Eavesdropping on Prey Alarm Calls to Detect the Presence of Predators

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Jungle chatter:
Eavesdropping on prey alarm calls to detect the presence of predators

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Abstract

Encounters between humans and large predators result in several human deaths each year, which erodes local support for large predator conservation, despite many large predator species being endangered or critically endangered. We describe how eavesdropping on the communication of different species can help to detect tigers and alert people to their presence. While tigers sometimes produce loud and distinctive roars, they do not produce sufficient vocal events to be tracked acoustically. However, tigers pose a danger to other animals and these animals reliably produce alarm calls in their presence, and forest rangers commonly use these alarm calls to locate tigers in the field. We tested the responses of prey species in the Terai region of Nepal to an artificial tiger model and used automated detection of chital deer (*Axis axis*) alarm calls to generate a heatmap of tiger presence, which can be used to alert villagers of areas of increased risk of tiger encounters.

Index Terms: alarm calls, automatic detection, human-wildlife conflict, interspecific eavesdropping, tigers

1. Introduction

Tigers (*Panthera tigris*) are a keystone species that are fundamental to maintaining balance and supporting biodiversity in ecosystems but are listed as Endangered throughout their range [1]. Although tiger populations have been increasing in Nepal in recent years, this recovery is threatened by escalating conflicts with humans over attacks on humans and livestock, leading to 32 human fatalities between 2007-2014 [2]. Local populations that use the forest as a subsistence resource suffer the bulk of tiger attacks but remain generally supportive of tiger conservation. Knowing precisely where tigers are present could help prevent some of these conflicts and in turn help to facilitate coexistence between humans and tigers. However, due to their solitary nature and large home ranges, tigers are notoriously difficult to locate and track. Existing options for monitoring tiger movements include GPS tracking and the use of camera traps, but GPS collars are invasive and costly, requiring capturing and sedating individual tigers, and camera traps can only survey a small area in front of individual cameras so can easily miss detecting tigers when they are present. As such, non-invasive methods that can monitor tiger presence over large spatial scales and alert in near real-time, would be invaluable to help those living alongside tigers to make informed decisions about when it is safest to enter the forest or when they need to move or guard their livestock.

The forest is, however, home to many prey species that have evolved natural vigilance behaviors to protect against tiger predation. In particular, certain species of deer and monkeys, particularly chital deer (*Axis axis*), gray langurs (*Semnopithecus schistaceus*), and rhesus macaques (*Macaca mulatta*), issue loud alarm calls when a predator is spotted [3], [4], and this complex interspecific assemblage of vocalizations can be used to assess the risk of tiger presence. In fact, nature guides and forest rangers routinely listen for prey alarm calls to alert them to the presence of large predators. Our ongoing project aims to combine this local knowledge and evolutionary behavior of animals with advancements in technology to create risk maps of tiger presence in an area. By eavesdropping on the alarm calls of prey species and using their naturally evolved response to predators, automating and computerizing detections, and translating this into a central digitized interface where tiger risk can be visualized, we can convey this information to at-risk populations such as local villagers foraging in the forests.

Passive acoustic monitoring (PAM) is a growing field in wildlife research, providing the ability to gather large amounts of data on animal behavior and distribution in a non-invasive way [5]. Autonomous recording devices are deployed across a landscape and record audio continuously if necessary, or at scheduled times of day. Previous studies have demonstrated the effectiveness of PAM in monitoring landscape use, interspecific interactions, and conservation priorities for a wide range of terrestrial species [6], [7], [8]. However, acoustic monitoring is only effective where a species vocalizes regularly, and at a volume that makes detection on a grid of monitoring devices realistic. Although social predator species such as wolves vocalize to maintain social links between individuals [9], many predator species remain largely silent in an attempt to avoid detection by prey. Tigers, in particular, vocalize loudly, but only in territorial contexts, and only rarely [10]. Therefore, tracking tigers using PAM must rely on the vocal responses of other species to tiger presence.

Here we present the results of a development project in which we deployed PAM devices with onboard automatic detection of chital deer alarm calls in forests in the Terai region of southern Nepal, with a high risk of tiger-human conflict. Each device, based on the open-source CARACAL hardware [11], also uses a sub-Gigahertz radio to communicate with a base station, which gathers alarm vocalization events and generates a heat map indicating the risk of tiger presence, based on the frequency and intensity of alarm calls.

To determine whether prey species alarm calls are reliably generated in response to tiger presence, we presented an artificial tiger model to chital deer, grey langurs, and rhesus macaques, and recorded their vocal responses. We also monitored the vocal activity of these species in the absence of tiger presence, and our findings strongly suggest that prey alarm calls can be used as a reliable indicator of the prey species' perception of predator risk.

2. Methods

With the support of the local community, this study was carried out in the Dalla (28.40421° N, 81.22958° E) and Khata (28.36813° N, 81.21630° E) community forests around Bardia National Park in southern Nepal (Figure 1). Community forests provide the opportunity for villagers to perform traditional foraging tasks such as collecting firewood and grazing livestock, which maintains a productive balance in the natural ecosystem [12], but exposes them to injury from wildlife. Management of the forests is performed by local trained rangers employed by the national Forestry Department. Rangers are also tasked with monitoring for the presence of tigers and other potentially dangerous species such as leopards (*Panthera pardus*), rhinos (*Rhinocerous unicornis*) and elephants (*Elephas maximus*). The forests are dominated by sal (*Shorea robusta*), and kamala (*Mallotus philippensis*) [13], with various grass species (e.g. *Tripidium bengalense*) collected by villagers for traditional uses [14].

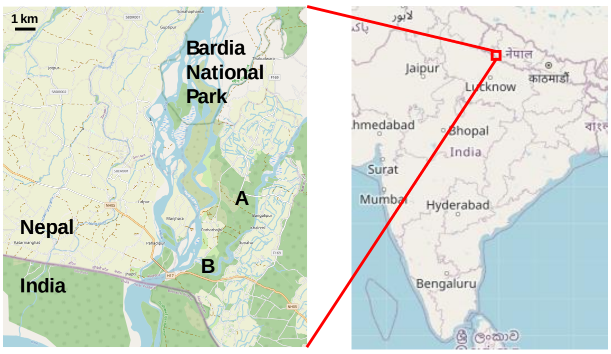

Figure 1. *Map of the study area, showing (A) Dalla Community Forest, and (B) Khata Community Forest.*

We deployed 10 CARACAL acoustic recording devices in each of the forests during December 2023 and March 2024. The devices were placed ~100 m from one another. Each CARACAL device is equipped with four MEMS microphones for beamforming to determine direction of arrival of sound signals, and integrated GPS clock synchronization for localization of sound sources using multilateration. For this project, we added an 868 MHz LoRa radio transmitter (iLabs Challenger RP2040, Invector Labs, Tomelilla, Sweden) that transmitted information on alarm detections every 30 seconds (Figure 2).

Figure 2. *A CARACAL acoustic recording device deployed in the Dalla community forest.*

All three focal prey species produce predator alarm calls; however we ultimately focused our system on the chital deer alarm call. The chital deer alarm call [3] is loudest and most characteristic (Figure 3), being a strongly modulated narrowband chirp between 0.75 and 1.25 kHz.

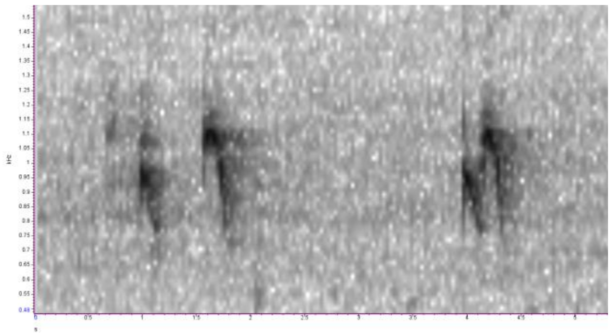

Figure 3. *Spectrographic representation of chital deer alarm calls, showing their characteristic 0.75 – 1.25 kHz chirp.*

Rhesus macaque alarm calls [4] (Figure 4) are noisy, broadband sequences lasting 1-5 seconds and given repeatedly. Each call is a series of short pulses (about 200ms).

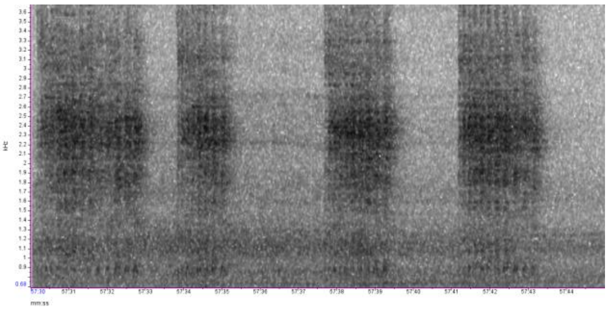

Figure 4. *Rhesus macaque alarm calls, being a series of short pulses, repeating in sets of 1-5 seconds length.*

Grey langurs produce shorter, single alarm calls [3] (Figure 5), each about 200ms in length, very broadband (with significant energy well beyond the 8 kHz Nyquist limit of our recordings), but with a concentration of energy in a chirp at similar frequencies to the chital call.

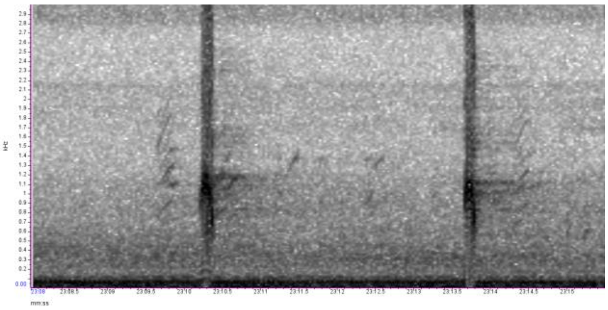

Figure 5. *Langur alarm calls, very broadband short bursts.*

We verified that these alarm calls were given in response to tigers by presenting wild chital deer with a tiger model in the form of a faux tiger skin (https://www.vidaxl.co.uk/e/vidaxl-tiger-carpet-plush-144-cm-brown/8718475509172.html), draped over one of the researchers. Previous studies have shown that prey animals respond strongly to artificial predator models [15].

For the experimental protocol, we first identified groups of the focal prey animal who were showing normal (non-stressed) behavior and who were close to the side of the road. One of the researchers would then descend from the vehicle and hide while putting on the tiger costume. They would then slowly approach the animals through the forest, attempting to imitate the motion of a tiger. (Figure 6). A presentation was considered successful if the animals did not bolt before seeing the tiger model. The predator presentation continued for 15 minutes, or until the prey animals had left the area. During this time, another researcher was recording the prey animal responses on a DR-44WL handheld recording device (TASCAM, CA, USA) with an AT8035 shotgun condenser microphone (Audio-Technica, OH, USA) at a 16kHz rate.

Figure 6. *Presentation of a faux tiger model to chital deer.*

3. Results

In total, we attempted 61 presentations to prey groups. In some of these cases (19.6%), the animals spotted us preparing the experiment and fled without making any vocalizations, leading to the presentation being aborted. However, we succeeded in carrying out 7 predator presentations to chital deer, 5 to macaques, and 2 to langurs. In each of these successful cases (100%) where the animals saw the tiger model before bolting, they produced characteristic alarm calls.

In addition to the 12 aborted predator model presentations, there were numerous occasions in which the prey animals encountered the researchers moving through the forest without the tiger costume. We succeeded in carrying out 14 human presentations to chital deer, 10 to macaques, and 11 to langurs. In all but one of these cases, the animals remained silent. There was one instance of a chital deer calling to a human, but in that case, the deer also saw the rest of the research team with shotgun microphones and camera equipment.

In total, the CARACAL devices recorded approximately 2800 hours of audio, of which, approximately 1300 hours has been analysed manually to date. Using the CARACAL devices recording ambient sound passively (i.e. without predator model presentations), chital alarm calls were recorded at a rate of approximately 0.1 per hour during the daytime hours, macaques 0.14 per hour, and langurs 0.008 per hour.

4. Discussion

Our results showed that a predator model is an effective way to elicit alarm calls in the target prey species, and that the alarm calls are highly specific to predator presence, as determined by the artificial model. This is a strong indication that interspecific eavesdropping allows humans to infer predator presence from prey alarm calls.

We did not have the opportunity to witness prey interactions with real tigers, however this is not surprising as such events are difficult to predict and infrequent. Nonetheless, the alarm calls generated by the predator model are acoustically very similar to opportunistic recordings made by local wildlife guides of prey alarm calls heard in the case of real encouters of prey with predators. Moreover, the use of prey alarm calls by rangers and wildlife guides is a strong indication that these are reliable signs of predator presence.

The absence of alarm calls in response to humans, while not unexpected given the specificity of many animal predator alarm calls [16], [17], [18], is an encouraging sign when designing a predator warning system for local people. The system must detect areas that prey animals consider high risk from predators, while not identifying areas as "dangerous" where humans themselves are the only potential predators present.

Specificity of the prey alarm calls to tigers is difficult to determine. Leopards also prey on both monkeys and deer, and it is likely that the prey animals do not distinguish in their alarm calls between different types of big cats. However, as leopards also pose a threat to humans working in the forest, the alarming of prey species in response to leopard presence is an advantage, rather than a disadvantage.

Preliminary analysis of the CARACAL recordings indicates that alarm calls are relatively infrequent, meaning that any warning system based on prey alarm calls is unlikely to be rendered unhelpful by being overwhelmed by large numbers of calls. The ability of the CARACAL to localize the sound source is an additional potential strength, as it would allow alarms to be further validated by their spatial correlation between recording devices.

Any future warning system will rely on effective automatic detection of alarm call on the CARACAL devices. Our project is currently testing such a system, which, combined with the remote notification through sub-GHz radio, will allow the deployment of a widespread and novel tool to prevent loss of human life and enhance conservation efforts.

5. Conclusions

We have shown using a faux tiger model that three prey species - chital deer, grey langurs, and rhesus macaques - respond reliably to perceived tiger presence with distinctive alarm calls, which can be monitored and interpreted by humans to build a broadly deployed warning system to identify areas of high tiger risk, and to warn local villagers of areas of the forest to avoid.

In the next implementation of our system, we plan to deploy a first of its kind, fully-operational pilot system in southern Nepal, which will use the communication of other animal species to inform humans of potentially dangerous predator presence in the forest.

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