



# Predator scent influences olfactory investigation and feeding choices in urban free-ranging dogs

Saugat Timalaena<sup>1</sup>, Laxman Khanal<sup>1,2\*</sup>

<sup>1</sup> Central Department of Zoology, Institute of Science and Technology, Tribhuvan University, Kathmandu 44618, Nepal

<sup>2</sup> International Centre for Biodiversity and Primate Conservation, Dali University, Dali, China

**Abstract:** Olfaction is a key tool for dogs for finding food, identifying threats, navigating space, and communicating socially. Urban free-ranging dogs adapt their smelling behavior in several important ways to survive in complex, human-dominated environments. This study examines how feeding choices of urban free-ranging dogs is affected by the predator scent, based on a treatment of meat bait with the urine of leopard cat (*Prionailurus bengalensis*), a meso-predator of lowland ecosystem in Nepal. This experiment was done in 43 dogs in Itahari Sub-metropolitan City in Sunsari District of Koshi Province, Nepal. Each experimental dog was presented with plain meat (normal meat) and meat dipped in leopard cat urine (predator-scented meat). Majority of dogs chose normal meat first (67.4%) likely indicating a preference for the safer option. Dogs spent significantly longer time on sniffing the predator-scented meat ( $5.44 \pm 2.69$  sec) compared to the normal meat ( $1.30 \pm 0.63$  sec) ( $t=10.07$ ,  $df=42$ ,  $p < 0.001$ ). Four dogs (9.30%) completely rejected the predator-scented meat bait. Tail and ear postures showed mild caution, but the aggressive behavior was not detected. These findings support the notion that free-ranging dogs retain an innate sensitivity to predator odors, which can modify both their approach behavior and feeding decisions even within urban environments where direct encounters with wild carnivores are rare. Therefore, predator scent cues could serve as a natural, non-invasive means to deter or guide their movements in urban areas.

**Key Words:** Avoidance behavior, Olfactory cue, Predator scent, Risk assessment, scent-mediated interaction.

\* Corresponding Author: laxman.khanal@cdz.tu.edu.np

## 1. Introduction

Predator-prey interactions play an important role in developing animal behavior and also make them better suited in an environment while going through evolutionary adaptations. Prey species detect predation risk primarily through sensory cues, particularly olfactory signals (Siepielski et al., 2016). Chemical cues of the predators often serve as key signals for the prey to understand the risk and they can adjust their behavior accordingly (Apfelbach et al., 2005; Lima & Bednekoff, 1999). The prey species foraging decisions, selection of habitat and their own avoidance strategy decision can be seen because of the chemical communication especially by the scents of predators (Finnerty et al., 2022). This can be an information which affects how prey animals choose where to feed, live, and avoid danger (Parsons et al., 2018). Chemosensory cues like urine and feces of the predator can vary the behavioral responses of other animals which includes avoidance, increase in vigilance and change feeding choices (Apfelbach et al., 2005; Parsons et al., 2018). Studies have also confirmed that those cues can trigger innate reaction (Ferrero et al., 2011) and even can trigger some physiological changes such as increased heart rate indicating stress and increased alertness/vigilance (Beerda et al., 1998). Instant response of mammals that could be the diet of predator can recognize and avoid the cues altering their feeding activity (Dickman et al., 2022).

Majority of the research on predator-prey interactions have focused on wild species' reactions to predator's scents but very limited studies have investigated on the reactions of urban or free ranging animals to such signals (Dias & Ressler, 2014; Martel & Dill, 1993). Leopard cats (*Prionailurus bengalensis*) are small wild cat that are common in some urban and peri-urban areas and they mark territories with urine containing species-specific chemical signals (Ferrero et al., 2011). Those signals can potentially alter sympatric carnivores' behavior, including dogs where

optimum resource utilization and risk-taking behavior can be studied. As urban areas have both ecological challenges as well as opportunities that influence the behavioral adaptation of urban stray dogs (*Canis lupus familiaris*) (Hughes & Macdonald, 2013). Most of these dogs develop their own foraging strategies and social behaviors to use the anthropogenic resources (Bhattarai et al., 2021; Sarkar et al., 2023). At the same time, they carry on the risk of potential predators and human disturbance (Vanak & Gompper, 2009). Studies have indicated that free-roaming dogs in the urban and semi-urban areas have been significantly affected on their movement distances and patterns (Raynor et al., 2020). After grasping the facts about these behavioral changes, it can help in management of free ranging dogs and associated conflicts in urban and semi urban areas.

Predator scents and other olfactory cues play an essential role in controlling predator and prey interactions such as influencing risk assessment, and affecting survival behavior (Apfelbach et al., 2005; Parsons et al., 2018). Chemical cues influence prey species by stimulating avoidance behavior and spatial distribution change to minimize the threat of predation (Apfelbach et al., 2005; Parsons et al., 2018). Predator mammal territorial marking by scent involves cues employed for predator presence detection by prey and may induce overt and latent responses like avoidance or cautious investigation (Hughes & Macdonald, 2013). The lingering of predator scents in the environment provides a scent landscape that shapes the vigilance, habitat selection, and foraging choice of the prey (Banks et al., 2016). These chemical cues also form an “olfactory web” where both the predator and the prey eavesdrop for chemical cues to refine their survival tactics (Banks et al., 2016). The evolutionary importance of scent-based interactions in mammalian communities is highlighted by such complex chemical communication. As animals like dog have gained many olfactory capabilities from their wild ancestors, it makes them sensitive to the scent of predator even in urban areas (Dias & Ressler, 2014). Understanding how urban dogs behaviorally respond to the predator scents can contribute to the knowledge of innate vs learned adaptations. In the studies of canid responses to predator scents, while less prolific than in their rodent prey, demonstrated striking behavioral and physiological changes. Samuel et al. (2020) observed that pet dogs developed the ability to reduce visitation near brown bear and lynx fecal odors. They also showed increased heart rates which indicate their inborn ability to recognize predator cues. When a meso-predator such as the red fox (*Vulpes vulpes*) encountered with the scats of Eurasian lynx (*Lynx lynx*), they showed behaviors like sniffing, alerting, and over-marking at the scat stations (Wikenros et al., 2017). These studies indicate that canids respond to heterospecific carnivore odor cues and can modulate their spatial or foraging activity based on these cues. These actions can be adaptive: in pet or free-roaming dogs facing wild carnivores or their odors where they can amount to changed feeding or movement decisions when carnivore cues are detectable.

Predation risk can often shape the feeding decisions and the foraging behavior in animals so animals must balance their need for food with the danger of being caught by predators (Apfelbach et al., 2005; Lima & Bednekoff, 1999; Parsons et al., 2018). Predator scents like urine from mink, coyote or bobcat significantly reduced food consumption in prey species, which suggested inborn dislike and feeding suppression (Epple et al., 1993). As Predator scents have a significant impact on foraging behavior by modifying prey risk perception and diet selection, typically reducing foraging or modifying feeding behavior (Epple et al., 1993; Lima & Bednekoff, 1999). The smell of predator urine or feces near food source can reduce feeding because of increased feeling of threat, showing a balance between danger of predation and need of energy (Apfelbach et al., 2005; Epple et al., 1993; Parsons et al., 2018). The behavioral responses include avoiding, more alertness, or changing their foraging area to reduce predation but not much energy intake (Lima & Bednekoff, 1999). Understanding this kind of interaction helps to know how animals mix different environmental signals to survive and use resources better.

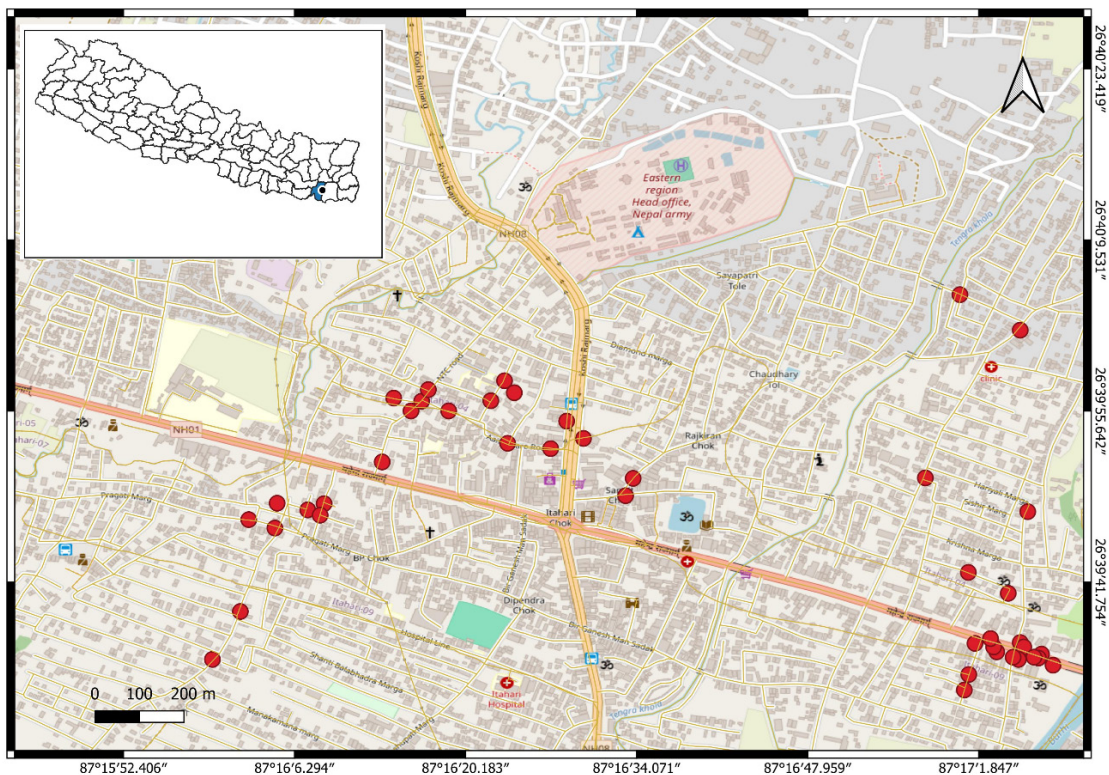
Despite an extensive literature base detailing the impact of predator odor in the prey scenario, as well as the ecology of free-range urban dogs, there are crucial gaps that are of immediacy to our experiment. Firstly, behavioral responses of free-ranging urban dogs to predator odor cues are still not

clearly investigated as much of the literature upon canids relates to scent description, not subsequent feeding decision (Samuel et al., 2020). Secondly, most predator scent foraging studies entail species in their natural habitats, not constructed urban settings where the risk landscape and resource availability diverge profoundly (Apfelbach et al., 2005; Stryjek et al., 2018). Thirdly, the combination of differing cues like predator scent, food bait, resource availability in the urban landscape is unusual. This study therefore hypothesizes a conceptual scenario wherein feeding choice (accept/reject bait) of free-ranging urban dogs is influenced by predator-olfactory cues. In urban environments when dogs encounter predator odors along with the presence of food, their behavior can change in interesting ways. Studying these reactions helps us understand how domesticated animals recognize and respond to ecological risks while making decisions in their environment. Therefore, this study aimed to test how predator scent affects the feeding choices and other behavioral responses of urban dogs. The specific hypotheses we tested were, i) Free-ranging dogs will tend to choose the normal (unscented) meat first rather than the meat scented with predator urine; ii) Free-ranging dogs will sniff the predator-scented meat for longer duration and tend to show more cautious investigation, i.e., longer sniffing.

## 2. Materials and methods

### 2.1 Study area

Itahari Sub-Metropolitan City lies in Sunsari District, Koshi Province, Nepal (Figure 1). It is a sub-metropolitan city located at geographic coordinates between 26.62° N and 26.74° N and between 87.23° E and 87.32° E. It generally has tropical monsoon climate (Itahari Municipality, 2025). Itahari lies in the Terai–Churia transition which is nearby Dharan forests, a remaining

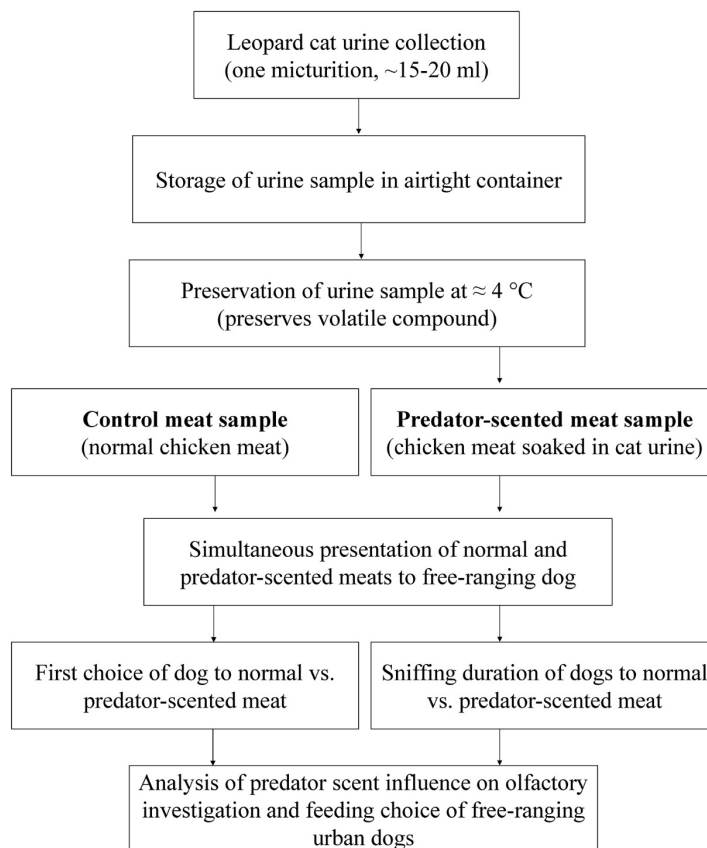


**Figure 1.** Map of the study area showing the experimental sites (red circles) in Itahari Sub-Metropolitan City, Nepal.

block of tropical evergreen and Sal (*Shorea robusta*) mixed forest. These patches and surrounding riparian zones support typical Terai plant assemblages (Sal, mixed evergreen, riverine reeds/gravels in floodplain areas) (Key Biodiversity Areas, 2025). The nearest protected area from Itahari is Koshi Tappu Wildlife Reserve (Ramsar wetland, important for waterbirds and wetland biodiversity). The human population density of Itahari sub-metropolitan city is 2,103/km<sup>2</sup> according to National Population and Housing Census 2021 (National Statistics Office, 2021). Cities like Itahari typically host sizeable populations of free-roaming dogs concentrated around predictable resource patches like municipal garbage dumps, markets, temples, food stalls and areas where residents feed dogs and their distribution is strongly associated with food availability and human behavior (Massei et al., 2017).

### 2.3 Experimental design

This study employed a controlled behavioral choice experiment to evaluate the effect of predator scent on the feeding decisions of free-ranging urban dogs in the Itahari Sub-metropolitan City. Leopard cat urine was collected, preserved at low temperature to retain volatile compounds, and used to prepare a treatment (predator-scented meat) meat sample, while untreated chicken meat served as the control (normal meat). Both samples were simultaneously presented to individual dogs to assess their first feeding choice and the duration of sniffing toward each option. These behavioral responses were then analyzed to determine how predator scent influences olfactory investigation and food selection in free-ranging dogs. A detailed flow chart of the experimental setup is presented in Figure 2.



**Figure 2.** Flow chart showing the experimental design of this study.

## 2.4 Experimental procedure and data collection

The urine sample of the leopard cat in the captivity of Hariyali Community Forest User Group, Sunsari District was collected by placing a double layer of clean plastic sheet below its cage (Figure 3a). When it urinated, the plastic sheet was pulled out from the cage to maintain a safe distance for the collection of urine samples. Then, with the help of a caretaker of the zoo, the urine sample was transferred to the airtight plastic bottle (Figure 3b). Fresh chicken meat baits were chopped in smaller pieces (Figure 3c) such that it would be easy for the dogs to engulf them, and those chopped meats were carried to the experimentation sites inside the bag. Dogs were chosen opportunistically and they were selected for the experiment whenever they were far from the pack of dogs such that there won't be any risk for the dogs to be experimented with and the researcher. Dipping of the meat was done in experimentation sites only and great care was done such that the normal meat won't be contaminated with the urine sample. Meat baits were immersed in urine for at least five seconds before being offered to the dog. A total of 43 free-ranging urban dogs (25 males, 18 females) were experimented across multiple sites in Itahari Sub-Metropolitan City. Each of the dogs was presented with both kinds of meat i.e. predator-scented meat (meat dipped in leopard cat urine) and normal meat (Figure 3d-f). It was done in such a way that the dog had equal opportunity of sniffing both meat baits from its initial distance, regardless of how it approached the meat baits. Other behavioral parameters such as first choice, sniffing duration and ear and tail positions were noted to know responses toward predator scent. Sniffing duration was



**Figure 3.** Experimental procedure employed in this study from predator urine sample collection to meat presentation to free-ranging urban dogs; a: leopard cat in the captivity of Hariyali Community Forest User Group, Sunsari, b: Leopard cat urine collected in the closed container, c: chicken meat prepared for experimentation, and d-f: normal meat (yellow encircled) and predator-scented meat (red encircled) meats presented to experimental free-ranging urban dogs.

calculated from the moment the dog positioned its nose when it was around 2-3 cm away from the meat bait for sniffing till it withdrew its nose away from the bait. To record all these parameters, video was recorded by iPhone Xs Max with 12 mega pixel camera at the resolution of 3840 x 2160 pixels (4K UHD) at 60 frames per second. Sniffing duration for both meat baits was calculated from the video playback later.

Data was collected in a data sheet paper and later it was tabulated in computer. Date, time, site ID, individual dog ID and their genders along with geographic location (latitude and longitude) were noted for tracking the location so that it could be mapped accurately. The predator-scented meat side (left or right) was changed at frequent intervals so that there wouldn't be any side-related bias. For each experimental dog, we also recorded: the first meat bait chosen (predator-scented or normal), the first bait to be completely consumed, any rejection of predator-scented meat or walking away from it, and tail and ear posture while sniffing predator-scented meat. All of these categorical and numerical data were entered in the excel sheet.

## 2.5 Data analysis

Data were analyzed to evaluate the effects of predator scent on food choice and olfactory investigation behavior of free-ranging urban dogs. Descriptive statistics were first used to summarize the sex ratio of the observed dogs and to calculate the frequencies and percentages of their first-choice preferences and their rejection of predator-scented meat. The initial choice of dogs toward the normal or predator-scented meat was expressed as proportions to describe overall feeding preference patterns.

Sniffing duration (in seconds) toward normal and predator-scented meat was summarized using mean  $\pm$  standard deviation. Because each dog was exposed to both normal and predator-scented meat samples simultaneously, a paired-sample t-test was applied to compare sniffing durations between the two conditions. This test evaluated whether predator-scented meat elicited significantly different investigation behavior relative to normal meat. R Studio (R Core Team 2024) was used for statistical analyses.

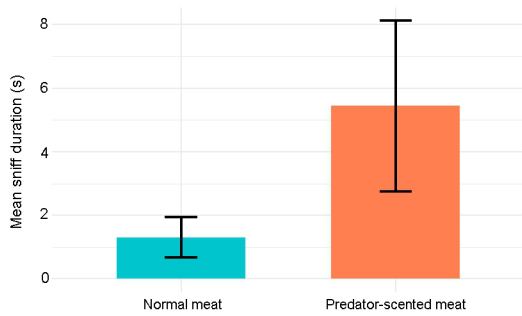
## 3. Results

### 3.1 First choice and consumption behavior

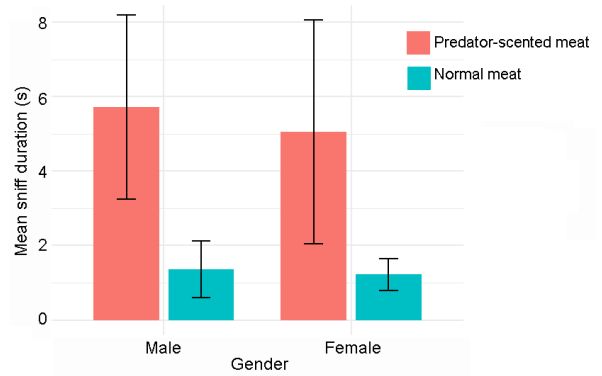
Out of 43 dogs examined, male: female was estimated at 25:18 with male dogs occurring more frequently during the early morning trials. When given a choice between the predator-scented meat bait containing leopard cat urine and the normal bait consisting of meat alone, 14 dogs (32.6%) initially approached the predator-scented meat side, whereas 29 dogs (67.4%) first chose the normal meat side. The experimental dogs showed a significant preference for the normal meat over the predator-scented meat for the first choice ( $\chi^2=5.23$ ,  $df = 1$ ,  $p < 0.05$ ). Out of 43 experimental trials, dogs completely rejected the predator-scented meat in four (9%, 4/43) trials.

### 3.2 Sniffing duration and rejection

The average sniff duration on the predator-scented meat was  $5.44 \pm 2.69$  seconds and that of the normal meat was remarkably lower ( $1.30 \pm 0.63$  seconds) (Figure 4). Paired sample t-test revealed a significant difference ( $t= 10.07$ ,  $df=42$ ,  $p < 0.001$ ) in sniffing duration between the normal and predator-scented meat setups. Sex-based analysis also revealed significantly different sniffing duration on either sex (males,  $t= 8.50$ ,  $df=24$ ,  $p < 0.001$ ; and females,  $t= 5.57$ ,  $df=17$ ,  $p < 0.001$ ) (Figure 5).



**Figure 4.** Average sniff duration of overall dogs to normal and predator-scented meat samples.



**Figure 5.** Sex-based difference of average sniff duration to normal and predator-scented meat samples.

## 5. Discussion

This study examined the olfactory responses of free-ranging urban dogs to predator scents (leopard cat urine) using meat baits. The results demonstrate that predator-associated olfactory cues can significantly influence the food-selection behavior and investigative responses of free-ranging urban dogs. When simultaneously presented with predator-scented and unscented meat, a clear majority of dogs initially selected the normal meat bait, and a proportion of individuals completely rejected the leopard cat urine-treated meat, indicating an overall avoidance tendency toward predator-associated cues. In addition, dogs spent significantly more time sniffing predator-scented meat bait than normal meat bait, suggesting heightened risk assessment and caution in the presence of predator scent. Prolonged sniffing of predator scents by dogs may reflect novelty detection or enhanced information gathering rather than aversion alone, as unfamiliar or ambiguous odors require extended olfactory analysis to assess threat level and scrutinize potential danger cues closely before deciding on avoidance or engagement. (Concha et al., 2014; Samuel et al., 2020). These findings support the notion that free-ranging dogs retain an innate sensitivity to predator odors, which can modify both their approach behavior and feeding decisions even within urban environments where direct encounters with wild carnivores are rare.

Preference for normal meat at first choice, and much longer sniffing on leopard-cat-urine treated meat suggests that leopard cat urine served as a cue that signaled danger. The cue led animals to approach it cautiously instead of being scared away from it. More sniffing with fewer initial approaches is compatible with a risk-assessment approach: animals sniff more carefully on the cue in order to gain more information but often do not eat when cue suggests riskiness (Apfelbach et al., 2005; Wikenros et al., 2017). The fact that four dogs completely avoided the predator-scented meat adds further support that predator smell can cause certain individuals to eat less even when food is available.

Posture and vocalization data revealed cautious rather than extreme reactions: lowered tails and sideways ears predominated, with no barking or aggression toward predator-scented meat, consistent with prior research (Samuel et al., 2020). Predator smell mostly gives graded response, not just yes or no reaction. It makes animals more alert or careful, sometimes changing their moving area or behavior. But it doesn't always make them run away or fight in every case (Apfelbach et al., 2005; Samuel et al., 2020). In human-related or urbane environments, habituation, pre-exposure, and a relative lack of real predation danger may additionally tip reactions in investigation rather than maximum avoidance (Sunde et al., 2022).

Our observations demonstrate that the free-ranging urban dogs can detect and respond to predator olfactory cues (e.g. leopard cat urine) enriching the understanding of predator–prey interactions in urban ecosystems. Cautious behavior of the dogs indicates its alertness towards predator-scented baits even in human-dominated areas such that they retain the ability to perceive and interpret predator-related risk signals, consistent with evidence that domestic dogs innately sense predator scents. These findings reveal that predator scent cues (such as carnivore urine) could be used as a natural, non-invasive method to deter or guide the movements of urban free-ranging dogs, aligning with the well-documented effect of predator odors in inducing avoidance behavior in mammals.

The results from this study should be interpreted carefully because predator scent studies often show mixed outcomes. Many factors can change how animals respond, such as the scent type used, how fresh or concentrated the predator cue is along with the hunger of that animal and how often that has been exposed to such cues (Apfelbach et al., 2005; Banks et al., 2016; Sunde et al., 2022). Animals that generally live near predators might be observed reacting differently than those who do not interact with them. Some mesopredator and other carnivore might even go closer to these scents or mark over them to gather information or find food, which does not match with simple avoidance behavior (Wikenros et al., 2017) Overall, the results of this study seem to show a small and a context-based approach for checking of the leopard cat urine on urban dogs rather than a strong and universal repelling effect.

In future studies, it would be valuable to combine behavioral measures with physiological indices (heart rate or stress hormones), to continue replications across times of day and locations, and to standardize age and doses of scent to enhance inference about deterrent effectiveness. For future studies or management plans focused on discouraging feeding choices, predator odor could be utilized as a tool for shaping dog behavior. Cautious testing for duration of persistence, habituation, spatial extent applicability and unintended ecological effects (Banks et al., 2016; Sunde et al., 2022) should be required prior to broader application of these findings.

## 5. Conclusions

This study demonstrated that leopard cat urine, used as a predator cue, exerted a modest but detectable influence on the feeding preferences and behaviors of urban dogs in Itahari Sub-metropolitan City, Nepal. While most dogs favored unscented meat, they spent significantly longer sniffing predator urine-dipped meat, suggesting the odor served as a cautionary signal that elicited heightened vigilance rather than outright fear, as evidenced by subtle changes in tail and ear postures indicative of alertness or hesitation rather than panic. These findings indicate that urban dogs retain a partial capacity to detect and respond to predator cues despite inhabiting human-dominated environments with minimal direct predator encounters. The present study provides preliminary behavioral evidence that urban dogs retain partial sensitivity to predator cues. Further research with larger dog samples, integrating behavioral observations with physiological measures such as heart rate or stress biomarkers, could better elucidate the nature of their reactions.

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### *Conflicts of interest*

The authors declare no conflict of interest.

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## L'odore del predatore influenza l'esplorazione olfattiva e le scelte alimentari nei cani urbani a vita libera

Saugat Timalsena<sup>1</sup>, Laxman Khanal<sup>1,2\*</sup>

<sup>1</sup> Dipartimento Centrale di Zoologia, Istituto di Scienza e Tecnologia,  
Università di Tribhuvan, Kathmandu 44618, Nepal

<sup>2</sup> Centro Internazionale per la Biodiversità e la Conservazione dei Primati,  
Università di Dali, Dali, Cina

### Sintesi

L'olfatto è uno strumento fondamentale per i cani per trovare cibo, identificare minacce, orientarsi nello spazio e comunicare socialmente. I cani urbani a vita libera adattano il loro comportamento olfattivo in diversi modi importanti per sopravvivere in ambienti complessi dominati dall'uomo. Questo studio esamina come le scelte alimentari dei cani urbani a vita libera siano influenzate dall'odore di un predatore, utilizzando come esca carne immersa nell'urina del gatto leopardo (*Prionailurus bengalensis*), un mesopredatore dell'ecosistema di pianura in Nepal.

L'esperimento è stato condotto su 43 cani nella Città Sub-metropolitana di Itahari, nel Distretto di Sunsari, nella Provincia di Koshi, Nepal. A ciascun cane è stata presentata carne normale (non trattata) e carne immersa nell'urina di gatto leopardo (carne con odore di predatore). La maggior parte dei cani ha scelto per prima la carne normale (67,4%), indicando probabilmente una preferenza per l'opzione più sicura.

I cani hanno trascorso un tempo significativamente più lungo ad annusare la carne con odore di predatore (5,44 ± 2,69 secondi) rispetto alla carne normale (1,30 ± 0,63 secondi) (t = 10,07, df = 42, p < 0,001). Quattro cani (9,30%) hanno rifiutato completamente l'esca con odore di predatore. Le posture della coda e delle orecchie hanno mostrato una lieve cautela, ma non sono stati rilevati comportamenti aggressivi.

Questi risultati supportano l'idea che i cani a vita libera conservino una sensibilità innata agli odori dei predatori, che può modificare sia il loro comportamento di avvicinamento sia le decisioni alimentari, anche in ambienti urbani dove gli incontri diretti con carnivori selvatici sono rari. Pertanto, i segnali olfattivi dei predatori potrebbero rappresentare un mezzo naturale e non invasivo per dissuadere o guidare i loro movimenti nelle aree urbane.