Animal Welfare

www.cambridge.org/awf

Rapid systematic literature review: Camera trap sampling in ecological studies: Considerations of wildlife welfare

Emeline Nogues, Ava Arends and Marina A.G. von Keyserlingk

Animal Welfare Program, Faculty of Land and Food Systems, The University of British Columbia, 2357 Main Mall, Vancouver, BC, Canada V6T 1Z4

Systematic Review

Cite this article: Nogues E, Arends A and von Keyserlingk MAG (2025). Rapid systematic literature review: Camera trap sampling in ecological studies: Considerations of wildlife welfare. *Animal Welfare*, **34**, e44, 1–7
https://doi.org/10.1017/awf.2025.10014

Received: 05 February 2025
Revised: 06 May 2025
Accepted: 28 May 2025

Keywords:
Animal welfare; behaviour; conservation science; ecology; ethics; wild animals

Corresponding author:
Marina A.G. von Keyserlingk;
Email: nina@mail.ubc.ca

Author contributions:
Conceptualisation: EN, AA, MvK; Investigation: EN, AA; Writing – Original Draft: EN, AA, MvK; Writing – Review & Editing: MvK

Abstract

The use of camera traps in wildlife conservation and ecological research is a popular method of data capture due in large part to the perceived low interference levels for the animals being studied. However, evidence exists that some species alter their behaviour when exposed to this technology. The primary aim of this study was to address whether researchers working with this technology in the ecology and forestry fields are making considerations for the possible impacts of cameras on animal behaviour. A secondary aim was to investigate how the use of this technology is framed in recent publications. In this rapid systematic literature review, we conducted a search on Web of Science and we identified 267 papers published in the last five years, in the fields of ecology and forestry, that met our inclusion criteria. We screened the studies for mentions of the impact of camera traps on the welfare of wildlife. Surprisingly, only 7.5% of the papers considered the possible animal welfare impacts of camera use on the wildlife species of interest in their study, with most comparing it to invasive methods and therefore framing this technology positively. We strongly encourage researchers working in this field to consider the impact of this technology on the specific species being studied. Whilst we recognise that the use of camera traps avoids direct handling of the animals, the short- and long-term effects of using this technology should not be ignored and should, at a minimum, be acknowledged in the limitations.

Introduction

Concerns regarding wildlife welfare have increased, due in part to increased awareness of the public regarding wildlife and human conflict (Liordos *et al.* 2017), but also in part to increased conservation research focused on anthropogenic impacts on wildlife habitats (Berg *et al.* 2020; Zemanova 2020). Despite these concerns, some have argued that leading conservationists have prioritised the interests of the population with little to no attention paid to the individual animal (Ramp & Bekoff 2015). Whilst capture, handling and even killing of some wild animals in pursuit of conservation research have been justified by some (Powell & Proulx 2003), the question of when the welfare of the individual matters has also been raised (Bekoff 2013).

Ethical considerations of how technologies are used to capture data from animals are now being questioned (Wathes *et al.* 2008; Wathes 2010), driven by the fact that it is not always clear how the technology impacts animal welfare (for further discussion, see Dawkins 2021). In the case of non-invasive technologies, knowledge on whether the technology alters behaviour of certain species or if animals show signs of distress is key if researchers are to implement best practices that mitigate harms, with the choice of method potentially impacting the viability of study results (Fraser 2010).

The use of camera traps, a relatively new technology, has gained considerable traction over the last 20 years, driven by the need to study, monitor or observe wildlife populations (Wearn & Glover-Kapfer 2017; Zemanova 2020; Fisher 2023). This tool is generally assumed to avoid potential injuries and distress associated with capture and handling of the wild animal in question (Meek *et al.* 2016). In addition to reducing the cost of research, camera traps have been argued by some to improve the welfare of wildlife given that they are viewed as being non-invasive (Meek *et al.* 2014a). Whilst arguments such as these have no doubt contributed to the increased use of this technology amongst wildlife researchers, there is also a degree of evidence that the creation of light and sound from the cameras, and human odour associated with camera trap placement can be intrusive to species thereby affecting the natural behavioural patterns of the animals being studied (Meek *et al.* 2016).

Given the wide use of this technology and this new evidence that there may be negative effects on some animals, our primary aim was to understand how the use of camera traps deployed to monitor wildlife have been described in the field of ecology and forestry in relation to animal welfare. We addressed this aim by undertaking a rapid systematic review where we first set out to determine how authors that collected data on a wild species using camera traps framed this technology in their study. Our secondary aim was to investigate whether the use of this technology is discussed in relation to wildlife welfare and if authors specifically addressed how this technology may have affected their results.

Materials and methods

Ethical approval

Not applicable for this rapid systematic literature review.

Search strategy

The protocol for this review was not registered. A systematic search was conducted through the Web of Science (WoS) search engine on June 29, 2023. A librarian (K Miller) from The University of British Columbia was consulted to develop the following terms for the database search, with * indicating a truncation of the search terms and " " indicating a phrase: "camera trap*" AND conserv* AND population* AND wildlife OR "large mammal*" OR ungulate* OR carnivore* OR herbivore*. The following meso citation categories: 3.35 Zoology & Animal Ecology or 3.40 Forestry were applied to isolate studies in the relevant fields of study. All papers were required to be articles or early access articles available through The University of British Columbia library, published in the English language in the last five years (i.e. January 2019–June 2023). We recognise that five years is a limited number of years but given that this research was carried out as part of an undergraduate course, we needed to limit the scope so that it could be completed in a four-month period; we acknowledge this limitation and discuss how this decision may have impacted our results in the *Study limitations* section.

Inclusion and exclusion criteria

Articles were included if camera trapping was the primary methodology for data collection. Studies were eligible if the authors focused on species of wildlife living in their natural habitat (e.g. studies in zoos were not included). Studies were included if camera trapping was the sole method of data capture or when used in conjunction with other methodologies with direct human interference, such as trapping or tagging.

Studies were excluded if they involved captive-bred or raised wildlife, or animals that had been interfered with (e.g. capture-mark-recapture, release, or translocated) shortly before or during the study. Articles were also ineligible if the study utilised an attractant introduced into the environment (e.g. food baits or scent lures) or some form of modification of the landscape (e.g. new wildlife corridor). Articles were also excluded if the research intended to assess the camera traps' viability or the viability of another methodology. Reviews were also excluded.

Article screening

The papers from the systematic literature search were uploaded to the review software Covidence (Covidence Systematic Review Software, Veritas Health Innovation, Melbourne, VIC, Australia) to identify and eliminate duplicates.

The inclusion criteria were first applied to the title and abstract of the papers. A reliability assessment was performed on 40 papers selected at random by two of the authors (AA and EN). Disagreements were resolved by consensus and if no consensus could be reached the study was then moved for the full-text review. The reliability assessment also allowed for the refinement of the exclusionary criteria. The remaining abstracts and titles of the papers were screened by AA. An article was excluded if the reviewer selected 'no' or it was advanced to the full-text review if the reviewer selected 'yes' or 'maybe'.

The same criteria were applied during the full-text review. This time, reliability was performed on 20 studies randomly selected by the same two authors, and AA then proceeded with the remainder of the screening.

Data extraction

The following data items were collected from the articles: author, publication year, species studied, location and duration of the study, number of cameras used, relevant quotes and works cited by the authors if applicable. The papers were divided into those that specifically mentioned the impact of the camera traps on the wildlife, and those that did not; the former were then divided into those that addressed animal welfare and those that failed to do so (Table 1).

Data extraction reliability was performed on the same 20 papers selected at random during the full-text review by AA and EN. Having achieved 100% agreement, AA then proceeded with the remainder of the studies. During the data extraction, each paper was categorised as described above by first reading the abstracts and methods section and then screening the full text for the following keywords: disturbance*, invasive/non-invasive, behavio*, light, sound, flash, manipulative, attract, response, infrared, stress, fear, intrusive, react, ethics, indirect, welfare, and trap response (Figure 1). These specific screening terms were used to reduce errors in categorisation.

Results

Study selection

The flow diagram illustrates the screening and exclusion process (Figure 1). We initially started with 458 articles and excluded 191 based on the exclusion criteria, resulting in 267 studies that were used for data extraction.

Table 1. Categories used to identify different levels of consideration given to the potential impact of using camera traps for empirical research on wildlife welfare applied to 267 studies published between January 2019 and June 2023

Category 1: No Impact Mentioned	Category 2: Methodology Impact Mentioned
	Category 2a: The paper does not elaborate beyond descriptions of methodology in terms of impact on the welfare of wildlife. - This may include words such as non-invasive or non-intrusive to justify camera usage.
	Category 2b: Explains the impact of the methodology on the welfare of the wildlife recorded by the camera traps. - Researchers elaborate beyond a description of the methodology and discuss possible effects of the technology usage within their study. - This may include considerations regarding aversions or attractions to camera traps or other behavioural effects. - Researchers cite other work to justify camera usage.

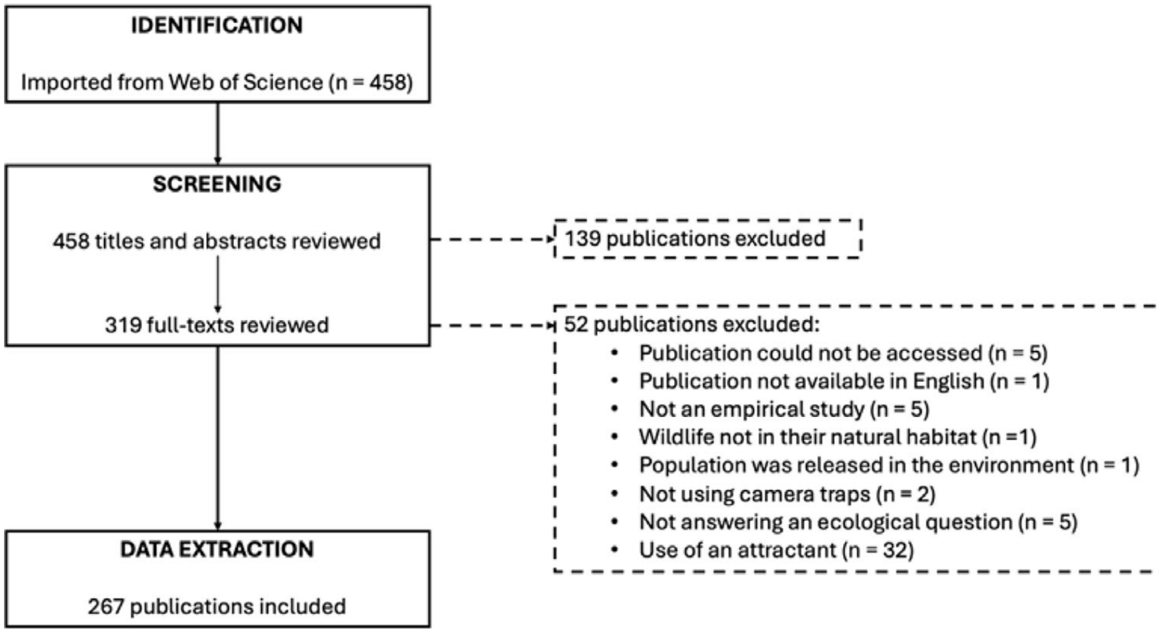

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) study flow diagram (adapted from PRISMA 2020; Page *et al.* 2021) for a rapid systematic review of the potential impact of using camera traps for empirical research on wildlife welfare in their natural habitat. A search was conducted for the studies published between January 2019 and June 2023.

Welfare considerations

Most of the papers identified in this rapid systematic review failed to consider possible camera trapping impacts on the welfare of wildlife species being studied. Of the 267 articles retained for data extraction: 203 papers (76%) were placed in Category 1, where the methodology impact of camera use on welfare was not mentioned. There were 44 papers (16.5%) assigned to Category 2a where the methodology impacts of cameras on welfare were mentioned but was limited to descriptive language. The remaining 20 (7.5%) papers were placed into Category 2b where the methodology impact of cameras on animal welfare was specifically mentioned and discussed for the wildlife species being studied.

The 44 papers categorised as 2a are listed online in the Supplementary material found at https://doi.org/10.5683/SP3/OJURD4. In sum, all the studies categorised as 2a utilised descriptors to positively frame camera trapping as an advantageous methodology because it is "*observational*" (Phumanee *et al.* 2021; p 9). Authors framed camera traps in a positive manner using descriptive terms such as "*non-invasive*" (Pal *et al.* 2022; p 9), "*nonintrusive*" (Hazwan *et al.* 2022; p 2), or "*non-manipulative*" (Lundgren *et al.* 2022; p 2,351). Six studies also used language to positively frame camera trapping by stating that alternative methods would be more aversive while camera traps allow data collection "*without the need for invasive and costly collaring*", and without "*handling, capture, or immobilization*" (quotes from Müller *et al.* 2022; p 11 and Braczkowski *et al.* 2022; p 17; other references: Gimenez *et al.* 2019; Havmøller *et al.* 2019; Li *et al.* 2020; Morris *et al.* 2022). Two papers categorised as 2a (Soyumert *et al.* 2019; Piña-Covarrubias *et al.* 2023) did not discuss welfare concerns or potential invasiveness associated with the use of cameras aside from referring to the data captured as "*indirect*" evidence. Most of these papers were broad in their claims and offered no further justification for their reasoning as to how the technology was non-invasive nor applied these claims to the wildlife species within their study. A single study out of the 44 in Category 2a included a reference to support their choice of descriptor of the technology (Oberosler *et al.* 2022).

The papers in Category 2b (n = 20) elaborate beyond descriptors for the technology and discuss possible welfare benefits or concerns when utilising camera traps for wildlife studies (metadata presented in Appendix 1; see Supplementary material; https://doi.org/10.5683/SP3/OJURD4). Animal welfare was considered mostly in terms of behavioural changes or responses that could occur in reaction to camera traps. Seven of these papers argued that there is minimal concern for behavioural changes in their wildlife species of interest. For example, Edwards *et al.* (2019; p 522) state cameras were "*passive detectors*". Satter *et al.* (2019; p 292) argued that the traps "*were not baited*" so it would be unexpected to have a behavioural response, and Gueye *et al.* (2021; p 5) claim all photographs were taken "*within the daylight period*" minimising the effect of a flash and therefore reducing the chance of a behavioural response to the cameras. Palmero *et al.* (2021), Green *et al.* (2023), and Laporte-Devylder (2023) justified the use of the camera trap using statements regarding the welfare considerations of other sampling methods that are more "*intensive*" (Laporte-Devylder *et al.* 2023; p 215) as they cause wildlife to be "*manipulated in a way that would cause distress or pain*" (Green *et al.* 2023; p 121) or subject animals to "*stressful … immobilization*" (Palmero *et al.* 2021; p 2) in comparison to camera traps that "*minimize stress and disturbance*" (Laporte-Devylder *et al.* 2023; p 215). These seven papers out of the 20 in Category 2b all positively frame the welfare benefits of using camera traps.

Interestingly, although the papers in Category 2b discussed possible behavioural responses to the camera traps and the concerns associated with using the technology, only four papers (Lamichhane *et al.* 2019; Brommer *et al.* 2021; Farhadinia *et al.* 2021; Rather *et al.* 2021) considered a possible behavioural trap response as part of their data analysis models because they "*expected the … behavior to change after being detected*" (Farhadinia *et al.* 2021; p 366). These four publications were also the only studies that discussed how technology may impact the validity of the values of their recorded sightings. Jayasekara *et al.* (2021; p 144) also provided a behavioural change example where "*elephants were highly reactive to the cameras and*

https://doi.org/10.1017/awf.2025.10014 Published online by Cambridge University Press

were often found attacking them". Although this reactive behaviour may be unique to elephants exposed to camera traps, it does highlight the need to re-examine whether this technology may also be aversive to other species of wildlife as failing to do so may introduce bias unless proven otherwise. In contrast, Ünal *et al.* (2019a) specifically stated that disturbances arising from the camera traps causing behavioural avoidance were limited to instances when humans visited the camera traps.

Six of the 20 papers in Category 2b introduced observations specific to the species within the study (Anile *et al.* 2019; Satter *et al.* 2019; Tang *et al.* 2019; Jayasekara *et al.* 2021; Bhattacharya *et al.* 2022; Séguigne *et al.* 2022). For example, Tang *et al.* (2019; p 3) state how the "*lynx did not show any fear from the infrared lights and the operators' odor left on the digital cameras*"; however, despite stating this the authors failed to provide clear evidence to this effect. In contrast, Séguigne *et al.* (2022; p 7) discussed how the species within their study, the *Potos flavus (*kinkajou), displayed avoidance behaviour toward flash photography, a finding that resulted in the researchers abandoning the flash camera in favour of an "*infrared moving sensor camera*". Additional evidence that some animals react to the cameras comes from Jayasekara *et al.* (2021) who mentioned discarding their camera footage of *Prionailurus viverrinus* (fishing cats) and *Viverricula indica* (ring-tailed civets) because they were unable to observe natural behaviour. Fourteen studies addressed the limitations of their data collection method and were transparent in identifying possible biases, with some describing that the choice of camera type was meant to improve the reliability of their study results (e.g. Jayasekara *et al.* 2021; Séguigne *et al.* 2022).

Discussion

Rising anthropogenic pressures and loss of wildlife habitat have caused a biodiversity crisis and concern for the welfare of wildlife (Zemanova 2020). Generally, conservation research is focused on addressing concerns about the population of a species within an ecological system, which at times can be at odds with animal welfare, a construct that encompasses the physical health, natural behaviour, and affective state of individual animals (Fraser *et al.* 1997; Beausoleil 2020; Lynch *et al.* 2025). A perpetuated view in wildlife research is that the impacts of potentially harmful research methods are "*outweighed by the benefits to the population or species*" (Zemanova 2020; p 9). However, ignoring the welfare of individual animals places society at odds with much of the wildlife conservation research. In contrast, by combining ecological and animal welfare research, more reliable field results to solve conservation issues would be achieved (Fraser 2010). More modern ethical frameworks, such as conservation welfare and compassionate welfare, combine these fields and argue collectively that the welfare of individual animals should be prioritised; research efforts should try to minimise harm to every animal being studied (Beausoleil 2020).

Some research methods involving wildlife fail to consider the animal's welfare, and thus may cause undue suffering and increase the chances of mortality (e.g. when directly marking, capturing, or handling wildlife; Zemanova 2020). Instead, accounting for welfare can favour positive conservation outcomes. For example, providing species-specific enrichments when rehabilitating wildlife encourages the expression of natural behaviours, which in turn increases reintroduction success (Reading *et al.* 2013). In addition, the use of affective- and behaviour-based deterrents (e.g. hazing) for urban wildlife, such as *Canis latrans (*coyotes), can reduce the need for lethal control (Sampson & Van Patter 2020). Welfare considerations have also led to the development of alternative methods of sampling and studying wildlife, such as camera traps, that are intended to be 'non-invasive' (Zemanova 2020).

Camera trapping has provided researchers with the ability to document elusive wildlife in remote areas and study their behaviour to an extent that would not otherwise be possible (Caravaggi *et al.* 2017; Houa *et al.* 2022). However, there is evidence that some species show behavioural responses to cameras and may avoid or be attracted to them (Rowcliffe *et al.* 2008; Wearn & Glover-Kapfer 2017). White-flash cameras "*startle animals* …[causing] *a flight response*" (Meek *et al.* 2014b; p 15), and even findings from infrared camera studies have shown that some species can detect the flash illumination. The "*odour left by human contact on or around*" (Houa *et al.* 2022; p 16) camera traps has also been observed to cause attraction at camera trap locations. Behavioural reactions can "*bias negatively or positively density estimates*" (Houa *et al.* 2022; p 3) of wildlife populations and lead to under or overestimates of populations. These behavioural responses to cameras may have implications for the reliability of population estimates; data that can have a profound influence on conservation decisions.

Unfortunately, most studies that were identified in this rapid systematic review remained silent on any potential welfare considerations regarding camera trapping. Somewhat worrisome is also that even within those that did discuss animal welfare, most refuted or only briefly acknowledged the possible disturbances to animals that may come with use of the technology, and only eight of 20 included a reference to support their claim. For example, behavioural disturbances are likely generalisable to all the studies included in this review, but four publications dismiss this risk on the basis that they are not luring, baiting, or otherwise modifying the environment around the camera (Satter *et al.* 2019; Bhattacharya *et al.* 2022; Lombardi *et al.* 2022; Green *et al.* 2023). When considering potential harms associated with using animals in research, most scientists are trained to trade-off potential benefits against possible harms (Schuppli & Fraser 2007). In the case of utilising camera traps the trade-offs have been argued as being lower than those associated with direct sampling methods, where higher cortisol levels from stress greatly increase the mortality rates of sampled individuals (Zemanova 2020). Arguments in favour of the use of camera traps also include lowest impacts on wildlife and its relatively low cost which collectively have contributed to this technology being increasingly used for conservation work (Wearn & Glover-Kapfer 2017). However, we encourage researchers to reflect upon how to minimise harms and disturbances with camera traps as they have with other techniques considered to be more invasive (Jewell 2013).

Another statement used by some was that "*animal welfare implications of research methods are simply not known*" (Zemanova 2020; p 9) due to the relatively new adoption of this sampling methodology (Burton *et al.* 2015). Many ecologists and wildlife biologists who conduct conservation research may also be unaware of possible biases and harms that can arise from different types of sampling. Education regarding the effects of methods used in conservation studies on animal welfare have received little discussion in wildlife research programmes and very few universities require students to take these courses (Zemanova 2023). Lastly, there may not be an emphasis on animal welfare or varied attitudes towards animals in the different geo-political and cultural regions where researchers originate from and where these studies took place (Sinclair *et al.* 2022).

Future directions

Through the application of conservation welfare, researchers working in the fields of ecology and conservation are encouraged to

https://doi.org/10.1017/awf.2025.10014 Published online by Cambridge University Press

incorporate animal welfare knowledge when developing sampling methods as any form of data capture in wildlife habitats may negatively impact the well-being of individual animals (Fraser 2010: Beausoleil 2020; Caravaggi *et al.* 2021). Placing more emphasis on animal welfare education and encouraging future ecologists to consider animal welfare, could help with the development of conservation study methods that are more humane. Examining the potential disturbance of cameras, despite being non-invasive, is essential for protecting the well-being of wildlife in ecological studies. The potential avoidance behaviour from the species studied can be detrimental, particularly for those studies conducted in ecologically sensitive locations (Kumbhojkar *et al.* 2020; Silva *et al.* 2021). One of the studies included in this review reflected on the type of camera to use prior to data collection both to minimise welfare impact and ensure reliable data (Séguigne *et al.* 2022: choice of using infrared over flash photography), and we encourage other researchers to follow a similar process. Although ethical approval is not always obtainable nor required, journals might consider requesting the inclusion of a reflection statement by the authors on the potential disturbances and welfare implications of the research on the individual animals studied.

Study limitations

As stated in the *Materials and methods*, this research arose out of an undergraduate-directed studies course. Given this constraint we only had a four-month window within which to run the search criteria as so the decision was made to target the last five years. Ideally, we would have liked to have included at least two additional search engines and have gone back at least a decade. Inclusion of more than one search engine increases the likelihood that we would capture a higher proportion of the work completed using camera traps.

We also had specific criteria that excluded papers that used attractants for wildlife and those that were an assessment of the efficacy of camera trapping methodologies. These two criteria and the focus of these papers within forestry and ecology fields of study were used to ensure only ecological studies intended to study wildlife without disturbance were being assessed. However, by excluding some papers we may have missed a portion that were transparent about their considerations for the welfare of the wildlife. Lastly, although the data extraction carried out by the authors was reliable, some relevant descriptors or welfare considerations may have later been missed.

Animal welfare implications

We hope this rapid systematic literature review will encourage researchers working in the field of ecology to carefully consider animal welfare, not only for the benefit of wildlife but also to improve sampling methods and the credibility of their scientific process and results. Research on the welfare impacts of using camera traps will no doubt continue to expand; our hope is that a more comprehensive understanding of how camera trapping affects wildlife behaviour and affective states will accompany this growth.

Conclusion

Our results indicate that consideration of animal welfare is relatively low in camera trapping conservation studies. Furthermore, researchers are cautioned from making assumptions regarding the non-invasive nature of camera trapping methodology in the absence of evidence. Researchers are also strongly encouraged to consider the sensitivity of animals to human disturbance when designing survey methods for certain wildlife species. As the usage of camera traps continues to grow, employing a conservation welfare framework in ecological research studies would lead to more valid results that could reduce stress or behavioural changes in the species being studied and allow more judicial use of funds in trying to protect wildlife populations.

Supplementary material. The supplementary material for this article can be found at http://doi.org/10.1017/awf.2025.10014.

Acknowledgements. AA completed this work as part of a directed studies course completed in Applied Biology (APBI 497) in the Faculty of Land and Food Systems at The University of British Columbia (UBC). No external funds were secured for this study.

Competing interests. None.

References

Anile S, Devillard S, Ragni B, Rovero F, Mattucci F and Valvo ML 2019 Habitat fragmentation and anthropogenic factors affect wildcat *Felis silvestris silvestris* occupancy and detectability on Mt Etna. *Wildlife Biology* **2019**(1): 1–13. https://doi.org/10.2981/wlb.00561

Beausoleil NJ 2020 I am a compassionate conservation welfare scientist: Considering the theoretical and practical differences between compassionate conservation and conservation welfare. *Animals* **10**(2): 257. https://doi.org/10.3390/ani10020257

Bekoff M 2013 *Ignoring Nature No More: The Case for Compassionate Conservation*. The University of Chicago Press: Chicago, USA.

Berg C, Lerner H, Butterworth A and Walzer C 2020 Editorial: Wildlife welfare. *Frontiers in Veterinary Science* **7**. https://doi.org/10.3389/fvets.2020.576095

Bhattacharya A, Chatterjee N, Angrish K, Meena D, Sinha BC and Habib B 2022 Population estimation of Asiatic black bear in the Himalayan Region of India using camera traps. *Ursus* **2022**(33e8): 1–10. https://doi.org/10.2192/URSUS-D-21-00002.2

Braczkowski A, Schenk R, Samarasinghe D, Biggs D, Richardson A, Swanson N, Swanson M, Dheer A and Fattebert J 2022 Leopard and spotted hyena densities in the Lake Mburo National Park, southwestern Uganda. *PeerJ* **10**: e12307. https://doi.org/10.7717/peerj.12307

Brommer JE, Poutanen J, Pusenius J and Wikström M 2021 Estimating preharvest density, adult sex ratio, and fecundity of white-tailed deer using noninvasive sampling techniques. *Ecology and Evolution* **11**(20): 14312–14326. https://doi.org/10.1002/ece3.8149

Burton AC, Neilson E, Moreira D, Ladle A, Steenweg R, Fisher JT, Bayne E and Boutin S 2015 Review: Wildlife camera trapping: a review and recommendations for linking surveys to ecological processes. *Journal of Applied Ecology* **52**(3): 675–685. https://doi.org/10.1111/1365-2664.12432

Caravaggi A, Amado TF, Brook RK, Ciuti S, Darimont CT, Drouilly M, English HM, Field KA, Iossa G, Martin JE, McElligott AG, Mohammadi A, Nayeri D, O'Neill HMK, Paquet PC, Périquet S, Proulx G, Rabaiotti D, Recio MR, Soulsbury CD, Tadich T and Wynn-Grant R 2021 On the need for rigorous welfare and methodological reporting for the live capture of large carnivores: A response to de Araujo et al. (2021). *Methods in Ecology and Evolution* **12**(10): 1793–1799. https://doi.org/10.1111/2041-210X.13664

Caravaggi A, Banks PB, Burton AC, Finlay CMV, Haswell PM, Hayward MW, Rowcliffe MJ and Wood MD 2017 A review of camera trapping for conservation behaviour research. *Remote Sensing in Ecology and Conservation* **3**(3): 109–122. https://doi.org/10.1002/rse2.48

Dawkins MS 2021 Does smart farming improve or damage animal welfare? Technology and what animals want. *Frontiers in Animal Science* **2**. https://doi.org/10.3389/fanim.2021.736536

Edwards S, Noack J, Heyns L and Rodenwoldt D 2019 Evidence of a high-density brown hyena population within an enclosed reserve: the role of fenced systems in conservation. *Mammal Research* **64**(4): 519–527. https://doi.org/10.1007/s13364-019-00432-7

Farhadinia MS, **Behnoud P**, **Hobeali K**, **Mousavi SJ**, **Hosseini-Zavarei F**, **Gholikhani N**, **Akbari H**, **Braczkowski A**, **Eslami M**, **Moghadas P and Macdonald DW** 2021 Estimating the density of a small population of leopards (*Panthera pardus*) in central Iran using multi-session photographic-sampling data. *Mammalian Biology* **101**(3): 363–371. https://doi.org/10.1007/s42991-020-00096-w

Fisher JT 2023 Camera trapping in ecology: A new section for wildlife research. *Ecology and Evolution* **13**(3): e9925. https://doi.org/10.1002/ece3.9925

Fraser D 2010 Toward a synthesis of conservation and animal welfare science. *Animal Welfare* **19**(2): 121–124. https://doi.org/10.1017/S0962728600001378

Fraser D, **Weary DM**, **Pajor EA and Milligan BN** 1997 A scientific conception of animal welfare that reflects ethical concerns. *Animal Welfare* **6**: 187–205.

Gimenez O, **Gatti S**, **Duchamp C**, **Germain E**, **Laurent A**, **Zimmermann F and Marboutin E** 2019 Spatial density estimates of Eurasian lynx (*Lynx lynx*) in the French Jura and Vosges Mountains. *Ecology and Evolution* **9**(20): 11707–11715. https://doi.org/10.1002/ece3.5668

Green AM, **Young E**, **Keller H**, **Grace T**, **Pendergast ME and Şekercioğlu ÇH** 2023 Variation in human diel activity patterns mediates periodic increases in recreational activity on mammal behavioural response: investigating the presence of a temporal 'weekend effect'. *Animal Behaviour* **198**: 117–129. https://doi.org/10.1016/j.anbehav.2023.02.002

Gueye M, **Brandlová K**, **Rabeil T**, **Diop MM**, **Diop B and Hejcmanová P** 2021 Spatially restricted occurrence and low abundance as key tools for conservation of critically endangered large antelope in West African savannah. *Scientific Reports* **11**(1): 19397. https://doi.org/10.1038/s41598-021-98649-7

Havmøller RW, **Tenan S**, **Scharff N and Rovero F** 2019 Reserve size and anthropogenic disturbance affect the density of an African leopard (*Panthera pardus*) meta-population. *PLoS ONE* **14**(6): e0209541. https://doi.org/10.1371/journal.pone.0209541

Hazwan M, **Samantha LD**, **Tee SL**, **Kamarudin N**, **Norhisham AR**, **Lechner AM and Azhar B** 2022 Habitat fragmentation and logging affect the occurrence of lesser mouse-deer in tropical forest reserves. *Ecology and Evolution* **12**(3): e8745. https://doi.org/10.1002/ece3.8745

Houa NA, **Cappelle N**, **Bitty EA**, **Normand E**, **Kablan YA and Boesch C** 2022 Animal reactivity to camera traps and its effects on abundance estimate using distance sampling in the Taï National Park, Côte d'Ivoire. *PeerJ* **10**: e13510. https://doi.org/10.7717/peerj.13510

Jayasekara D, **Mahaulpatha D and Miththapala S** 2021 Population density estimation of meso-mammal carnivores using camera traps without the individual recognition in Maduru Oya National Park, Sri Lanka. *Hystrix, the Italian Journal of Mammalogy* **32**(2): 137–146. https://doi.org/10.4404/hystrix-00452-2021

Jewell Z 2013 Effect of monitoring technique on quality of conservation science. *Conservation Biology* **27**(3): 501–508. https://doi.org/10.1111/cobi.12066

Kumbhojkar S, **Yosef R**, **Mehta A and Rakholia S** 2020 A camera-trap home-range analysis of the Indian leopard (*Panthera pardus fusca*) in Jaipur, India. *Animals* **10**(9): 1600. https://doi.org/10.3390/ani10091600

Lamichhane BR, **Leirs H**, **Persoon GA**, **Subedi N**, **Dhakal M**, **Oli BN**, **Reynaert S**, **Sluydts V**, **Pokheral CP**, **Poudyal LP**, **Malla S and de Iongh HH** 2019 Factors associated with co-occurrence of large carnivores in a human-dominated landscape. *Biodiversity and Conservation* **28**(6): 1473–1491. https://doi.org/10.1007/s10531-019-01737-4

Laporte-Devylder L, **Ulvund KR**, **Rød-Eriksen L**, **Olsson O**, **Flagstad Ø**, **Landa A**, **Eide NE and Jackson CR** 2023 A camera trap-based assessment of climate-driven phenotypic plasticity of seasonal moulting in an endangered carnivore. *Remote Sensing in Ecology and Conservation* **9**(2): 210–221. https://doi.org/10.1002/rse2.304

Li J, **Xue Y**, **Zhang Y**, **Dong W**, **Shan G**, **Sun R**, **Hacker C**, **Wu B and Li D** 2020 Spatial and temporal activity patterns of Golden takin (*Budorcas taxicolor bedfordi*) recorded by camera trapping. *PeerJ* **8**: e10353. https://doi.org/10.7717/peerj.10353

Liordos V, **Kontsiotis VJ**, **Georgari M**, **Baltzi K and Baltzi I** 2017 Public acceptance of management methods under different human–wildlife conflict scenarios. *Science of The Total Environment* **579**: 685–693. https://doi.org/10.1016/j.scitotenv.2016.11.040

Lombardi JV, **Stasey WC**, **Caso A**, **Carvajal-Villarreal S and Tewes ME** 2022 Ocelot density and habitat use in Tamaulipan thornshrub and tropical deciduous forests in Northeastern México. *Journal of Mammalogy* **103**(1): 57–67. https://doi.org/10.1093/jmammal/gyab134

Lundgren EJ, **Ramp D**, **Middleton OS**, **Wooster EIF**, **Kusch E**, **Balisi M**, **Ripple WJ**, **Hasselerharm CD**, **Sanchez JN**, **Mills M and Wallach AD** 2022 A novel trophic cascade between cougars and feral donkeys shapes desert wetlands. *Journal of Animal Ecology* **91**(12): 2348–2357. https://doi.org/10.1111/1365-2656.13766

Lynch KE, **Allen BL**, **Berger-Tal O**, **Fidler F**, **Garrard GE**, **Hampton JO**, **Lean CH**, **Parris KM**, **Sherwen SL**, **White TE**, **Wong BBM and Blumstein DT** 2025 Explicit value trade-offs in conservation: integrating animal welfare. *Trends in Ecology & Evolution* **40**(6). https://doi.org/10.1016/j.tree.2025.03.013

Meek PD, **Ballard G**, **Claridge A**, **Kays R**, **Moseby K**, **O'Brien T**, **O'Connell A**, **Sanderson J**, **Swann DE**, **Tobler M and Townsend S** 2014a Recommended guiding principles for reporting on camera trapping research. *Biodiversity and Conservation* **23**(9): 2321–2343. https://doi.org/10.1007/s10531-014-0712-8

Meek PD, **Ballard G**, **Fleming P and Falzon G** 2016 Are we getting the full picture? Animal responses to camera traps and implications for predator studies. *Ecology and Evolution* **6**(10): 3216–3225. https://doi.org/10.1002/ece3.2111

Meek PD, **Ballard G-A**, **Fleming PJS**, **Schaefer M**, **Williams W and Falzon G** 2014b Camera traps can be heard and seen by animals. *PLoS ONE* **9**(10): e110832. https://doi.org/10.1371/journal.pone.0110832

Morris DR, **Boardman WSJ**, **Swanepoel LH**, **Simpson G**, **Coetzee J**, **Camacho GJ and McWhorter TJ** 2022 Population density estimate of leopards (*Panthera pardus*) in north-western Mpumalanga, South Africa, determined using spatially explicit capture–recapture methods. *Mammalian Biology* **102**(4): 1173–1183. https://doi.org/10.1007/s42991-021-00179-2

Müller L, **Briers-Louw WD**, **Seele BC**, **Lochner CS and Amin R** 2022 Population size, density, and ranging behaviour in a key leopard population in the Western Cape, South Africa. *PLoS ONE* **17**(5): e0254507. https://doi.org/10.1371/journal.pone.0254507

Oberosler V, **Tenan S**, **Groff C**, **Krofel M**, **Augugliaro C**, **Munkhtsog B and Rovero F** 2022 First spatially-explicit density estimate for a snow leopard population in the Altai Mountains. *Biodiversity and Conservation* **31**(1): 261–275. https://doi.org/10.1007/s10531-021-02333-1

Page MJ, **McKenzie JE**, **Bossuyt PM**, **Boutron I**, **Hoffmann TC**, **Mulrow CD**, **Shamseer L**, **Tetzlaff JM**, **Akl EA**, **Brennan SE**, **Chou R**, **Glanville J**, **Grimshaw JM**, **Hróbjartsson A**, **Lalu MM**, **Li T**, **Loder EW**, **Mayo-Wilson E**, **McDonald S**, **McGuinness LA**, **Stewart LA**, **Thomas J**, **Tricco AC**, **Welch VA**, **Whiting P and Moher D** 2021 The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Systematic Reviews* **10**(1): 89. https://doi.org/10.1186/s13643-021-01626-4

Pal R, **Panwar A**, **Goyal SP and Sathyakumar S** 2022 Space use by woolly wolf *Canis lupus* chanco in Gangotri National Park, Western Himalaya, India. *Frontiers in Ecology and Evolution* **9**. https://doi.org/10.3389/fevo.2021.782339

Palmero S, **Belotti E**, **Bufka L**, **Gahbauer M**, **Heibl C**, **Premier J**, **Weingarth-Dachs K and Heurich M** 2021 Demography of a Eurasian lynx (*Lynx lynx*) population within a strictly protected area in Central Europe. *Scientific Reports* **11**(1): 19868. https://doi.org/10.1038/s41598-021-99337-2

Phumanee W, **Steinmetz R**, **Phoonjampa R**, **Weingdow S**, **Phokamanee S**, **Bhumpakphan N and Savini T** 2021 Tiger density, movements, and immigration outside of a tiger source site in Thailand. *Conservation Science and Practice* **3**(12): e560. https://doi.org/10.1111/csp2.560

Piña-Covarrubias E, **Chávez C**, **Chapman MA**, **Morales M**, **Elizalde-Arellano C and Doncaster CP** 2023 Ecology of large felids and their prey in small reserves of the Yucatán Peninsula of Mexico. *Journal of Mammalogy* **104**(1): 115–127. https://doi.org/10.1093/jmammal/gyac090

Powell RA and Proulx G 2003 Trapping and marking terrestrial mammals for research: Integrating ethics, performance criteria, techniques, and common sense. *ILAR Journal* **44**(4): 259–276. https://doi.org/10.1093/ilar.44.4.259

Ramp D and Bekoff M 2015 Compassion as a practical and evolved ethic for conservation. *BioScience* **65**(3): 323–327. https://doi.org/10.1093/biosci/biu223

Rather TA, **Kumar S and Khan JA** 2021 Density estimation of tiger and leopard using spatially explicit capture–recapture framework. *PeerJ* **9**: e10634. https://doi.org/10.7717/peerj.10634

Reading RP, **Miller B and Shepherdson D** 2013 The value of enrichment to reintroduction success. *Zoo Biology* **32**(3): 332–341. https://doi.org/10.1002/zoo.21054

Rowcliffe JM, **Field J**, **Turvey ST and Carbone C** 2008 Estimating animal density using camera traps without the need for individual recognition. *Journal of Applied Ecology* **45**(4): 1228–1236. https://doi.org/10.1111/j.1365-2664.2008.01473.x

Sampson L and Van Patter L 2020 Advancing best practices for aversion conditioning (humane hazing) to mitigate human–coyote conflicts in urban areas. *Human-Wildlife Interactions* **14**(2): 166–183.

Satter CB, **Augustine BC**, **Harmsen BJ**, **Foster RJ**, **Sanchez EE**, **Wultsch C**, **Davis ML and Kelly MJ** 2019 Long-term monitoring of ocelot densities in Belize. *The Journal of Wildlife Management* **83**(2): 283–294. https://doi.org/10.1002/jwmg.21598

Schuppli CA and Fraser D 2007 Factors influencing the effectiveness of research ethics committees. *Journal of Medical Ethics* **33**(5): 294–301. https://doi.org/10.1136/jme.2005.015057

Séguigne M, **Coutant O**, **Bouton B**, **Picart L**, **Guilbert É and Forget P-M** 2022 Arboreal camera trap reveals the frequent occurrence of a frugivore-carnivore in neotropical nutmeg trees. *Scientific Reports* **12**(1): 7513. https://doi.org/10.1038/s41598-022-11568-z

Silva M, **Rosalino LM**, **Alcobia S and Santos-Reis M** 2021 Sett use, density and breeding phenology of badgers in Mediterranean agro-sylvo-pastoral systems. *Animals* **11**(9): 2663. https://doi.org/10.3390/ani11092663

Sinclair M, **Lee NYP**, **Hötzel MJ**, **de Luna MCT**, **Sharma A**, **Idris M**, **Derkley T**, **Li C**, **Islam MA**, **Iyasere OS**, **Navarro G**, **Ahmed AA**, **Khruapradab C**, **Curry M**, **Burns GL and Marchant JN** 2022 International perceptions of animals and the importance of their welfare. *Frontiers in Animal Science* **3**. https://doi.org/10.3389/fanim.2022.960379

Soyumert A, **Ertürk A and Tavşanoğlu Ç** 2019 The importance of lagomorphs for the Eurasian lynx in Western Asia: Results from a large scale camera-trapping survey in Turkey. *Mammalian Biology* **95**: 18–25. https://doi.org/10.1016/j.mambio.2019.01.003

Tang X, **Tang S**, **Li X**, **Menghe D**, **Bao W**, **Xiang C**, **Gao F and Bao W** 2019 A study of population size and activity patterns and their relationship to the prey species of the Eurasian lynx using a camera trapping approach. *Animals* **9**(11): 864. https://doi.org/10.3390/ani9110864

Ünal Y, **Pekin BK**, **Oğurlu İ**, **Süel H and Koca A** 2019a Human, domestic animal, Caracal (*Caracal caracal*), and other wildlife species interactions in a Mediterranean forest landscape. *European Journal of Wildlife Research* **66**(1): 5. https://doi.org/10.1007/s10344-019-1343-x

Wathes CM 2010 Lives worth living? *Veterinary Record* **166**(15): 468–469. https://doi.org/10.1136/vr.c849

Wathes CM, **Kristensen HH**, **Aerts J-M and Berckmans D** 2008 Is precision livestock farming an engineer's daydream or nightmare, an animal's friend or foe, and a farmer's panacea or pitfall? *Computers and Electronics in Agriculture* **64**(1): 2–10. https://doi.org/10.1016/j.compag.2008.05.005

Wearn O and Glover-Kapfer P 2017 *Camera-trapping for conservation: a guide to best-practices.* https://doi.org/10.13140/RG.2.2.23409.17767

Zemanova MA 2020 Towards more compassionate wildlife research through the 3Rs principles: moving from invasive to non-invasive methods. *Wildlife Biology* **2020**(1). https://doi.org/10.2981/wlb.00607

Zemanova MA 2023 Crucial but neglected: Limited availability of animal welfare courses in education of wildlife researchers. *Animals* **13**(18): 2907. https://doi.org/10.3390/ani13182907