] The Chao2 estimator was chosen due to its suitability for the sampling design and current knowledge of the study site.[26, 32, 36]

Statistical analysis

A Chi-square test was used to evaluate differences in frequency between wild and domestic mammals across seasons and designated sampling zones (dry season: December–May; rainy season: June–November). All statistical analyses were conducted using SPSS.

Results

The study included 20 survey walks and 255 camera-trap days, totaling 26 089 hours of sampling effort. A total of 182 independent events were recorded, corresponding to four orders, seven families, and nine identified mammal species.

A total of 25 different *Canis lupus familiaris* individuals were recorded by the camera traps. These dogs were classified as feral based on behavioral indicators such as signs of disorientation, lack of human association, and poor physical condition. Two solitary dogs showed evident signs of malnutrition. The remaining individuals were documented in small groups or packs, with up to six animals recorded together. *C. lupus familiaris* was detected throughout the study area, including within the ZSEC, although frequencies varied by zone. Both feral dogs and *Felis catus* (considered peridomestic) were recorded at various times of day, showing no consistent temporal activity pattern.

Camera-trap monitoring documented the following species: dog (*Canis lupus familiaris)* (24 %), gray fox (*Urocyon cinereoargenteus)* (23 %), cacomixtle (*Bassariscus astutus)* (23 %), North American opossum (*Didelphis virginiana)* (14 %), cat (*Felis catus)* (5 %), Eastern cottontail (*Sylvilagus floridanus)* (4 %), rock squirrel (*Otospermophilus variegatus)* (4 %), southern spotted skunk (*Spilogale angustifrons)* (2 %), and mexican gray squirrel (*Sciurus aureogaster)* (1 %) (**Figure 2**).

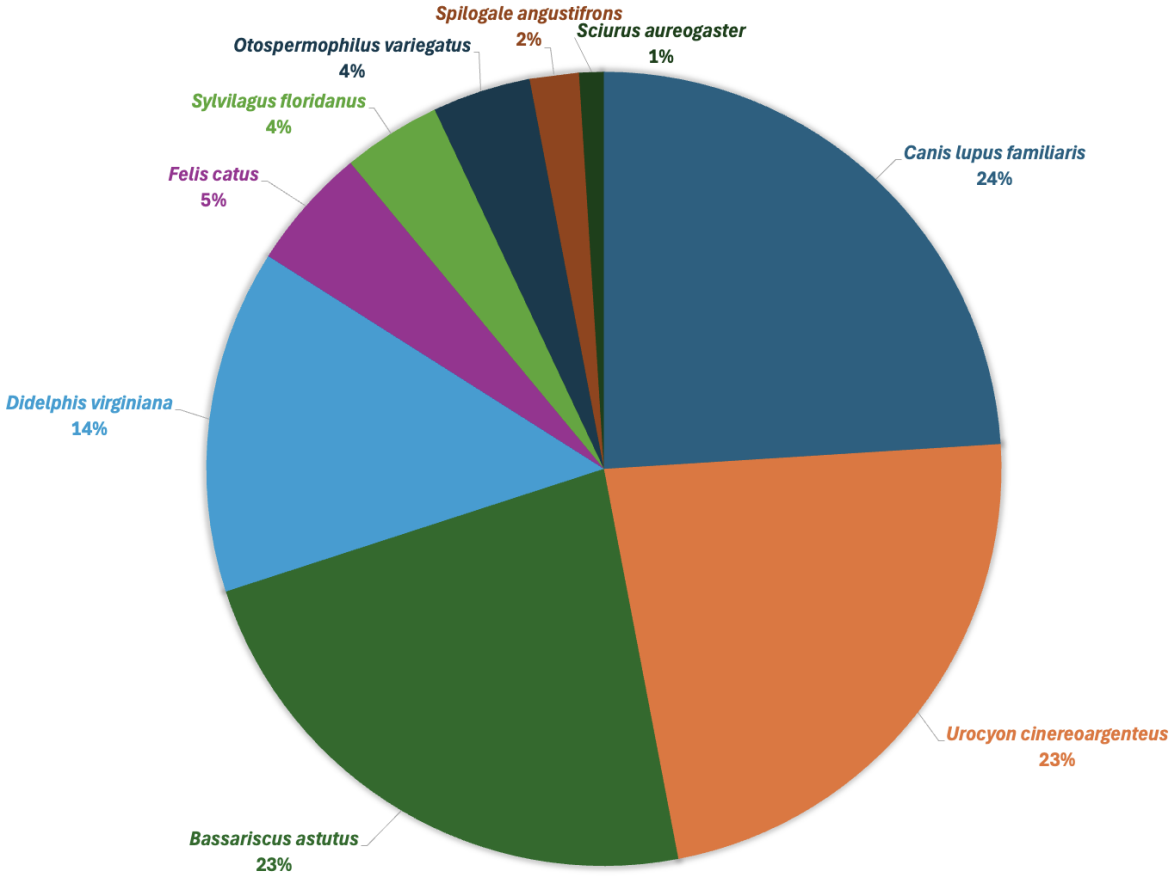

Figure 2. Relative abundance of medium-sized mammals recorded in Sierra de Guadalupe, Mexico. dog (*Canis lupus familiaris)*, gray fox (*Urocyon cinereoargenteus)*, cacomixtle (*Bassariscus astutus)*, North American opossum (*Didelphis virginiana)*, cat (*Felis catus)*, Eastern cottontail (*Sylvilagus floridanus)*, rock squirrel (*Otospermophilus variegatus)*, southern spotted skunk (*Spilogale angustifrons)*, and mexican gray squirrel (*Sciurus aureogaster).*

Carnivores were the most abundant order in the area, both in terms of species richness (five out of nine species) and number of independent capture events. The most frequently recorded species was the feral dog (n = 25), with a relative abundance of 24 %. In

contrast, the least abundant was the red-bellied squirrel, *S. aureogaster* (n = 3), with a relative abundance of 2.65 %, roughly one-tenth that of dogs. The dominance of feral dogs in the assemblage may be partially explained by the absence of native apex predators in the area.

Some species, such as gray fox, cacomixtle, North American opossum, and southern spotted skunk, exhibited primarily crepuscular and nocturnal activity, while others, including mexican gray squirrel, rock squirrel, and Eastern cottontail, showed diurnal habits (**Figures 3** and **4**).

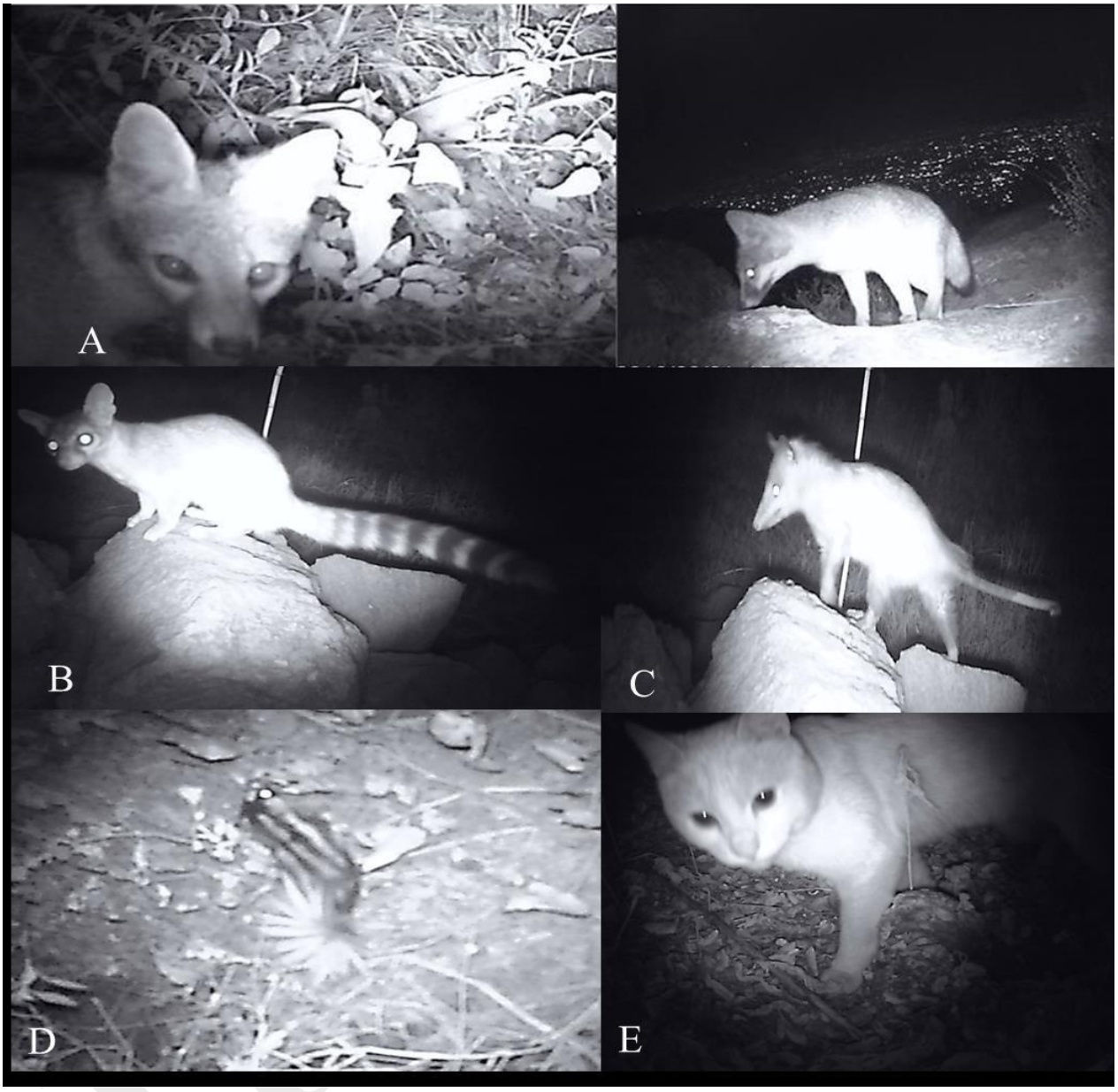

Figure 3. Nocturnal animals. A. Gray fox (*Urocyon cinereoargenteus)*, B. Cacomixtle (*Bassariscus astutus)*, C. North American opossum (*Didelphis virginiana)*, D. Southern spotted skunk (*Spilogale angustifrons)*, E. Cat *(Felis catus)*.

Figure 4. Diurnal animals. A. Mexican gray squirrel (*Sciurus aureogaster)*, B. Rock squirrel (*Otospermophilus variegatus)*, C. Eastern cottontail (*Sylvilagus floridanus)*, D. Dog (*Canis lupus familiaris)*.

Regarding the estimation of species richness in Sierra de Guadalupe, the mean and lower confidence limit of the Chao2 estimator indicated a total of 9 species, while the upper confidence limit estimated 10.37 species. These results were obtained from 100 iterations using the EstimateS software. All 9 species predicted by the mean estimate were recorded during the study, representing 100 % of the expected richness (**Figures 5** and **6**).

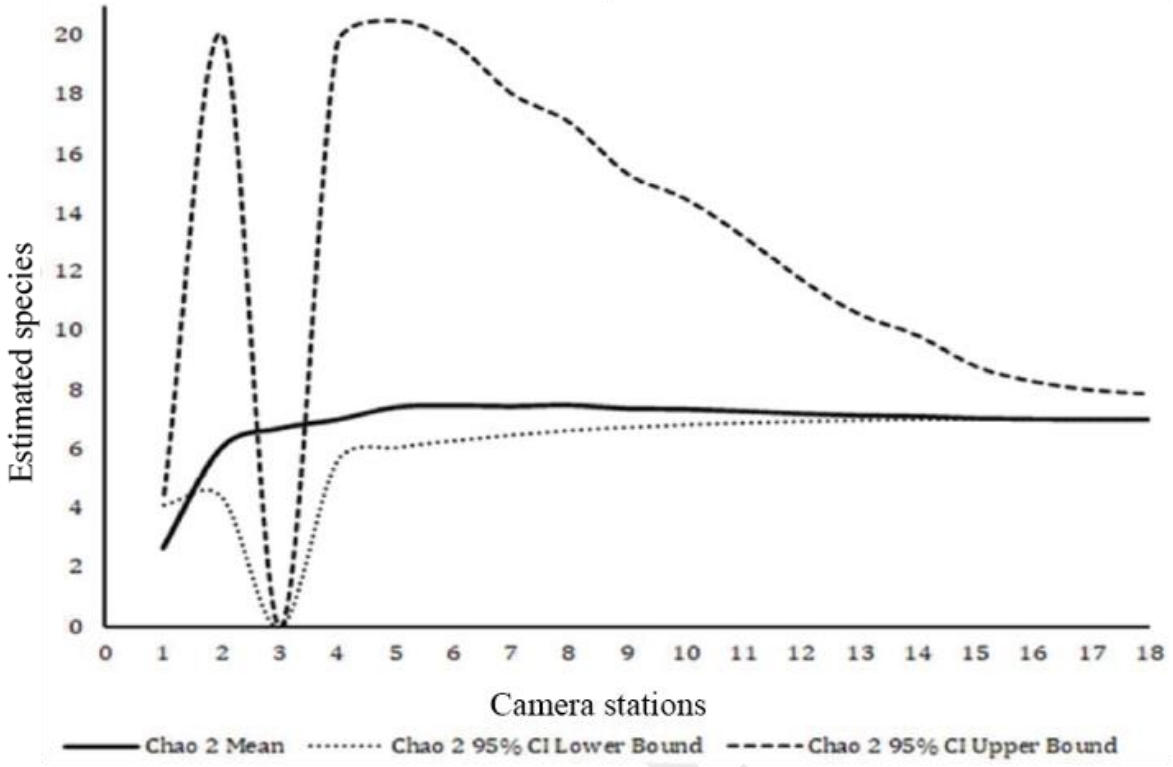

Figure 5. Species richness estimation using the Chao2 estimator. Chao2: Species richness estimation

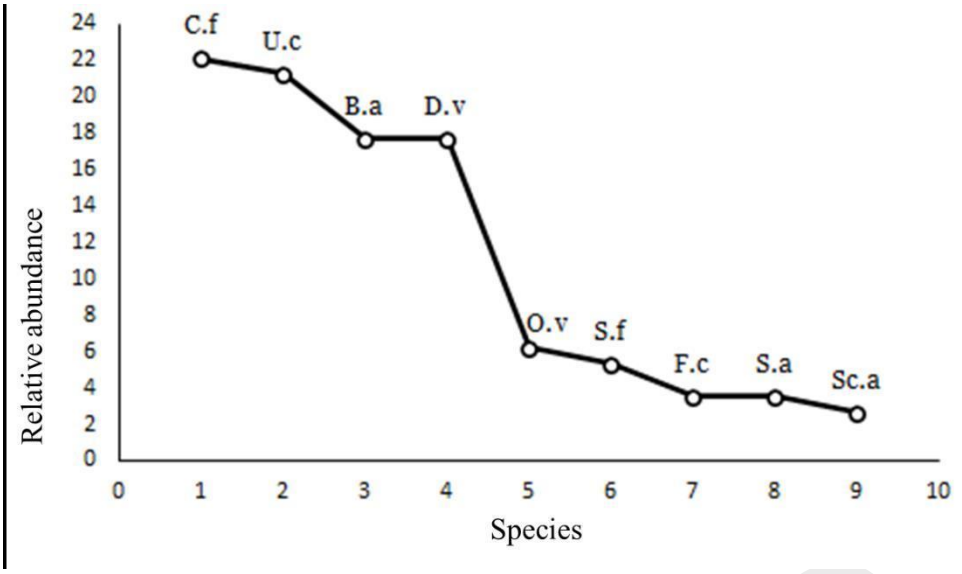

Figure 6. Rank-abundance curve of mammal species recorded in Sierra de Guadalupe. C.f) Dog (*Canis lupus familiaris)*; U.c) Gray fox (*Urocyon cinereoargenteus)*; B.a) Cacomixtle (*Bassariscus astutus)*; D.v) North American opossum (*Didelphis virginiana)*; O.v) Rock squirrel (*Otospermophilus variegatus)*; Sf) Eastern cottontail (*Sylvilagus floridanus)*; F.c) Cat (*Felis catus)*; S.a) Southern spotted skunk (*Spilogale angustifrons)*; Sc.a) Mexican gray squirrel (*Sciurus aureogaster).*

According to the statistical analysis, there were no significant differences in the proportion of feral or peridomestic animal records between the dry and rainy seasons ($P > 0.05$). However, spatial variation was observed. In region 1 (Arboledas), which is adjacent to urban areas, feral and peridomestic mammals were recorded more frequently than wild species. In contrast, within the core in region 3 (La Armella), wild species were more frequently detected, suggesting a potential buffering effect of the conservation zone.

Discussion

Due to isolation from other green areas caused by urban expansion, the Sierra de Guadalupe functions as an insular ecosystem. A defining feature of such ecosystems is the ecological dominance of exotic species, often resulting in biological homogenization and the displacement of native fauna.[37] Rapid urban growth and the encroachment of domestic and semi-feral animals into natural areas disrupt ecological balance and pose serious threats to biodiversity.[38]

In this study, we described the abundance and relative dominance of feral and wild mammals using camera traps in Sierra de Gudalupe, an urban protected area within one of the world's ten largest megacities. Our findings indicate that the dominant species in terms of relative abundance was dog. Domestic dogs and cats, when released or abandoned, can develop feral behavior—shifting their survival strategies to include hunting and territorial defense, thereby becoming effective predators and competitors within native ecosystems.[37, 39, 40]

To better contextualize these behaviors, we incorporated ethological and legal definitions of feral animals. According to Slater,[41] Levy and Crawford,[42] feral animals exist along a continuum that includes truly feral individuals (born in the wild, fearful of humans), semi-feral animals (intermittent human contact), and formerly domesticated animals in a street situation (abandoned or lost, but previously domesticated). The legislation of Mexico City (Ley de Protección a los Animales de la Ciudad de México) [43] reinforces this continuum establishing distinct management categories based on origin and behavior. In our study, behavioral indicators such as robust body condition,

gregariousness, absence of human proximity, and territorial behaviors were used to classify individuals as likely feral.

Camera-trap data documented packs of up to six dogs, while two solitary individuals showed signs of malnutrition, suggesting recent abandonment. In contrast, informal observations recorded during fieldwork and testimonies from local residents revealed larger groups—packs of up to ten dogs—described as muscular, alert, and apparently well-adapted to wild conditions. These accounts support the classification of some individuals as truly feral, distinct from peridomestic or recently abandoned animals. Notably, during survey walks, approximately 50 dogs were observed, although an exact count was impeded by aggressive behavior, particularly from females guarding pups. Several of these dogs were seen within or near the Zone Subject to Ecological Conservation, despite the presence of guarded entrances, demonstrating the permeability of the protected zone.

Local testimonies also reported attacks by dogs on wild fauna such as gray fox and North American opossum, and on domestic livestock, including cattle. Additionally, multiple incidents of dog aggression toward visitors were mentioned. While anecdotal, these accounts offer valuable ecological and public health context and align with the patterns recorded through systematic monitoring.

Feral or semi-feral dogs have been implicated in aggressive interactions that do not always involve predation but reflect interspecific competition or territoriality further contributing to the stress and displacement of native species.[44, 45] Similar concerns arise with feral cats, which were found to be active both day and night, potentially impacting multiple groups, including birds, reptiles, and small mammals.[23]

The ecological dominance of dogs in Sierra de Guadalupe is particularly notable, exceeding values reported for other urban protected areas in Mexico.[23] This dominance does not refer to ethological hierarchy, but to ecological prevalence based on camera-trap detections. Their adaptive plasticity, gregariousness, and lack of natural predators facilitate the emergence of feral dogs as functional apex predators in defaunated urban systems. Although the presence of the gray fox suggests some level of co-occurrence, the lower frequency of its detection may reflect spatial displacement or behavioral adaptation in response to competition with dogs.

From a public health and bioethical perspective, the proliferation of unvaccinated, free-ranging feral dogs in a protected area raises concerns for both ecological integrity and human safety. The coexistence of humans, livestock, and feral carnivores in an urban conservation zone necessitates urgent management strategies.

Current guidelines from SEMARNAT and institutional programs[46, 47] propose various remediation strategies such as sterilization, relocation, and environmental education. However, such interventions must be implemented with ethical rigor, considering both animal welfare and ecological consequences. Our findings emphasize the importance of integrating structured monitoring, community testimonies, and institutional frameworks[48] to develop effective and humane management strategies for feral fauna.

By providing a descriptive account of the relative abundance, behavior, and ecological role of feral and wild mammals in Sierra de Guadalupe, our study contributes to the growing body of literature highlighting the challenges and complexities of managing

feral fauna in urban protected areas. Future studies should aim to integrate structured surveys with ethological assessments and participatory approaches to better understand and mitigate the ecological impacts of feral populations.

Conclusions

Feral mammals represent a significant and growing threat to native mammal communities in urban and peri-urban protected areas worldwide. In ecosystems such as the Sierra de Guadalupe, the ecological dominance of dogs—as evidenced by its high relative abundance and behavioral adaptation—poses a direct threat to biodiversity. Beyond predation, feral dogs can displace native species, compete for resources, and alter natural activity patterns. Additionally, their presence in recreational protected areas introduces potential zoonotic risks and safety concerns for both visitors and livestock.

Our findings highlight the urgency of implementing ethical and ecologically sound strategies to mitigate the presence of feral animals. These should include sterilization campaigns, controlled removal, and community education programs that are informed by both systematic monitoring and local knowledge. Protecting native mammalian fauna and reducing zoonotic risks requires coordinated action between environmental authorities, local communities, and scientific institutions.

This study contributes valuable baseline data for understanding feral mammal dynamics in urban conservation areas and supports the development of integrated management approaches aimed at preserving biodiversity and promoting public health.

Data availability

Data is available on request.

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Conflicts of interest

The authors have no conflict of interest to declare in regard to this publication.

Author contributions

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Funding acquisition: PMC Acevedo-Ramírez.

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Project administration: PMC Acevedo-Ramírez, E Torres-Gutiérrez.

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Supervision: PMC Acevedo-Ramírez, E Torres-Gutiérrez, A Rodríguez-Caballero.

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Writing–review and editing: PMC Acevedo-Ramírez, E Torres-Gutiérrez, JU Gante-Escudero, A Rodríguez-Caballero, R Ulloa-Arvizu, Y Jiménez-Tinajero, GB Hernández-Salinas.

All authors read and approved the manuscript.

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