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Behaviour 160 (2023) 807–815

Behaviour
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Effects of snow leopards (*Panthera uncia*) on olfactory communication of Pallas's cats (*Otocolobus manul*) in the Altai Mountains, Mongolia

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Received 9 March 2023; initial decision 31 March 2023; revised 13 June 2023; accepted 14 June 2023; published online 11 July 2023

Abstract

Olfactory communication is important for many solitary carnivores to delineate territories and communicate with potential mates and competitors. Pallas's cats (*Otocolobus manul*) are small felids with little published research on their ecology and behaviour, including if they avoid or change behaviours due to dominant carnivores. We studied their olfactory communication and visitation at scent-marking sites using camera traps in two study areas in Mongolia. We documented four types of olfactory communication behaviours, and olfaction (sniffing) was the most frequent. Pallas's cats used olfactory communication most frequently at sites that were not visited by snow leopards (*Panthera uncia*) and when they used communal scent-marking sites, they were more likely to use olfactory communication when a longer time had elapsed since the last visit by a snow leopard.

Published with license by Koninklijke Brill NV | DOI: 10.1163/1568539X-bja10229
 | ISSN: 0005-7959 (print) 1568-539X (online)

This suggests that Pallas's cats may reduce advertising their presence in response to occurrence of snow leopards, possibly to limit predation risk.

Keywords
behaviour, camera trap, Mongolia, *Otocolobus manul*, *Panthera uncia*, scent marking.

1. Introduction

Solitary carnivores that have infrequent direct conspecific interactions often rely on olfactory communication (i.e., scent marking) to delineate territories and communicate with potential mates and competitors (Smith et al., 1989; Allen et al., 2014; Cornhill & Kerley, 2020a). Despite similarities in purpose, many solitary carnivores show variation in forms of olfactory communication — even within a given family (e.g., Felidae; Allen et al., 2016). It is often difficult to document olfactory communication by cryptic carnivores, and olfactory communication behaviours are unknown for nearly a quarter of felid species (Allen et al., 2016), and the behaviours of many of the species are only known from captive animals (e.g., Mellen, 1993).

Pallas's cat or manul (*Otocolobus manul*) is a small felid that is listed as least concern by the IUCN due to its wide range and what is assumed to be a large population (Ross et al., 2020), but there is concern that Pallas's cats populations are declining (Greenspan & Giordano, 2021), often due to interspecific predation from dominant species (Ross et al., 2020) such as snow leopards (*Panthera uncia*). Pallas's cats remain understudied across their range, partly because it is difficult to obtain funding to perform dedicated surveys. Using 'by-catch' data from surveys dedicated to large, charismatic species (e.g., large carnivores) can sometimes provide insights into such understudied species.

Pallas's cats in captivity have been documented using four olfactory communication behaviours: urine spraying by males, cheek rubbing by females, and claw marking and flehmen response by both sexes (Mellen, 1993). The only study to document olfactory communication of Pallas's cats in the wild was limited to two observations of olfaction and one of urine spraying (Li et al., 2013). Pallas's cats often use the same scent-marking sites as snow leopards (Li et al., 2013; Salvatori et al., 2022), but subordinate felids and other carnivores can change visitation and/or behaviours at marking sites used by dominant carnivores (Allen et al., 2017; Haswell et al., 2018; Cornhill &

Kerley, 2020b), and it remains unknown how dominant snow leopards affect olfactory communication by subordinate Pallas's cats.

We used by-catch data from camera traps at sites predicted to be used by snow leopards for scent marking or travelling (Salvatori et al., 2021; Oberosler et al., 2022) to study Pallas's cat olfactory communication in the wild. We first determined the types and frequencies of Pallas's cat olfactory communication, and then evaluated the potential impact of snow leopard visits on the olfactory communication of Pallas's cats.

2. Materials and methods

2.1. Study area

We collected data in two study areas in the Altai Mountains in western Mongolia: the Khork Serkhe Strictly Protected Area (hereafter Khork Serkhe) (47°93′N, 90°99′E), and the Sutai mountain range (hereafter Sutai) (46°37′N, 93°35′E). Elevations range from about 500 m up to about 4500 m (Greco et al., 2022). The region has a cold, semi-arid climate with strong winds, with long cold winters (reaching −25°C) and short summers (reaching, 20°C), during which most of the 45 mm annual precipitation falls (Greco et al., 2022). Vegetation is generally desert-steppe, with small patches of larch (*Larix sibirica*) forests on the northern slopes (Salvatori et al., 2021).

2.2. Field methods

As part of research on snow leopard ecology and conservation, we placed one camera trap at each site in Sutai and two camera traps facing each other at each site in Khork Serkhe (Reconyx HC500, HC600, or Hyperfire2, Holmen, WI, USA). We placed camera traps on rocks (approximately 50 cm above the ground) along trails or at scent-marking sites predicted or observed to be used by snow leopards (Salvatori et al., 2021; Oberosler et al., 2022). Because we were interested in documenting olfactory communication, we did not use any bait or lure, and aimed the cameras at the relatively small areas where olfactory communication occurred. We programmed cameras to take continuous photos with no delay as long as motion was detected (Li et al., 2013; Vogt et al., 2014; Panda et al., 2023). In the Khork Serkhe we monitored 63 sites from March 17 to July 1, 2018. In the Sutai Mountains we monitored 61 sites from March 16 to June 29, 2019. Where possible, we placed camera traps based on a regular grid with cells of 4 km^2 over an area of 1110 km^2 in Khork Serkhe and 843 km^2 in Sutai, but it was not possible to place some cameras due to inaccessible terrain (for details see Salvatori et al., 2021).

2.3. Statistical analyses

For each recorded visit by a Pallas's cat, we documented olfactory communication behaviours (Table 1), and the number of days since the previous visit by a snow leopard. For consistency, the lead author scored all photos from Khork Serke, and reviewed all images from Sutai. We were unable to identify the sex or identity of any of the Pallas's cats, so we did not make any comparisons among sexes or individuals.

We used program R version 4.1.2 (R Core Team, 2021) for statistical analyses, and considered $p \leqslant 0.05$ to be statistically significant. We first calculated summary statistics for multiple variables, and then, due to our small sample sizes, we used t-tests to test whether the number of days since a snow leopard visited the site affected whether Pallas's cats exhibited a communication behaviour.

Table 1.
Ethogram of communication behaviours.

Behaviour	Description
Claw marking	The Pallas's cat scratches it claws on an object
Faecal deposition	The Pallas's cat defecates, leaving a scat at a scent-marking site
Head and/or body rubbing	The Pallas's cat rubs its cheek (and sebaceous glands) on an object at the scent-marking site
Urine spraying	The Pallas's cat sprays urine backwards onto a rock, tree, or other object, or squats and sprays urine on the ground
Flehmen response	The Pallas's cat curls back its neck and lip to expose its vomeronasal organ to investigate scent, often after sniffing
Olfaction	The Pallas's cat sniffs objects or scent marks at the scent-marking site

The first four behaviours are producing behaviours, the last two behaviours are investigative behaviours that we expected Pallas's cat could exhibit based on Mellen (1993), Li et al. (2013), Allen et al. (2016), all listed in alphabetical order. The last four behaviours we documented in this study.

3. Results

We documented 68 visits by Pallas's cats at 23 sites (36.5% of sites, $\overline{x} = 2.96 \pm 0.72$ SE, range = 1–16 visits per visited site) in Khork Serkhe, and 24 visits at 13 sites (21.3% of sites, $\overline{x} = 1.69 \pm 0.33$ SE, range = 1–7 visits per site) in Sutai. Detection rates at sites that were visited averaged 42.0 days per visit ($\pm$ 5.1 SE, range = 4.2–70.0 days) in Khork Serkhe, and 73.2 days per visit ($\pm$ 8.2 SE, range = 18.4–99.0 days) in Sutai. All visits were by single individuals, and occurred throughout the day and night with no discernible circadian pattern.

We documented olfactory communication during, 20 of 68 visits (29.4%) (Figure 1) at 11 sites in Khork Serke, and during 11 of 24 visits (45.8%) at 7 sites in Sutai. Olfaction (sniffing) was the most frequent communication behaviour displayed in both areas ($N_{\text{Khork Serkhe}} = 14$ [26%], $N_{\text{Sutai}} = 10$ [42%], Figure 2). Urine spraying was the second most frequent behaviour in both areas ($N_{\text{Khork Serkhe}} = 11$ [16%], $N_{\text{Sutai}} = 3$ [13%], Figure 2), with urine

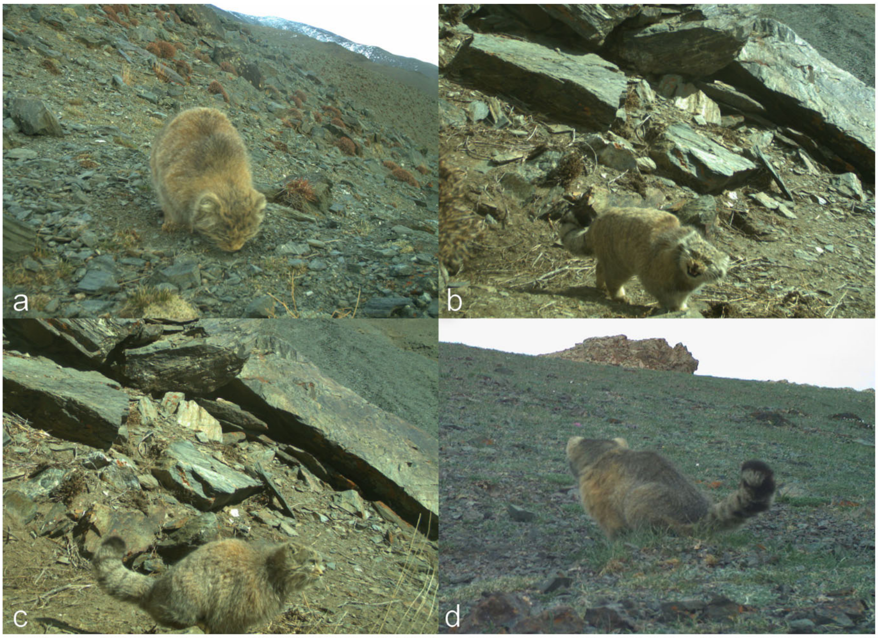

Figure 1. Examples of communication behaviours recorded in Pallas's cats in the Altai Mountains, Mongolia: a) olfaction of a possible scent mark, b) flehmen response, likely in response to urine spraying by another individual four days prior, c) urine spraying on the ground, and d) urine spraying a conspicuous clump of grass.

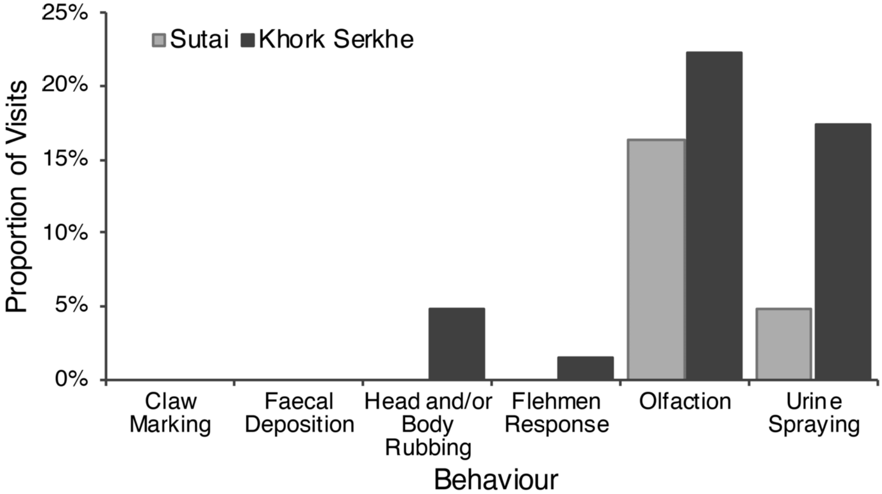

Figure 2. A figure demonstrating the proportion of communication behaviours documented in the two study sites in the Altai Mountains, Mongolia.

sprayed on conspicuous objects (a rock or grass clump) or on the ground. In Khork Serke, we also recorded head and shoulder rubbing during 3 (4.4%) visits, and the flehmen response during 1 (1.5%) visit (Figure 2).

In both study areas there was a wide range in the interval between a Pallas's cat visit and the previous visit by a snow leopard ($\text{range}_{\text{Khork Serkhe}} =$ 1.2–45.2; $\text{range}_{\text{Sutai}} = 1.3$–44.2). The time that had elapsed since the last snow leopard visit at the site had a significant effect on the probability of whether Pallas's cats used olfactory communication when visiting these sites (t-test, $\text{df}_{\text{Khork Serkhe}} = 4$, $p_{\text{Khork Serkeh}} = 0.004$; $\text{df}_{\text{Sutai}} = 10$, $p_{\text{Sutai}} = 0.04$; Figure 3). Specifically, Pallas's cats were more likely to use an olfactory communication when the interval since the previous visit by a snow leopard was longer (Figure 3). In addition, in both study areas the site that was most frequently visited ($N_{\text{Khork Serkhe}} = 16$ visits; $N_{\text{Sutai}} = 7$) and where most olfactory communication behaviours were recorded ($N_{\text{Khork Serkhe}} = 9$ visits; $N_{\text{Sutai}} = 4$ visits) had no recorded snow leopard visits.

4. Discussion

Although limited, our observations provide the most in-depth documentation of olfactory communication by Pallas's cats in the wild. Similar to the only

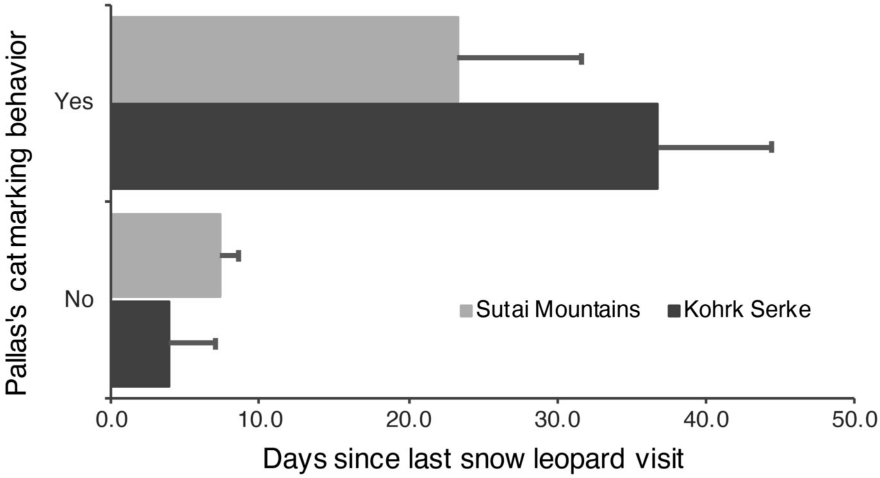

Figure 3. The effect of snow leopard visitation on communication behaviours of Pallas's cats in the Altai Mountains, Mongolia. We compared whether Pallas's cats used a communication behaviour with respect to the time since the last snow leopard visit. Effects were statistically significant in both study areas.

previous study of Pallas's cat olfactory communication in the wild (Li et al., 2013), we documented both olfaction and urine spraying, with olfaction being the most frequent behaviour in both study sites. Urine spraying is generally the most frequent signalling behaviour among solitary felids (Mellen, 1993; Allen et al., 2016), likely because it is an indirect but effective and long-lasting mean of communicating with conspecifics (Mohorović & Krofel, 2020). In addition to olfaction and urine spraying, we also documented head/body rubbing and the flehmen response, which were previously documented only in captive animals; Mellen, 1993; Table 1), but we did not document claw marking or faecal deposition.

Pallas's cats are known to use olfactory communication at the same sites as snow leopards (Li et al., 2013) and generally do not avoid this apex predator spatially or temporally (Salvatori et al., 2022). However, Pallas's cats were less likely to use olfactory communication when a snow leopard had been recently present, and in both study areas the highest rates of olfactory communication by Pallas's cats at sites where snow leopards were not detected. Reduced advertising of their presence in response to occurrence of snow leopards might help Pallas's cats to remain undetected by the apex predator and thus reduce their risk of predation. Our research using by-catch data from snow leopard surveys shows that olfactory communication of Pallas's cats is affected by snow leopard visits, and camera trapping surveys focused on Pallas's cats would likely provide better results than using by-catch data (Augugliaro et al., 2021).

Acknowledgements

We thank B.A. Schulte and two anonymous reviewers who provided constructive comments that improved our manuscript. We are grateful to the Ministry of Environment and Tourism of Mongolia for research permits and support, and to C. Janchivlamdan of Wildlife Initiative for logistic support. We also thank the following colleagues, field assistants, translators and rangers for invaluable help during the fieldwork: C. Groff, R. Rizzoli, P. Zorer, B. Barsuren, B. Munkh-Erdene, T. Yondonjamts, H. Baymanday and J. Khuantkan, B. Rosenbaum, E. Nurbat, I.E. Monti. We are grateful to S. Palmarini and R. Rizzoli also for their help with photo processing, as well as P. Christie and F. Zimmermann for support to the project and lending a portion of camera traps. This research was supported by Panthera Sabin Snow Leopard grants, Arca Foundation—Parco Natura Viva, Wildlife Initiative, Irbis Mongolia and the Altai institute for research and conservation. The Gino Zobele Fund supported V.O., the Herbette Foundation from the University of Lausanne supported C.A., and the Slovenian Research Agency supported M.K. (grants P4-0059 and N1-0163).

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