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Volume 12, 2025 Urban Naturalist Notes No. 10

Urban Naturalist

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Cover Photograph: A cat predating on the endemic Ring-tailed Squirrel (*Notocitellus annulatus*) in an urban protected natural area in Colima, western Mexico. Photo credit: The authors.

The ***Urban Naturalist*** (ISSN # 2328-8965) is published by the Eagle Hill Institute, PO Box 9, 59 Eagle Hill Road, Steuben, ME 04680-0009. Phone 207-546-2821 Ext. 4. E-mail: office@eaglehill.us. Webpage: http://www.eaglehill.us/urna.

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Predation of the Endemic Ring-tailed Ground Squirrel (*Notocitellus annulatus*) by Introduced Cats and Dogs in a Protected Natural Area in Colima, Western Mexico

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Abstract - The impact that introduced cats and dogs have on ecosystems is a growing topic of study. Their ecological effects have been well-documented on islands, but there is little information on continental environments, particularly across Latin America. We provide evidence of predation on native species by introduced dogs and cats in an urban protected natural area in Colima, Western Mexico. From June 2023 to March 2024, we installed camera traps in La Campana. We obtained a total of 320 photographs, which included one of a cat and another of a dog preying on the central-western Mexico endemic Ring-tailed Ground Squirrel (*Notocitellus annulatus*). Adverse effects of dogs and cats are expected not only on squirrel populations but also on other local animals such as raccoons, shrews, skunks, bats, birds, reptiles, and amphibians. Scientific evidence on the impact of dogs and cats on native species in urban contexts is crucial for establishing management and containment actions for introduced species.

Introduction

The ecological impact of introduced species on ecosystems is a growing topic of study. In particular, research suggests that *Canis lupus familiaris* L. (Dogs) and *Felis silvestris catus* L. (Cats) have a significant negative impact on the population numbers and distributions of native species (Carrasco-Román et al. 2021, Doherty et al. 2017, Guedes et al. 2021, Hernandez et al. 2018, Mella-Méndez et al. 2022, Oedin et al. 2021). Dogs and cats have an ancient and close association with humans, which has facilitated their spread all over the world (Turner and Bateson 2014, Udell et al. 2010). As a result, they have become two of the most abundant introduced carnivore species on Earth (Orduña-Villaseñor et al. 2023).

As introduced species, they generate various problems; for example, they are vectors of several diseases and parasites that can affect the native fauna of the natural systems they have invaded (Carrasco-Román et al. 2021, Doherty et al. 2017, Duffy and Capece 2012, Lessa et al. 2016). Furthermore, one of the main threats they pose is predation on local wild animals (e.g., birds, small mammals) (Loss et al. 2013, Medina et al. 2011, Ortega-Álvarez and

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Associate Editor: Jose Ramirez-Garofalo, Rutgers University.

Guevara 2024). In particular, cats are highly efficient as generalist predators, which causes a significant ecological impact, as they can assume the role of apex predators in the absence of other carnivores that regulate their populations (Duffy and Capece 2012, Parsons et al. 2020). The impact of dogs and cats as introduced species has been extensively studied on islands (Duffy and Capece 2012, Medina et al. 2011, Nogales et al. 2013, Palmas et al. 2023, Parsons et al. 2020), but there is little information available for continental ecosystems.

Urban systems typically include green areas that serve as recreational sites for the local human population. Simultaneously, these areas host various native wildlife species, which utilize them as temporal refuges or for all or part of their life cycles (Coronel-Arellano et al. 2021). Urban green areas are easily and quickly accessible to dogs and cats because both are highly adaptable, are deliberately introduced by people, may outcompete native carnivores, and benefit by human removal of local top predators (Bateman and Fleming 2012). As a result, these two introduced carnivores might turn into predators of native fauna. This situation poses an even greater challenge in protected areas, such as in "La Campana" Protected Natural Area (ANP) located in the state of Colima, western Mexico. The aim of this work is to provide novel photographic evidence on the predation of an endemic species of western Mexico, *Notocitellus annulatus* Audubon and Bachman (Ring-tailed Ground Squirrel), by introduced dogs and cats in the area of La Campana.

Materials and Methods

Study area

La Campana spans the municipalities of Villa de Álvarez and Colima and is designated as an Ecological and Cultural Zone (Gobierno del Estado de Colima 2023a). The region exhibits a calid subhumid climate with a mean annual temperature of 25 °C and summer rainfall. Mean annual precipitation is about 900 mm; the rainy season occurs from June to October, whereas the dry season starts in November and ends in May. La Campana covers an area of 94.75 hectares and encompasses archaeological remains, secondary vegetation of deciduous tropical forest, sub-deciduous tropical forest, and riparian vegetation. In terms of biodiversity, it is estimated to host approximately 205 species of flora, 32 mammal species, 167 bird species, and 40 amphibian and reptile species (Pacheco-Flores et al. 2023, Gobierno del Estado de Colima 2023b).

The area attracts numerous visitors due to its recreational, educational, cultural, sport, natural, and archaeological attractions (~5,226 visitors per month). Being entirely immersed in an urban area, La Campana faces daily anthropogenic disturbances such as species poaching, garbage pollution, cattle browsing, the introduction of fauna, infrastructure construction, and light pollution (Gobierno del Estado de Colima 2023b).

Camera trapping

Four Cuddeback H20IR camera traps were installed and monitored in La Campana from June 2023 to March 2024, following the criteria of Swann et al. (2011) (Fig. 1). Cameras were programmed to capture images through a burst of three photos and data was retrieved every month. Likewise, based on the experience of the work team and the conditions of the study site: a) each camera was separated from the others by at least 400 linear meters, b) they were installed off paths at an average height of 40 centimeters from the ground, c) no direct sunlight stroke the lens of the camera, and d) commercial perfume was used as an attractant to ensure that the animals remained in front of the camera for at least 60 seconds (Moreno 2000). The photographs were processed with

Camera Base, the processing of the photos was done by one person, and the review of the photographs was done one by one by one person as well. The criterion of independence for the records was 60 minutes.

Results

Over the course of the sampling period, we obtained a total of 320 photographs. From this set of images, 9 comprised individual dogs, 8 included different cats, and 27 were associated with the Ring-tailed Ground Squirrel. Two photographs evidenced both carnivores preying on local wildlife: one recorded a cat and another captured a dog preying on the Ring-tailed Ground Squirrel. The photograph of the cat was taken on 2 July, 2023, at 9:00 p.m. (Fig. 2a), while that of the dog was recorded on 21 November, 2023, at 1:22 p.m. (Fig. 2b). In both photographs, predators can be seen with the squirrel in their mouths.

Discussion

Currently in Mexico, urban green areas have become highly important sites for hosting native biodiversity. They serve as refuges from the expanding urban border and the various inconveniences of city life. One drawback of this is that urban areas also become

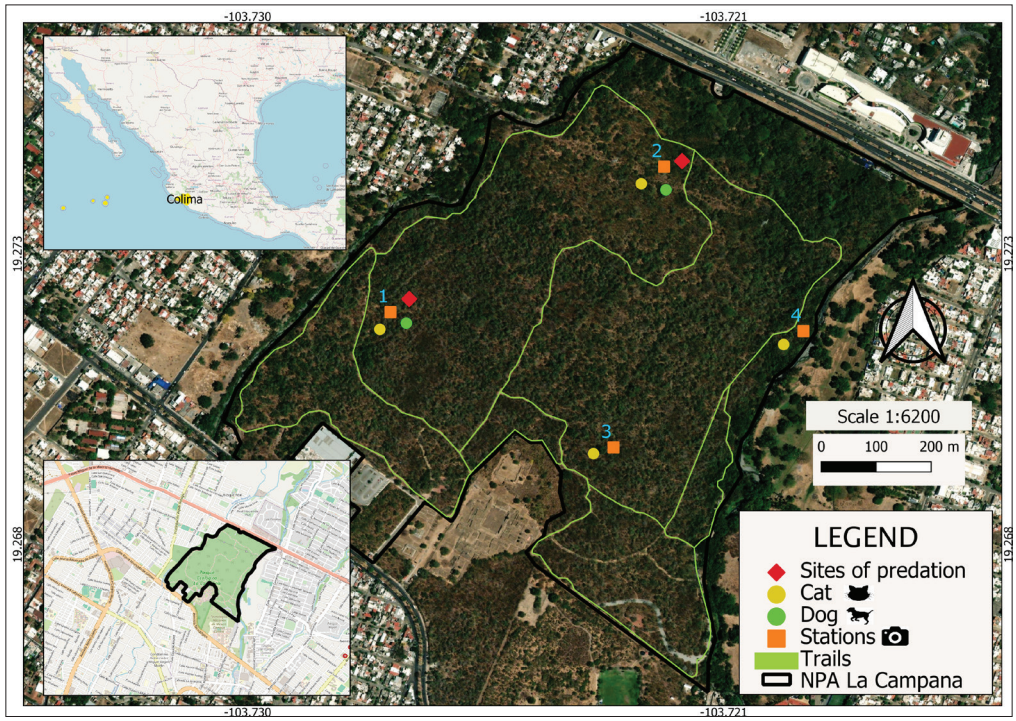

Figure 1. Location of the La Campana Protected Natural Area and the camera trap stations. Top left: Colima State, western Mexico. Bottom left: the black polygon depicts La Campana, at the northern region of the city. Central image: map of La Campana showing which cameras recorded dogs and cats. The sites where the cat and the dog were photographed preying on the Ring-tailed Squirrel are specified in red.

Figure 2. a) Cat and b) dog with a Ring-tailed Squirrel in its mouth.

refuges for introduced cats and dogs – which interact negatively with native fauna – with predation being one of their main interactions (Shionosaki et al. 2015). It has been proven that cats and dogs prey on native fauna in different places around the world; having a significant negative impact on populations of invertebrates, birds, small reptiles, and small mammals (Borroto-Páez and Mancina 2017, Carrasco-Román et al. 2021, Doherty et al. 2016, Woolley et al. 2020).

Having found a cat and a dog predating on Ring-tailed Ground Squirrels at different time points suggests that it is a priority to establish management actions to prevent dogs and cats from accessing the area. Otherwise, in the medium and long term, irreversible impacts could occur on the native fauna, especially on the endemic species. These adverse effects are expected not only on squirrel populations but also on other native animals recorded in La Campana, such as raccoons, shrews, skunks, bats, birds, reptiles, and amphibians. Although the current status of the Ring-tailed Ground Squirrel within the ANP is unknown, it is very likely that the two instances of their predation are just a sample of the negative interactions between dogs and cats and wildlife.

We recommend starting population monitoring of the Ring-tailed Ground Squirrel and introduced species at the site. Additionally, it is desirable for the management actions for introduced species to be defined in collaboration with the users and neighbors of La Campana, as they are the probable sources of the dogs and cats. For example, we have observed that in the neighboring residential areas of La Campana, domestic cats roam freely, and users of the protected natural area often walk their dogs without a leash. Although the area has surveillance and regulations that restrict the presence of unleashed dogs, controlling domestic animals largely depends on the users of La Campana. It is highly desirable that the definition of containment actions for dogs and cats in the area be carried out through a participatory scheme, as various studies have shown that management activities in protected natural areas have a higher probability of success when they include the local population (Andrade and Rhodes 2012).

Acknowledgements

The authors acknowledge the support from Secihti through the project RENAJEB-2023-20, as well as from Proyecto PAPIIT: Manejo y domesticación de biodiversidad en Mesoamérica, Andes y Amazonia: procesos culturales, ecológicos y evolutivos (PAPIIT, DGAPA, UNAM Proyecto IN224023). The first author thanks Atizimba López, Alberto Valencia, and Heberto Ferreira. We appreciate the permission provided by IMADES (Instituto para el Medio Ambiente y Desarrollo Sustentable) to access and perform research in La Campana.

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