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Human-animal interactions

Camera traps as research agents

Nicolas Lainé,[1,2]
Romain Simenel,[1]
Morgane Labadie,[3]
Nishant M. Srinivasaiah[4,5,6] &
Anindya Sinha[6,7]

1. UMR PALOC (IRD-MNHN-CNRS), Paris, France. Email: nicolas.laine@ird.fr
2. IRL HealthDEEP (CNRS, University of Kasetsart and Mahidol), Bangkok, Thailand
3. UMR ASTRE, University of Montpellier, CIRAD, INRAE, Montpellier, France
4. Foundation for Ecological Research, Advocacy and Learning, Bengaluru, India
5. Centre for Ecological Sciences, Indian Institute of Science, Bengaluru, India
6. Animal Behaviour and Cognition Programme, National Institute of Advanced Studies, Bengaluru, India
7. Centre for Wildlife Studies, Bengaluru, India

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Over the past two decades, technological advancements have significantly increased image-based methodologies, particularly the use of camera traps, across various social and natural science disciplines. In the field of ecology, camera traps have become invaluable tools for examining a wide range of ecological factors, such as animal activity patterns, habitat selection, abundance, density and distribution (Fedriani et al. 2000; Harmsen et al. 2010; Kelly 2008; Oliveira-Santos et al. 2008; Rowcliffe et al. 2008; Steenweg et al. 2017). Meanwhile, in anthropology and other disciplines within the humanities and social sciences, these image-based methodologies have provided researchers with new opportunities to explore embodied, affective, more-than-human and multispecies lifeworlds, going beyond traditional research methods that often focus solely on human perspectives (Despret 2004). By acting as novel surveillance agents, camera traps enable researchers to investigate the lived experiences and cognitive responses of nonhuman organisms as they navigate complex human-nonhuman entanglements across diverse places, practices, encounters and traditional cultures.

Anthropologist Nayanika Mathur (2021) recently observed that camera traps, often considered the future of conservation, have the potential to alter power dynamics between humans and animals. In the past, animals could observe humans without being seen, but with camera trap devices, they can now be observed without their knowledge. Furthermore, compared to more traditional research methods, camera traps offer access to remote areas that remain largely untouched by human presence, potentially unveiling the hidden lives of some of the world's rarest and most elusive animals (Karanth & Nichols 1998; Larrucea et al. 2007; Sanderson & Trolle 2005; Tobler et al. 2008; Trolle & Kéry 2003).

In the following sections, we will explore three diverse case studies to examine how and why camera traps transform research practices and methodologies. We will also investigate how animals perceive and adapt to these modern technologies and the ethical implications of using such devices in animal research. Drawing insights from these case studies, we aim to shed light on the complex interplay between technology, animal behaviour and research ethics in the rapidly evolving fields of human-animal interactions and wildlife studies.

Ethnographic input: The right place to observe

The first and most important question when using camera traps during fieldwork is where to place them. Positioning a camera trap requires consideration of many parameters, such as sound sources, animal trajectories, luminosity, clarity and vibration, ultimately approaching an ecosystemic perspective. In most cases, researchers are not well acquainted with the fieldwork site, especially anthropologists who may be working in unfamiliar settings.

In this respect, the best approach for an anthropologist is to be guided by the local population, as these individuals possess intimate knowledge of their territory and the species living within it. By involving local people in the placement of camera traps, the device becomes a powerful ethnographic tool, revealing local understandings of how to manage the various parameters to achieve the desired result: a clear, sharp image of an animal in action. The same principle applies to GPS (Global Positioning System) collars, as the participation of local populations in their deployment can allow researchers to tap into local knowledge of the anatomy and behaviour of the animals whose mobility they aim to track.

It is worth noting that certain points within a territory may have already been identified as promising locations for camera traps. For example, ritual areas often serve as nodal points of encounter between humans and nonhuman animals, making them fascinating sites for camera trap placement.

In a recent collaborative research project focusing on animal mobility and zoonotic diseases, Nicolas Lainé and Romain Simenel, the two anthropologists in our team, investigated ritual sites and offerings to shed light on their ecological role in interspecific interactions and potential disease transmission. The primary objective was to understand better where the animals that frequented these sacred sites and boundaries fed and foraged. This approach challenges the classical anthropological literature, which views rituals primarily as symbolic means of managing distance and proximity between humans and animals (both wild and domestic) or as tools for defining territorial boundaries between different spaces, such as forests and village areas. The central hypothesis guiding this research was that vegetarian or non-vegetarian offerings have a tangible impact on animals, either repelling or attracting them, which may have sanitary consequences at the human, animal and environmental levels.

At the outset of conducting fieldwork in ritual sites, one question immediately arises: how can researchers account for what transpires at the site before, during or after the ceremony without disturbing the event itself, the negotiation between the divinity to whom the offerings are made and the local population seeking protection or prosperity, and the animals who could quickly become aware of human presence and adapt their behaviour accordingly?

To address this challenge, we developed an innovative approach using camera traps installed at various sacred sites in India and Thailand, a few days before a particular ceremony was to be held. This allowed us to observe what would otherwise be inaccessible. Although camera traps are now widely used as non-intrusive tools in various disciplines such as ethology and conservation, for anthropologists, they represent a new way of expanding ethnography into the realm of digital multispecies studies while upholding one of the significant ambitions of anthropological research: understanding what makes sense locally and accessing the perspectives of others.

Example 1: Crow Day in India

In several parts of northern India, a 3,000-year-old ritual called *Pitr tarpan* is observed on a specific day between the 10-day festival of Ganesha, the elephant-headed remover of obstacles (*Ganesha utsava*) and the nine-night festival of the mother goddess Durga (*Navaratri*). During this ritual, many Hindu men face southward and offer mashed rice balls mixed with black sesame seeds, known as *pinda*, on blades of grass, often near water bodies. They pour water, called *tarpan*, over the *pinda* using the thumb of their right hand, which is stretched outward, away from the body.

This ritual is significant because house crows are encouraged to eat the offered rice. In the state of Himachal Pradesh, it is even believed that on that day one's ancestors are reincarnated in the bodies of crows, which are thus fed during the ceremony. Each family prepares food items placed on gourd leaves, accompanied by incense sticks. It is often customary to imitate the crows' calls to attract

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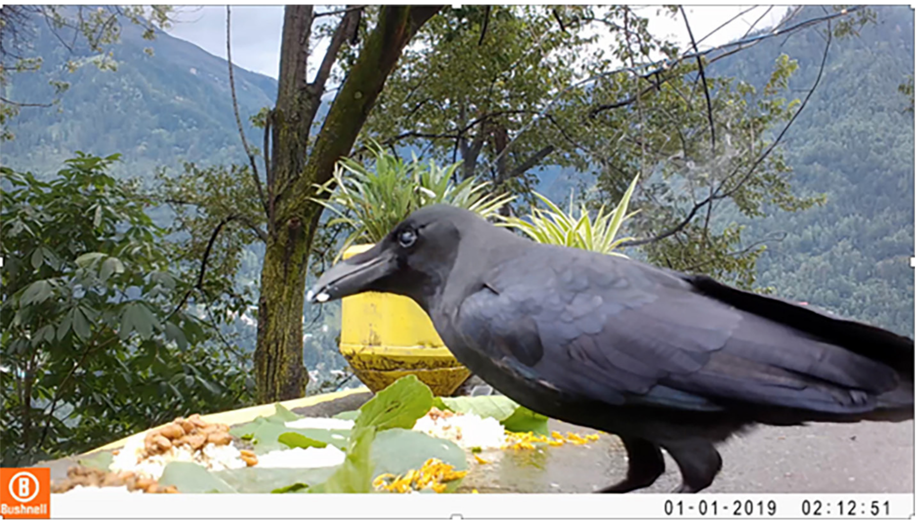
them. However, this may be unnecessary, as the crows are usually present in sufficient numbers to feast on these ritual offerings.

In this case study, a Bushnell Care 24 MP Low Glow camera, automatically triggered by motion detection, was used to record the ritual. The camera was installed just as the offerings were deposited on 7 October 2018, and the total recording time was approximately one hour. During this period, two birds, both crows, visited the site and were captured by the camera. By positioning the camera trap about 20 cm from the offering plate, it was revealed that the burning incense could disturb the crows, often causing them to move away from the smoke to access the food more easily (Fig. 1). Interestingly, the crows did not seem to be bothered by the presence of the camera trap itself, which allowed for convenient observation of their behaviour from a close distance. This contrasts with the typical flight distance of these birds, which is around 10 m, meaning they would typically fly away when an observer approached within this range.

*Example 2: Feeding the spirit (*lieng phi*) in Thailand*

The Lua raise buffalo in the Nan province of Thailand using an extensive farming system. This means the animals spend half the year in the village area and are seasonally released into the adjacent community forest, where they roam freely for months before the monsoon season. To seek protection for their animals, the Lua hold a ritual ceremony at a small altar (*tu phi*) located in the heart of the forest. The ceremony involves several offerings: chicken, flowers, incense sticks, alcohol and rice.

In July 2022, a camera trap was positioned on a tree near the sacred place three days before the ceremony and left in place for one month afterwards. The camera captured several species visiting the holy site, such as a herd of eight cows (Fig. 2) and buffalo, dogs, humans and bats during the ceremony or a few days later. Interestingly, some animals were also captured before the ceremony.



ROMAIN SIMENEL

Fig. 1. *A camera trap image of a crow feeding on an offering of rice, vegetable curry and* dal *(lentil soup) during* Pitr tarpan *in Himachal Pradesh state of northern India.*

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Fig. 2. *In Thailand, a day after a ritual devoted to the spirit of the land, a camera trap captured a small herd of cows around the sacred place.*

It is important to note that in this specific case, the objective was not to count precisely and identify the different species that visited the sacred place before and after the ceremony but rather to demonstrate that *tu phi* is not only a sacred space for villagers but also a place that attracts and brings together a diverse range of forest beings. These beings know human activities and are potentially drawn to the offerings. This observation opens the door for deeper consideration and exploration of the sacred site, allowing for a more nuanced ecological and anthropological interpretation of the presence of animals in this sacred human space.

Speciation of observation techniques

Observation tools like camera traps and GPS collars are increasingly being used to study animal behaviour, but their effectiveness can be limited if they are not adapted to the specific species being observed. Animals respond differently to these technologies depending on their sensory abilities, past experiences and temperaments. The time of day may also affect their experience (Caravaggi et al. 2020). For example, a reindeer may react differently to a GPS collar than a buffalo or an elephant, so it is essential to consider the sensitivity of each species when designing and deploying these tools. Similarly, camera traps can be intrusive, depending on factors like flash intensity (Ladd et al. 2022; Meek & Pittet 2012; Rovero et al. 2013), noise levels (Meek et al. 2014) and human scent (Muñoz et al. 2014).

Some animals, such as mustelids, are known to avoid camera traps as they have a strong sense of smell (Muñoz et al. 2014), while others may be startled or attracted by the device's auditory or visual cues (Meek et al. 2016). Failure to account for these species-specific responses can lead to biased or misleading results (ibid.). To optimize the use of observation tools in animal studies, researchers should aim to 'speciate' them by adapting their design and deployment protocols to the target species' sensory abilities, behaviours and ecological contexts.

Acknowledging the limitations of using camera traps for behavioural research (including individual, collective or interspecies research) is important. The restricted context captured by the images and the potential influence of temporal factors, such as day/night differences, can affect the interpretation of observed behaviours (Caravaggi et al. 2017). Researchers need to exercise caution when analyzing camera trap data and consider the specific context in which the images were captured. Combining camera trap observations with other methods, such as direct observation or GPS tracking, can help provide a more comprehensive understanding of animal behaviour (Frey et al. 2017).

In the coming years, pioneers in ethological technology will likely develop innovative ways to adapt tracking devices to better suit the anatomy and sensitivity of the studied animals. Researchers have several solutions at their disposal to achieve this goal. First, they can use materials familiar to the target species, as this can help minimize any potential disturbance caused by the tracking device. Second, it is crucial to anticipate the type of reaction the species in question might have to the technology used to observe or track them. In some cases, there can be unintended chain reactions, where the camera trap provokes a response from another species, inadvertently attracting the attention of the target species.

For example, the reflection from the protective glass of a camera trap's optics can vary depending on the moon's position and luminosity at the observation time, potentially

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Larrucea, E.S. et al. 2007. Censusing bobcats using remote cameras. *Western North American Naturalist* 67: 538-548.
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Muñoz, D. et al. 2014. Do available products to mask human scent influence camera trap survey results? *Wildlife Biology* 20(4): 246-252.
Natarajan, S. & A. Sinha 2022. Primate performances in a contact zone: Interspecies communication and benefaction in a synurbising forest of southern India. In *Performance at the urban periphery: Insights from south India* (eds) C. Turner et al. London: Routledge.
Oliveira-Santos, L.G.R. et al. 2008. Activity pattern of Atlantic Forest small arboreal mammals as revealed by camera traps. *Journal of Tropical Ecology* 24(5): 563-567.
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causing a more intense reflection. This reflection can have catastrophic consequences for certain species, such as the Northern Cardinal (*Cardinalis cardinalis*). Male Northern Cardinals, in particular, are known to peck at the glass of windows, mistaking their own reflected image for a rival (Klem 1989). The reflection from a camera trap may also attract various species, including certain birds and flying insects. The presence of these insects, in turn, can attract other species that feed on them, creating a cascade effect that ultimately draws the attention of the target species.

To minimize such unintended consequences, researchers must carefully consider the potential impact of their observation tools on the entire ecosystem, considering the complex interactions between species and their environment. By adapting tracking technologies to the specific needs and sensitivities of the animals being studied, researchers can gather more accurate and reliable data while reducing disturbance to the natural world.

A more-than-human vision of the camera trap

Camera traps have become one of the most common image-oriented techniques to enrich our understanding of nonhuman distribution, density, movement patterns and behavioural ecology. What remains largely unexplored, however, is how the other-than-human individuals 'trapped' by these cameras respond to the introduction of such intrusive foreign objects into their lives. Importantly, these responses serve as a more-than-human research methodology, incorporating three interwoven strands (Lorimer 2013; Turnbull & Searle 2022).

The first strand draws attention to the sentient, cognitively mediated behavioural strategies and responses of innovative other-than-human agents as they encounter previously unknown objects of 'human' origin (Hinchliffe 2007; Whatmore 2002).

The second strand suggests that establishing such ontologies yields novel epistemological concerns as we shift our focus from the implicit cognitive and representational underpinnings of other-than-human behaviour to those more evocative of affect, embodiment or performance. These represent distributed forces and capabilities that cut across human-nonhuman categories and their divides (Natarajan & Sinha 2022; Thrift 2007).

The third strand proposes that such methodologies give rise to a new body of politics and ethics, stemming from our newfound understanding and acceptance of other-than-human agencies and diverse intelligence, increasingly sympatric with us in the Anthropocene.

The emergence of this affective body of micropolitics and ethics compels us not only to confront our position in the ecospheres we co-inhabit with other beings but also to reconsider how we can facilitate their survival and well-being and, in the process, our own (Barua & Sinha 2019).

Like many other intelligent beings, elephants possess cognitive capabilities that enable them to perceive, interpret and respond appropriately to their surroundings, particularly in their gradually urbanizing environments (Srinivasaiah et al. 2022). In our long-term studies across a human-dominated landscape spanning the states of Karnataka and Tamil Nadu in southern India, we have explored the behavioural responses of approximately 300 individual elephants to the rapid changes in their socio-ecological environments brought about by human presence, activities and artefacts. In what follows, we examine the behavioural reactions of two male elephants in our study, Tintin (a young adult) and Sam (an adolescent), to the camera traps in their environment through the lens of the cognitive processes that potentially underlie their complex responses to these foreign objects (Figs 3-7).

Our interpretation of the observed behavioural responses of the elephants to the camera traps was based on the ad-libitum sampling method, a behavioural study technique typically used to record rare occurrences of behavioural states or events during direct observational studies of non-human species (Altmann 1974). The behaviours analyzed here were categorized according to an ethogram listing 104 observed behaviours of Asian elephants in this landscape, which were classified into different behavioural response types, such as affiliative, agonistic, self-directed and audience monitoring, based on their performance in different social contexts and as evident from systematically recorded camera trap images (Srinivasaiah 2020).

When these two individuals first encountered the camera trap and were startled by the flash, their initial reaction was to retreat. This was likely rooted in previous negative experiences of human presence. We believe that this response could be attributed to fear conditioning, wherein humans and nonhumans potentially learn to associate certain neutral stimuli – in this case, the flash – with adverse outcomes based on past encounters – here, being chased by people. They then begin to actively avoid the neutral stimulus (LeDoux 2000).

Subsequent images of the elephants, however, showed them turning back to face the camera and touching their faces with their trunks, indicating a state of ambivalence. Tintin and Sam appeared to be processing conflicting information and attempting to comprehend the situation better. Given their complex cognitive abilities and emotional intelligence, elephants seem to possess the ability to weigh the different elements present in a particular – often novel – context, based on the perceived value or significance of each component, and make certain decisions, typically involving a set of affective and cognitive processes that would perceptually evaluate the situation in terms of these elements (Phelps & LeDoux 2005).

In this case, more specifically, Tintin and Sam's ambivalent behaviour could reflect such an evaluative process, wherein they actively assessed the potential threats posed by the camera trap, integrating – in the process – their past experiences with humans, their understanding of the current environment and their innate instinct for self-preservation. Elephants have indeed been observed to exhibit a high level of such situational awareness, in which they perceive and assess the various stimuli in their immediate environment, recognize relevant cues, anticipate future events based on their assessment and make appropriate decisions, typically involving a set of coordinated cognitive processes (Dall et al. 2005).

The selected images aim to illustrate the process of habituation and learning in elephants despite the day/night differences. Similar behavioural patterns were observed across different temporal contexts, suggesting that the elephants' interactions with the camera traps were not solely dependent on diurnal or nocturnal factors.

After multiple encounters with the camera trap without experiencing any adverse effects, Tintin and Sam's cumulative cognitive processing possibly led to a shift in their responses (Figs 5-7). They began to increasingly make eye contact with the camera without any evident ambivalence, indicating a probable change in their mental model of a newly established environmental reality. This relatively long-term adaptive change suggested the emergence of a cognitive state of ultimate habituation, wherein repeated exposure to the same stimulus led to its initial response diminishing over time (Blumstein & Daniel 2005). Through this process, Sam and Tintin gradually incorporated the camera trap into their perceived reality of a time-space continuum. They adjusted their behaviour accordingly as they now understood that the camera trap did not threaten them.

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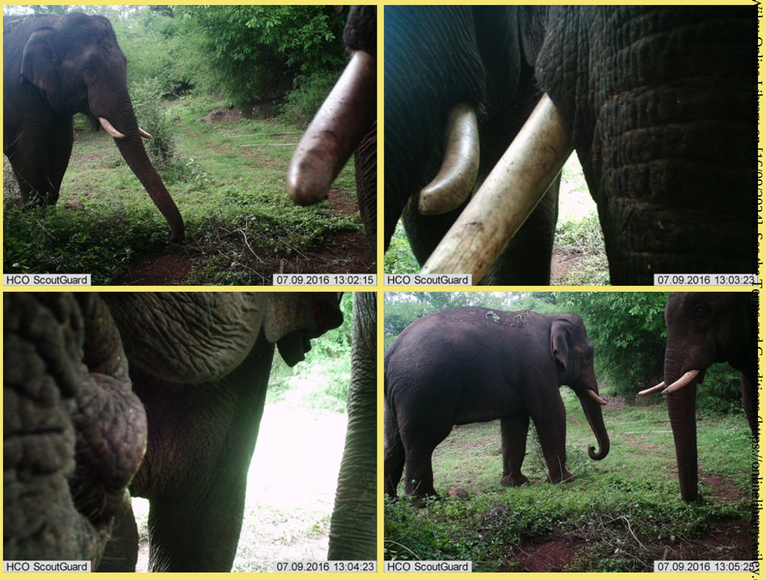

(From left to right, above to below)

(Photo credits: Nishant M. Srinivasaiah).

Fig. 3. *(A) The flash of the camera trap possibly reminds Tintin of the flashlights that farmers use to chase him away from their crop fields; (B) he beats a hasty retreat, only to realize that the flash is not followed by people chasing him; (C) he then turns around to engage with the camera.*

Fig. 4. *(D) Tintin seems unsure and shifts his weight from one leg to the other; (E) after a while, he displays his irritation by biting his trunk; (F) he finally walks past the camera without interacting with it any further.*

Fig. 5. *(G) On the next day, Sam arrives in front of the camera; (H) he seems to wonder about the novel alien object placed on a tree; (I) he initially turns around and moves away from the camera; (J) he then turns around to face the camera and walks past it at proximity.*

Fig. 6. *A few days later, both Tintin and Sam visit the camera trap once again, repeatedly interacting with it curiously, even touching it with their trunks, and finally, they move on, leaving the camera behind.*

Fig. 7. *Ten days later, Tintin and Sam approach the camera trap again, and Sam takes a long, final look at it before moving on.*

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Overall, the cognitive underpinnings of Tintin and Sam's behavioural responses to the camera trap involved gradually incorporating many cognitive processes, including fear conditioning, evaluative processing, situational awareness and ultimate habituation to a temporarily predictable socio-ecological reality. These cognitive capabilities enabled them to perceive, interpret and finally adapt to the presence of the camera trap in their environment, allowing them to navigate and respond to a novel stimulus that was initially assumed to threaten their survival in an unfamiliar and perplexing environmental situation.

The camera trap as an agent of change

The behavioural responses of Tintin and Sam to the camera trap may also be analyzed using the framework of Actor-Network-Theory (ANT) (Latour 2007). ANT views human and nonhuman entities as actors shaping social interactions and constructing an active perception of reality. Haraway's (2008) philosophy, which reflects the traditional beliefs of many Indigenous Australasian societies, complementarily emphasizes the interconnectedness of all beings – human and nonhuman – thus challenging more traditionally restrictive Western notions of identity and agency. ANT would suggest that the camera trap was not simply a passive object but an active participant in its interactions with Sam and Tintin, shaping their perceptions and cognitive-behavioural responses through its active presence and actions during these unique interactions. The camera trap thus becomes entangled in a network of relations that extends beyond the human/nonhuman dichotomy.

Here, the initial response of the elephants to the camera trap, triggered by its flash, can be understood as a reaction to the camera's agency, which, as an actor, disrupted the elephants' routine and invoked a sensation of fear in them. Probably influenced by prior experiences with humans, Sam and Tintin's responses to the camera trap – an agent that carries the symbolic weight of human presence and its potential threat – were thus not solely driven by their innate instincts but also shaped by their interactions with a more-than-human world. The subsequent response of ambivalence, expressed by both, possibly represented their attempts to negotiate their upcoming relationship with this more-than-human actor.

In contrast, their subsequent actions, turning back to face the camera and touching their faces with their trunks, could reflect an engagement with the camera as an active participant, a cognitively mediated expression of their perceptual and evaluative recognition of the camera trap's newfound significance within their environment. It is important to note that the camera trap – a technological device used for monitoring and surveillance – reflects human attempts to control and dominate the natural, more-than-human world (Simlai & Sandbrook 2021). Here, Tintin and Sam's response to it can thus also be construed as a negotiation of power dynamics as they navigated the presence and influence of new human technologies in their habitat. Finally, their repeated encounters with the camera trap allowed them to gradually learn to incorporate it into their mental model of changing reality. The camera trap thus became integral to their perceived environment, suggesting a shift in their understanding of what constitutes their essential socio-ecological world.

Conclusion

As demonstrated in the various experimental projects presented above, placing a camera trap is not a trivial act; it has multiple impacts that, if they are to be anticipated, require a consideration of all the ecosystem dynamics and sensitivities of the species that researchers are attempting to observe. This is where local knowledge becomes essential, as local populations are familiar with the behavioural and sensory differences between the species they encounter daily. The case studies from India and Thailand highlight the significance of ritual occasions in shaping human-animal interactions and the potential for camera traps to provide new insights into these dynamics. By capturing the behaviour of crows during the *Pitr tarpan* ritual in India and the presence of various animals at the *tu phi* altar in Thailand, the camera traps revealed the complex ways human practices and beliefs intersect with animal activity in sacred spaces. These examples underscore the importance of considering the sociocultural context in which human-animal interactions occur and the value of ethnographic knowledge in informing camera trap placement and data interpretation.

However, it is important to acknowledge the limitations of camera traps and the potential biases they could introduce. For example, camera traps may not capture the full context of an animal's behaviour or may influence the behaviour itself through their presence. Additionally, the placement of camera traps and the specific technologies used can affect the data collected. Researchers must be mindful of these limitations and work to mitigate them through careful study design and data analysis.

Despite these challenges, camera traps offer exciting possibilities for interdisciplinary research. They could be employed beyond conservation, biology and ethology as a tool for humanities and social science researchers to engage in dialogue across disciplines. This present exploratory article, involving anthropologists, ecologists and primatologists, exemplifies the potential for such multidisciplinary collaboration. Nevertheless, using camera traps effectively requires the development of robust methodologies for analyzing the pictures taken, especially sequences of images. Compared with interpretations from direct human observation typically made by ethnographers in their field sites, cameras only capture specific (and limited) angles and views. Considering the observable and relatively restricted context, caution is required when interpreting the pictures.

To build on this article's insights, future research could explore the use of camera traps in a wider range of cultural and ecological contexts, investigating how animals in different environments respond to and interact with these technologies. Developing new analytical techniques, such as machine learning algorithms for automated image processing, could also help address some of the methodological challenges associated with camera trap data. Collaborative projects that bring together researchers from diverse disciplinary backgrounds could further enhance our understanding of the complex relationships between humans, animals and technology.

Moreover, engaging with different philosophical perspectives allows for a deeper understanding of the cognitive underpinnings of animal behavioural responses and adaptations to the camera trap. Challenging the Western scientific dichotomies between humans and nonhumans encourages researchers to consider the sociopolitical implications of escalating human interventions in the structure and functioning of 'natural' worlds. Understanding the cognitive-behavioural processes – human and other-than-human – contributes to a more nuanced comprehension of the complex interactions between humans, nonhumans and technology in constructing a reality which is now far more threatening than ever before. By continuing to explore these issues through innovative research approaches and interdisciplinary dialogue, we can work towards a more holistic and ethical understanding of how technology shapes our relationships with the more-than-human world. ●

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