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Cover: Oil painting of Humpback Whale *Megaptera novaeangliae*. © R. Mahesh.



Large mammal diversity of Vietnam's Chu Yang Sin National Park and the first experimental assessment of their vulnerability to snaring

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Abstract: The Annamite Mountains of Indochina have high mammal endemism but also face a mammalian extinction crisis, primarily from the indiscriminate use of snares. Chu Yang Sin National Park in the southern Annamites of Vietnam is one of the few forests in Vietnam where the Critically Endangered Annamite endemic Large-antlered Muntjac is predicted to be present. The objectives of this study were to experimentally investigate and quantify the relative impact of snaring on local mammal populations by using camera trapping, with a focus on muntjac, and to provide a checklist of the large mammal species of the park. In 2020, a preliminary survey was executed to determine a study site in the park by observing the prevalence of signs indicative of large mammals. From December 2020 to February 2021, a 515-m long simulated continuous snare-line was constructed at the study site by five experienced local hunters. Camera-traps were then set up along 240-m of the snare-line to monitor animal movement. A total of 4,747 working camera-trap nights were logged and recorded the Large-antlered Muntjac and 10 other large mammal species along the snare-line. It was found that the Large-antlered Muntjac was more vulnerable to snares relative to the other mammals detected, exhibiting the highest probability of being 'captured' by a snare if an individual animal encountered the snare-line ($p = 0.67$). The finding suggests, as already theorized, that prolonged exposure to a snare-line will greatly reduce local large mammal populations, because with repeated encounters by an individual animal, the probability of capture increases close to $p = 1$. The study demonstrates here for the first time how some species are potentially more susceptible to snaring than others. Building on the experimental approach, future research could yield new insights into managing snare hunting more efficiently, using more data from other locations and over longer periods.

Keywords: Annamite Mountains, snare, Large-antlered Muntjac, tropical forests, Indochina, camera-trapping, poaching.

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INTRODUCTION

Southeast Asia has some of the richest biodiversity in the world (Hall 1998; Sodhi et al. 2010). It encompasses four of the 25 global biodiversity hotspots (Myers et al. 2000), and harbors one of the highest proportions of country-endemic mammal species (Sodhi et al. 2010). The Annamite Mountains of Indochina are perhaps best known for their particularly high levels of mammal endemism. This region has seen many extraordinary recent discoveries of large mammals (Coudrat 2022). Despite receiving significantly increased attention to conservation over the past few decades, continued survey and research efforts are needed to thoroughly investigate and monitor the ecosystems of the Annamite Bioregion (Hughes 2017).

The biodiversity of the Greater Annamites Ecoregion is experiencing a severe mammal extinction crisis; it also currently has the highest proportion of threatened species globally, many of which are large mammals (Conrad 2012; Duckworth et al. 2012). Forming much of the border between Vietnam, Laos, and Cambodia, the Annamites have been experiencing high-intensity illegal hunting, which is almost singularly driving the depletion of the region's large mammal populations; consequently, this is causing the spread of "empty forest syndrome" (Corlett 2007; Duckworth et al. 2012; Harrison et al. 2016). Given that illegal hunting is behind these current population declines (Rija et al. 2020), improved knowledge around how it impacts large mammals differently may be critical to developing effective and nuanced management responses and more effectively deploying law enforcement.

Large mammals (following the list noted by Duckworth et al. 1999) are hunted by many means, but primarily ground-dwelling large mammals are mainly hunted in the Annamite Mountains using snares, which can be categorized as primarily "opportunistic/passive", based on the way hunters use them (Harrison et al. 2016; Dobson et al. 2019). Snares are widely employed across large areas of tropical forests in the Annamite Mountains to meet the intensive demand of domestic and international trade markets (Duckworth et al. 2012). They are easily made from readily available cable wires, cheap to make and deploy, resilient for months in the forests, require less effort and skill than using a gun (per unit of catch), are hard to detect, and can be indiscriminate in what species they catch (Harrison et al. 2016; Gray et al. 2018; Dobson et al. 2019). The use of snares can be particularly effective when combined with simple "drift fences" made from forest undergrowth,

which leads to a "snare-line" of alternating fences and "snare-gaps" (O'Kelly et al. 2018). Snare-fences function as a channeling device, encouraging animals to 'seek' the 'gaps' as a way to pass through the fence, and thus encounter the actual snare strategically placed in the 'gap'. Each local hunting team might create several kilometers of these snare-lines, altogether incorporating hundreds of snares (Harrison et al. 2016). Despite this massive effort, many animals that get caught are left to die and rot, especially when snares are not checked in a timely way or ultimately abandoned by the hunters (Gray et al. 2017, 2018). Somewhat counter intuitively, snares have been found to be used more intensively in very depleted forests relative to those with more intact fauna as a way to catch any remaining wildlife in the area (Branch et al. 2013); although this may not be a widespread phenomenon, especially in the Annamite Mountains. Among those cultures where hunting rare wildlife is celebrated, and the established norm is that "wild meat is healthier than domestic meat", this extinction driver can be a particularly serious challenge to overcome (Brodie et al. 2009; Drury 2009; Dobson et al. 2019). The primary driver challenging effective solutions to snaring in the Annamite Mountains is poor legislation and poor enforcement due to a paucity of government resources and capacity.

In this study, we conducted the very first experimental effort to investigate the impact of snaring on large mammal species in the context of events occurring at a snare line. A checklist of large mammal species is presented for Chu Yang Sin National Park (NP), a critically important protected area located in the southern Annamite Mountains range of Vietnam.

Abbreviations: CR—Critically Endangered | CT—Camera-Trap | EN—Endangered | LC—Least Concern | MTAN—Minh Thi Anh Nguyen | NP—National Park | O—Observation | $p(C/Cr)$ —the probability of capture by the theoretical snare noose if the animal crossed the snare-gap, as a function of all snare-gap crossing events for a species | $p(C/E)$ —the probability of capture by any theoretical snare-noose if the animal was detected along the snare-line (snare-line encounter event), as a function of all snare-line encounter events for a species | $p(Cr)$ —the probability of crossing the snare-gap if the animal encountered (was camera-trapped adjacent to) the snare-gap, as a function of all snare-gap encounter events for a species | $p(E)$ —daily encounter rate with the snare-line for a species | $p(Sn/E)$ —the probability of encountering at least one snare-gap if the animal was detected along the snare-line, as a function of all snare-line encounter events for a species | VU—Vulnerable.

MATERIALS AND METHODS

Study Area

Chu Yang Sin NP covers an area of 590 km² in southeast Dak Lak Province in southern Vietnam with elevations ranging from less than 600 m to 2,442 m at the summit of Mount Chu Yang Sin (BirdLife International 2010) (Image 1). It is part of an extensively forested landscape in the southern Annamites, and is connected to several other protected areas, such as Bidoup–Nui Ba National Park to the south. Chu Yang Sin NP harbours exceptionally high biodiversity: its diverse forest types are home to at least 65 mammals, 250 birds, 112 amphibians and reptiles, 81 fish, and 248 butterflies species (BirdLife International 2010). Chu Yang Sin NP is one of only a few areas in Vietnam that may still hold a viable population of Large-antlered Muntjac *Muntiacus vuquangensis*, a 'Critically Endangered' (CR) ungulate endemic to the region (Timmins et al. 2016). Although there had been no further records of the species in

the park since 2009, there had also not been sufficient survey effort in the intervening period. It was believed that extensive suitable habitat, and its connection with large, protected forested areas, would have helped increase the probability that Large-antlered Muntjac persist in the park. It was also determined that for this reason, Chu Yang Sin NP was a potential site for the present study on the impact of snaring, with a particular focus on the species.

Snare experimental design

From 27 August to 02 September 2020, Minh Thi Anh Nguyen (MTAN) conducted a pilot survey to identify a field site inside Chu Yang Sin NP for the experimental snare-line project. The survey involved walking a 58 km route spanning various habitats at elevations ranging 750–1,300 m to record large mammal signs. Positive indications included direct species observations, frequent sightings of fresh tracks, and a diversity of track types, reflecting the presence of a diverse assemblage

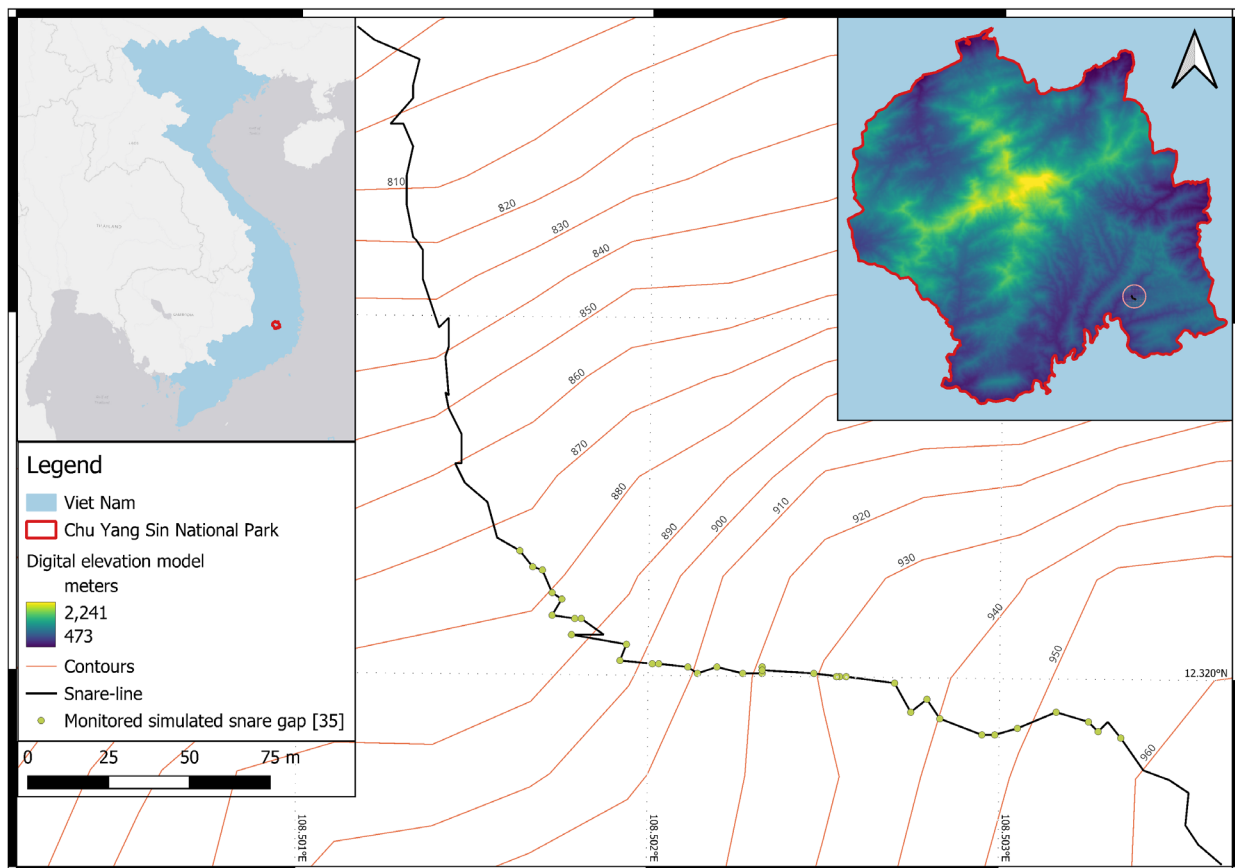


Image 1. Location of Chu Yang Sin National Park and the study site. The location of the simulated snare-line within Chu Yang Sin National Park is shown in the upper right inset; note shading reflects elevation with yellow highest and purple lowest. The simulated snare-line (main figure) was in reality relatively straight with regular placement of snare-gaps, but errors in GPS location coordinates give rise to an irregular alignment and placement of snare-gaps in the figure; all snare-gaps were at least 10 m apart. Scale bar and coordinates relate to the main figure only.

of mammal species. From 10–18 December 2020, work was conducted with local communities to identify five experienced hunters and learn about their snaring methods. At the field site, each hunter independently walked us through what a “real snare-line setup” would entail, even though no actual snares were ever set. Hunters explained how and where to set up the snare-line and snares, and this information was carefully recorded. Following this, all the hunters were asked to agree on where to place a single snare-line (Image 1). A typical snare-line, of alternating snare-fence and snare-gaps, but without actual snares, 515 m long, with 70 snare-gaps, was then constructed by the hunters. 101 camera-traps (Covert illuminator) were deployed along 240 m of the snare-line, beginning at the 28th snare-gap from the starting location of its construction. Two camera-traps in video mode, one on either side of the snare-line were used for monitoring animal movement at 35 consecutive snare-gap locations along the snare-line. The remaining camera-traps in photo mode were used to monitor animal movement along the snare-fence between snare-gaps; one camera between successive snare-gaps, with cameras alternating between the two sides of the snare-fence. This setup allowed us to understand which species encountered the snare-line, and whether, once encountering the snare-line, an individual animal subsequently crossed the snare-line through a snare-gap (or not), and whether (if they crossed) they would have been captured (or not) by putting a foot within the simulated (theoretical) snare-noose. All camera-traps were active between 18 December 2020 and 03 February 2021 (a total of 4,747 camera-trap nights, 47 camera-trap nights for each camera-trap unit). Consecutive photo and video captures less than 30 min apart for the same species, at any camera-trap location, were treated as a single snare-line encounter event. If there was more than one animal in a photograph or other evidence indicating the presence of two animals in the event, the single event was divided into a number of events equal to the number of animals. Note, there was no evidence of detections of individual animals at impossibly distant locations in quick succession, which would have indicated the presence of spatially separated individual animals being counted as a single event. The impossible distance is defined as the scenario where two photos taken within a 1-min interval cannot be captured by two cameras positioned more than 30 m apart. The exception to this was macaques, which proved problematic because they occur as groups of multiple individuals; thus, a minimum number of certainly different individuals were recorded in an event.

But this is probably an underestimate of the number of actual individuals present at an event. This allowed us to calculate the daily encounter rate with the snare-line $p(E)$ for an individual animal of each species as the total number of events divided by 47 camera-trap nights.

For analysis of capture probabilities resulting from snare-line encounter events, the following protocol was used. For each snare-line encounter event (i.e., captured by any camera-trap adjacent to the snare-fence and or snare-gap within a 30-min period), the outcome of an individual animal’s interaction with snare-gaps, and the simulated (theoretical) snare-noose at each snare-gap, was recorded. This included recording how many snare-gaps the animal encountered (snare-gap encounter event), and for each one, recording firstly whether it crossed the snare-gap (with potential outcomes recorded as - yes/no/unclear), and secondly, if it did cross the snare-gap, whether it put a foot within the simulated (theoretical) snare-noose (with potential outcomes recorded as — yes/no/unclear). In one snare-line encounter event, an individual animal might cross snare-gaps multiple times; for this analysis, each was counted as an independent ‘snare-gap crossing’ event, and for each such event, the outcome with regard to putting a foot within the simulated snare-noose was recorded. In the rare event of an animal crossing a snare-gap, and then subsequently in the same event recrossing the very same snare-gap (from the opposite side of the fence), this was treated as an additional snare-gap encounter event, with the outcome relative to the simulated snare-noose recorded for that event. Probabilities of theoretical capture in the simulated snare-noose $p(C/E)$ were thus calculated as:

$$p(Cr) = \frac{\text{Total number of times the species crossed snare - gaps for all snare - line encounter events}}{\text{Total number of snare - gaps the species encountered for all snare - line encounter events}}$$

$$p(C/Cr) = \frac{\text{Total number of times the species stepped into the simulated snare noose (was captured) for all snare - line encounter events}}{\text{Total number of times the species crossed snare-gaps for all snare - line encounter events}}$$

$$p(Sn/E) = \frac{\text{Number of snare - line encounter events the animal encountered at least one snare-gap}}{\text{Total number of snare - line encounter events}}$$

$$p(C/E) = p(Sn/E)p(Cr)p(C/Cr)$$

where $p(Cr)$ is the probability of the animal crossing the snare-gap if the animal encountered (was camera-

trapped adjacent to) the snare-gap; $p(C/Cr)$ is the probability of capture by the theoretical snare-noose if the animal crossed the snare-gap; $p(Sn/E)$ is the probability of the animal encountering at least one snare-gap per snare-line encounter event; $p(C/E)$ is the probability of being captured by the theoretical snare-noose per snare-line encounter event.

RESULTS AND DISCUSSION

Species detected

A total of 4,747 working camera-trap nights identified a total of 27 species of birds and mammals along the simulated snare-line; 11 of these were large mammals (excluding squirrels and treeshrews), two of which are classified as 'Vulnerable' (VU), and another as CR (Table 1). In addition, on 02 September 2020, during the pilot survey, a group of Black-shanked Douc *Pygathrix nigripes* was observed at 12.31° N, 108.56° E at 0700 h, and a male Stump-tailed Macaque *Macaca arctoides* killed by a real snare-line in the study area (Image 2) was brought back to the camp by team members, but neither species were captured by the camera-traps.

Although we only surveyed a small area of forest with the camera-traps (total ca. 240 m x 10 m = 2.40 ha) for 47 total nights, this intensive survey (i.e., a high density of sampling units) revealed that a good diversity of ground-dwelling large mammals was still present. This helps confirm Chu Yang Sin NP is still potentially important as a key protected area for large mammal conservation, especially for Annamite endemics like the Large-antlered Muntjac, which we successfully documented. Not surprisingly, our list of recorded species reflects a similar checklist of mammals compiled from a previous camera-trap survey by BirdLife International (2010) (see Table 1), except for the Sambar *Rusa unicolor* and Large Indian Civet *Viverra zibetha* which we did not detect during the survey. A similar pattern of occurrence was also found during a recent camera-trap survey in Chu Yang Sin NP to investigate more widely the occupancy of mammals (Vy T. Nguyen & Anthony J. Giordano, unpub. data). In this camera-trap survey, Vy T. Nguyen and Anthony J. Giordano recorded four more mammal species including Long-tailed Macaque *Macaca fascicularis*, Asian Brush-tailed Porcupine *Atherurus macrourus*, Sunda Pangolin *Manis javanica*, and Lesser Chevrotain *Tragulus kanchil* (see Table 1 & Image 3a–c). Together, findings from these surveys provide a representative picture of the diversity and abundance of large mammals still present in the protected area (Table 2).



Image 2. The carcass of a snared male Stump-tailed Macaque found in a real snare-line encountered during the pilot survey. © MTAN.

This survey is also a commentary on the impact of illegal hunting on large mammal populations in Chu Yang Sin NP, especially ungulates and carnivores. It was noted that high levels of hunting had previously been recorded during surveys by Birdlife International between 2006 and 2009, especially the use of snares. In 2020, for example, signs of hunting were observed that included areas of forest undergrowth burnt for hunting purposes, snare-lines, single snares, and hunting camps; in addition, hunters were encountered in the forest almost every day during the pilot survey. The carcass of a rotten muntjac was observed that had died in an abandoned snare-line, and a male Stump-tailed Macaque that died similarly. Vy T. Nguyen and Anthony J. Giordano recorded a male Northern Red Muntjac *Muntiacus vaginalis* missing his left hind leg on their camera-traps. Prolonged and high intensity snare hunting is a primary reason for the disappearance of many mammal species in the region (Harrison et al. 2016). Carnivore species with large home ranges and long ranging movements, including Leopard *Panthera pardus*, Asian Golden Cat *Pardofelis temminckii*, Mainland Clouded Leopard *Neofelis nebulosa*, and Dhole *Cuon alpinus*, are among the most vulnerable to snaring (Gray 2013; Sukmasuang

Table 1. Large mammals recorded in Chu Yang Sin National Park.

Species	Scientific name	IUCN Red List 2023	BirdLife International 2010	Pilot survey 2020	Snare-line experiment 2021	Vy T. Nguyen & Anthony J. Giordano (unpubl. data)
East Asian Porcupine	<i>Hystrix brachyura</i>	LC		O	CT	CT
Asian Brush-tailed Porcupine	<i>Atherurus macrourus</i>	LC				CT
Northern Pig-tailed Macaque	<i>Macaca leonina</i>	VU	CT		CT	CT
Stump-tailed Macaque	<i>Macaca arctoides</i>	VU	CT, O	O		CT
Long-tailed Macaque	<i>Macaca fascicularis</i>	EN				CT
Black-shanked Douc	<i>Pygathrix nigripes</i>	CR	O	O		
Southern Yellow-cheeked Gibbon	<i>Nomascus gabriellae</i>	EN	O			
Sunda Pangolin	<i>Manis javanica</i>	CR				CT
Mainland Leopard Cat	<i>Prionailurus bengalensis</i>	LC	CT		CT	CT
Large Indian Civet	<i>Viverra zibetha</i>	LC	CT			
Northern Common Palm Civet	<i>Paradoxurus hermaphroditus</i>	LC			CT	CT
Masked Palm Civet	<i>Paguma larvata</i>	LC			CT	CT
Owston's Civet	<i>Chrotogale owstoni</i>	EN	O			
Yellow-throated Marten	<i>Martes flavigula</i>	LC			CT	CT
Ferret Badger	<i>Melogale sp.(p)</i>	LC			CT	CT
Lesser Chevrotain	<i>Tragulus kanchil</i>	LC				CT
Eurasian Wild Pig	<i>Sus scrofa</i>	LC			CT	CT
Sambar	<i>Rusa unicorn</i>	VU	CT			CT
Northern Red Muntjac	<i>Muntiacus vaginalis</i>	LC	CT		CT	CT
Large-antlered Muntjac	<i>Muntiacus vuquangensis</i>	CR	CT		CT	CT
Western Serow	<i>Capricornis sumatraensis</i>	VU			CT	CT

Key: CT—camera-trap detection | O—direct observation | IUCN—International Union for Conservation of Nature | CR—Critically Endangered | EN—Endangered | VU—Vulnerable | LC—Least Concern. **Note:** Scientific and common names used are following Wildlife Conservation Society (WCS) 2024. Only species recorded by camera-traps and direct observation in Chu Yang Sin NP are included

et al. 2020; Giordano 2022). Although during 2006–2009, surveys conducted by Birdlife International detected two individuals of Asian Golden Cats in Chu Yang Sin NP, neither this species nor other larger carnivores, including Leopard, and Mainland Clouded Leopards, have officially been confirmed in southern Vietnam for more than a decade (Wilcox et al. 2014; Hoffmann et al. 2019). These species probably have been extirpated from the national park given that our and the other survey by Vy T. Nguyen and Anthony J. Giordano (unpub. data) have failed to detect them in Chu Yang Sin NP.

Populations of large-bodied ungulates are following the same declining pattern as the country's large carnivores, including the Large-antlered Muntjac (Timmins et al. 2015, 2016). This species has declined rapidly in recent years and has now disappeared from most of the Annamite landscape (Timmins et al. 2016). Recent intensive camera-trapping surveys in Vietnam have largely confirmed that remaining Large-antlered

Muntjac populations now appear small, fragmented, and isolated (Alexiou et al. 2022; Nguyen et al. 2024; Tilker et al. in press). The presence of Large-antlered Muntjac might suggest a potential source population for the recovery of this CR species. This can only occur if illegal hunting can be successfully controlled in the very near future. Because Chu Yang Sin NP is part of one of the largest remaining contiguous forested landscapes in Vietnam, connecting with Bidoup–Nui Ba National Park, Phuoc Binh National Park, other nature reserves, and state forest companies through its eastern and southern borders, recovery could have significant ramifications for the species' long-term future.

Species vulnerability to snares

Among all species we detected, we recorded the highest encounter rate for Ferret Badger (*Melogale sp.*) (p(E) = 0.91); this was followed by Mainland Leopard Cat *Prionailurus bengalensis*, East Asian Porcupine

Table 2. Annotated checklist of large mammal species historically presumed native to Chu Yang Sin National Park.

Name used following WCS (2024)	IUCN Red List scientific name	Current status
<i>Elephas maximus</i> Asian Elephant	<i>Elephas maximus</i>	EX
<i>Tupaia belangeri</i> Northern Treeshrew	<i>Tupaia belangeri</i>	Y*
<i>Dendrogale murina</i> Northern Slender-tailed Treeshrew	<i>Dendrogale murina</i>	Y*
<i>Galeopterus</i> sp. Indochinese Colugo	<i>Galeopterus variegatus</i>	Y
<i>Nycticebus pygmaeus</i> Pygmy Lorix	<i>Nycticebus pygmaeus</i>	Y
<i>Macaca leonina</i> Northern Pig-tailed Macaque	<i>Macaca leonina</i>	Y*
<i>Macaca arctoides</i> Stump-tailed Macaque	<i>Macaca arctoides</i>	Y*
<i>Macaca fascicularis</i> Long-tailed Macaque	<i>Macaca fascicularis</i>	?M ¹
<i>Trachypithecus germaini</i> Indochinese Silvered Leaf Monkey [including 'margarita']	<i>Trachypithecus margarita</i>	?M
<i>Pygathrix nigripes</i> Black-shanked Douc	<i>Pygathrix nigripes</i>	Y
<i>Nomascus gabriellae</i> Southern Yellow-cheeked Gibbon	<i>Nomascus gabriellae</i>	Y
<i>Nesolagus timminsi</i> Annamite Striped Rabbit	<i>Nesolagus timminsi</i>	Y
<i>Hystrix brachyura</i> East Asian Porcupine	<i>Hystrix brachyura</i>	Y*
<i>Atherurus macrourus</i> Asian Brush-tailed Porcupine	<i>Atherurus macrourus</i>	Y
<i>Ratufa bicolor</i> Black Giant Squirrel	<i>Ratufa bicolor</i>	Y
<i>Callosciurus erythraeus</i> Pallas's Squirrel	<i>Callosciurus erythraeus</i>	Y*
<i>Menetes berdmorei</i> Berdmore's Squirrel	<i>Menetes berdmorei</i>	?M
<i>Tamiops rodolphii</i> Cambodian Striped Squirrel	<i>Tamiops rodolphii</i>	?
<i>Tamiops maritimus</i> Eastern Striped Squirrel	<i>Tamiops maritimus</i>	Y*
<i>Dremomys rufigenis</i> Red-cheeked Squirrel	<i>Dremomys rufigenis</i>	Y*
<i>Hylopetes spadiceus</i> Red-cheeked Flying Squirrel	<i>Hylopetes spadiceus</i>	?
<i>Hylopetes alboniger</i> Particolored Flying Squirrel	<i>Hylopetes alboniger</i>	?
<i>Hylopetes phayrei</i> Phayre's Flying Squirrel	<i>Hylopetes phayrei</i>	?
<i>Petinomys setosus</i> White-bellied Flying Squirrel	<i>Petinomys setosus</i>	?
<i>Belomys pearsonii</i> Hairy-footed Flying Squirrel	<i>Belomys pearsonii</i>	?
<i>Biswamoyopterus laoensis</i> Lao Giant Flying Squirrel	<i>Biswamoyopterus laoensis</i>	?
<i>Petaurista petaurista</i> Red Giant Flying Squirrel	<i>Petaurista petaurista</i>	?
<i>Petaurista philippensis</i> Indian Giant Flying Squirrel	<i>Petaurista philippensis</i>	Y
<i>Petaurista elegans</i> Lesser Giant Flying Squirrel	<i>Petaurista elegans</i>	Y
<i>Manis pentadactyla</i> Chinese Pangolin	<i>Manis pentadactyla</i>	?
<i>Manis javanica</i> Sunda Pangolin	<i>Manis javanica</i>	Y
<i>Prionodon pardicolor</i> Spotted Linsang	<i>Prionodon pardicolor</i>	Y
<i>Prionailurus viverrinus</i> Fishing Cat	<i>Prionailurus viverrinus</i>	?M
<i>Prionailurus bengalensis</i> Mainland Leopard Cat	<i>Prionailurus bengalensis</i>	Y*
<i>Catopuma temminckii</i> Asian Golden Cat	<i>Catopuma temminckii</i>	EX
<i>Pardofelis marmorata</i> Marbled Cat	<i>Pardofelis marmorata</i>	Y
<i>Neofelis nebulosa</i> Mainland Clouded Leopard	<i>Neofelis nebulosa</i>	EX
<i>Panthera pardus</i> Leopard	<i>Panthera pardus</i>	EX
<i>Panthera tigris</i> Tiger	<i>Panthera tigris</i>	EX

Name used following WCS (2024)	IUCN Red List scientific name	Current status
<i>Viverra zibetha</i> Large Indian Civet	<i>Viverra zibetha</i>	Y
<i>Viverricula indica</i> Small Indian Civet	<i>Viverricula indica</i>	?M
<i>Paradoxurus hermaphroditus</i> Northern Common Palm Civet	<i>Paradoxurus hermaphroditus</i>	Y*
<i>Paguma larvata</i> Masked Palm Civet	<i>Paguma larvata</i>	Y*
<i>Arctictis binturong</i> Binturong	<i>Arctictis binturong</i>	Y
<i>Arctogalidia trivirgata</i> Small-toothed Palm Civet	<i>Arctogalidia trivirgata</i>	Y
<i>Chrotogale owstoni</i> Owston's Civet	<i>Chrotogale owstoni</i>	Y
<i>Urva javanicus</i> Javan Mongoose	<i>Herpestes javanicus</i>	?M
<i>Urva urva</i> Crab-eating Mongoose	<i>Herpestes urva</i>	Y
<i>Canis aureus</i> Golden Jackal	<i>Canis aureus</i>	?M
<i>Cuon alpinus</i> Dhole	<i>Cuon alpinus</i>	EX
<i>Ursus thibetanus</i> Asian Black Bear	<i>Ursus thibetanus</i>	Y
<i>Ursus malayanus</i> Sun Bear	<i>Helarctos malayanus</i>	Y
<i>Mustela kathiah</i> Yellow-bellied Weasel	<i>Mustela kathiah</i>	Y
<i>Mustela strigidorsa</i> Stripe-backed Weasel	<i>Mustela strigidorsa</i>	Y
<i>Martes flavigula</i> Yellow-throated Marten	<i>Martes flavigula</i>	Y*
<i>Arctonyx collaris</i> Greater Hog Badger	<i>Arctonyx collaris</i>	Y
<i>Melogale personata</i> Large-toothed Ferret Badger	<i>Melogale personata</i>	?M
<i>Melogale moschata</i> Small-toothed Ferret Badger	<i>Melogale moschata</i>	Y
<i>Lutra lutra</i> Eurasian Otter	<i>Lutra lutra</i>	Y
<i>Lutra sumatrana</i> Hairy-nosed Otter	<i>Lutra sumatrana</i>	?M-EX
<i>Lutrogale perspicillata</i> Smooth-coated Otter	<i>Lutrogale perspicillata</i>	?M-EX
<i>Aonyx cinereus</i> Oriental Small-clawed Otter	<i>Aonyx cinereus</i>	Y
<i>Rhinoceros sondaicus</i> Javan Rhinoceros	<i>Rhinoceros sondaicus</i>	EX
<i>Dicerorhinus sumatrensis</i> Sumatran Rhinoceros	<i>Dicerorhinus sumatrensis</i>	EX
<i>Sus scrofa</i> Eurasian Wild Pig	<i>Sus scrofa</i>	Y*
<i>Tragulus kanchil</i> Lesser Chevrotain	<i>Tragulus kanchil</i>	Y
<i>Rusa unicolor</i> Sambar	<i>Rusa unicolor</i>	Y
<i>Muntiacus vaginalis</i> Northern Red Muntjac	<i>Muntiacus vaginalis</i>	Y*
<i>Muntiacus vuquangensis</i> Large-antlered Muntjac	<i>Muntiacus vuquangensis</i>	Y*
<i>Bos gaurus</i> Gaur	<i>Bos gaurus</i>	Y
<i>Pseudoryx nghetinhensis</i> Saola	<i>Pseudoryx nghetinhensis</i>	?
<i>Capricornis sumatraensis</i> Western Serow	<i>Capricornis sumatraensis</i>	Y*

Key: Y—Presumed native and still to be present | EX—Presumed to be extirpated | ?EX—Possibly extirpated | M—Possibly present, but would be very marginal (lowland and open country species) | ?—Presence and distribution (historically and at present) are uncertain in the southern Annamites | *—Species detected during the study | 1—Although detected by Vy T. Nguyen and Anthony J. Giordani (unpub. data, Image 3B), it is unclear if the species is native to Chu Yang Sin NP, as animals confiscated from the wildlife trade network in Vietnam are routinely released in protected areas, and the habitats in Chu Yang Sin NP are somewhat atypical for this species. Note: Presumed historical status was determined by R.J. Timmins via reference to a large number of published and unpublished studies and other data sources on species distribution and ecological factors relevant to compatibility of habitats in Chu Yang Sin NP with species native presence; key references included but are not limited to Dang et al. (1994), Duckworth et al. (1999), Duckworth & Hills (2008), Francis (2017), Hoffmann et al. (2019), Nguyen & Timmins (2020), WCS (2024), along with reference to current IUCN Red List species accounts (iucnredlist.org) to provide further data on most likely current status.

Table 3. Summary of encounters with the simulated snare-line (events) and snare-gaps, crossing the snare-gap and being captured by the simulated snare-noose, and capture probabilities.

Species	Total number of events	Total number of snare-gaps of encounters for all events	Number of events with at least one snare-gap encounter	Total number of times snare-gaps were crossed for all events	Total number of captures by simulated snares for all events	p(E)	p(Cr)	p(C/Cr)	p(Sn/E)	p(C/E)
Large-antlered Muntjac	4	9	4	6	6	0.09	0.67	1	1	0.67
Mainland Leopard Cat	8	9	7	4	4	0.17	0.44	1	0.88	0.39
Common Palm Civet	3	2	2	1	1	0.06	0.5	1	0.67	0.34
East Asian Porcupine	7	10	7	3	3	0.15	0.3	1	1	0.3
Ferret Badger	43	29	28	8	8	0.91	0.28	1	0.65	0.18
Masked Palm Civet	5	6	5	1	1	0.11	0.17	1	1	0.17
Northern Red Muntjac	5	5	4	1	1	0.11	0.2	1	0.8	0.16
Northern Pig-tailed Macaque	6	5	5	0	0	0.13	0	0	0.83	0
Western Serow	1	5	1	1	0	0.02	0.2	0	1	0
Eurasian Wild Pig	2	1	1	0	0	0.04	0	0	0.5	0
Yellow-throated Marten	5	8	5	1	0	0.11	0.125	0	1	0

Hystrix brachyura, Northern Pig-tailed Macaque *Macaca leonina*, Masked Palm Civet *Paguma larvata*, and Northern Red Muntjac (p(E) varied from 0.17 to 0.11). Western Serow *Capricornis sumatraensis*, Eurasian Wild Pig *Sus scrofa*, and Northern Common Palm Civet *Paradoxurus hermaphroditus* had the lowest encounter rates (p(E) 0.02 – 0.06). Large-antlered Muntjac and Yellow-throated Marten *Martes flavigula* also showed low encounter rates of p(E) 0.09 and 0.11, respectively (Table 3).

Although our sample size is small for most species, our data suggested that overall, most ground-dwelling large mammals are vulnerable to snares in some way. One of the most compelling results was the apparent effectiveness of the construction of the snare-gap in the resulting probability of an animal being captured by a snare strategically placed in the snare-gap. Every snare-gap crossing event recorded (n = 25; Table 3), across all species (n = 8), with a single exception, resulted in the theoretical capture of the animal. In other words, if an animal crosses a snare-gap, its probability of capture would appear to be very high. However, other factors interact to determine the theoretical probability of capture at a snare-line; for example, Large-antlered Muntjac was the most vulnerable with a high probability of capture per snare-line encounter event (p(C/E) = 0.67), thus although the species' encounter rate was low, theoretically most animals in the vicinity of the snare-line were likely to have been captured. Data for the Large-antlered Muntjac came mostly from a single juvenile animal and one event of an adult female; if the snare-line had real snares the probability of capture of the juvenile over the entire period would have been p(C/E) = 1 (100%). In contrast, Ferret Badger was less likely to be captured per event (p(C/E) = 0.18), the high encounter rate (p(E) = 0.91) is likely to ensure in reality a high probability of being captured over the lifetime of the snare-line. Based on our conversations with hunters, we know that hunters in Chu Yang Sin NP often abandon actual snare-lines after three months, with no snares ever being removed from the forest. Interestingly, Western Serow, Northern Pig-tailed Macaques, Eurasian Wild Pig, and Yellow-throated Marten, all had low capture rates with evidence visible on the videos and photographs to suggest that behaviour might play a crucial role in lowering their susceptibility to being captured in snares; including potentially increased wariness and active avoidance of the snare-gap, avoidance of crossing snare-gaps for other reasons and crossing the snare-line by other means (e.g., through the fence or climbing vegetation adjacent to the snare-line).

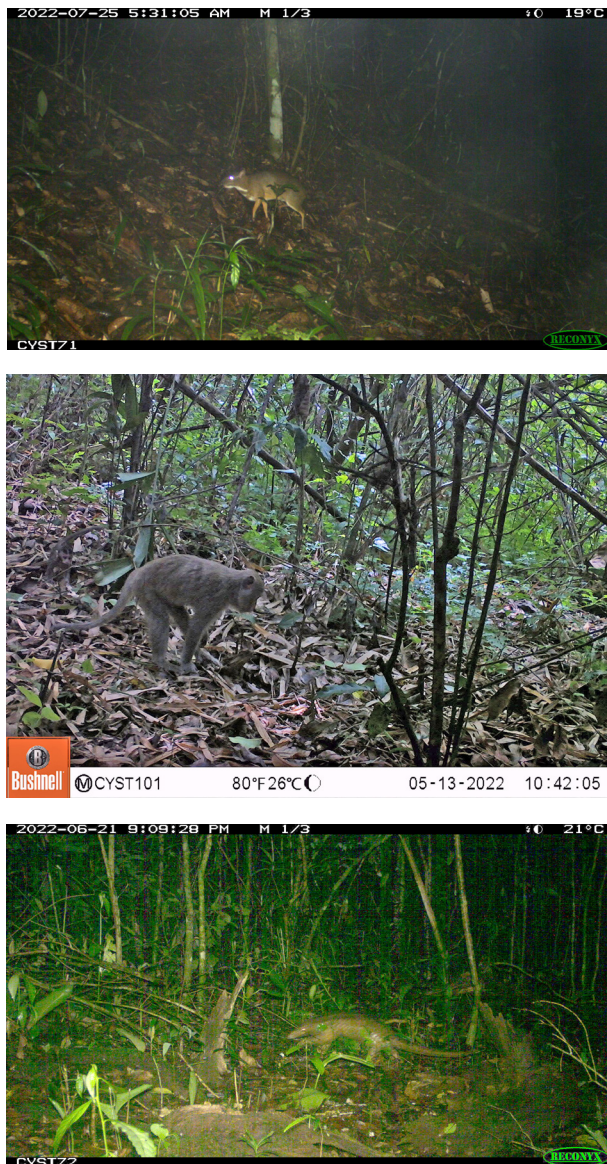


Image 3. Some mammal species recorded by VT. Nguyen & A. J. Giordano (unpublished data): A—Lesser Chevrotain | B—Long-tailed Macaque | C—Sunda Pangolin.

For example, in the only encounter of Western Serow (one individual) with the snare-line the animal appeared to show a high level of caution. It appeared to actively avoid crossing the first three snare-gaps that it met, attempted but failed to get through/over the vegetation of a section of snare-fence, before finally crossing the fourth snare-gap, but in a way that avoided placing any of its feet within the theoretical snare. Yellow-throated Marten tended to move over/through the snare-line by climbing trees or jumping over the gap directly, rather than going through the center of the snare-gap (five events with eight snare-gaps encountered and one

crossing but none captured). Northern Red Muntjac (at least two different individuals encountered) also appeared to show indications of wariness on the videos and photographs with the probability of being captured four times lower than Large-antlered Muntjac ($p(C/E) = 0.16$). The data for Large-antlered Muntjac was largely based on a single juvenile animal, and it is plausible that significant differences exist in behaviour between juveniles and adults.

This experiment showed important empirical evidence supporting the assumption that different species display different levels of vulnerability to capture in snare-lines. From this it can be theorized that different species potentially have very different thresholds to ‘intensity’ of snaring that affect their population viability. Understanding these thresholds potentially opens the door to better management of the snaring crisis. Tackling the snaring crisis is a highly complex problem, requiring both in situ and ex situ interventions at multiple levels, with many different stakeholders. Knowledge of population viability thresholds can guide conservation planning by prioritizing the protection of species most sensitive to snaring. Since snares are difficult to detect and snare eradication efforts are constrained by limited resources, achieving zero snaring is unrealistic at least in the short-term. Biodiversity conservation effort and resources therefore need to be strategically targeted to interventions that prevent local population extirpation of priority species. To achieve this, continuously monitoring population viability thresholds in response to ‘intensity’ of snaring can help answer critical questions about the intensity of snaring that could be tolerated to prevent species’ local population extirpations. Determining the effort and spatial scale required for snare removal activities to reduce snare intensity below species viability thresholds to ensure the continued survival of large mammal populations is essential for guiding law enforcement actions. Over the long term, this approach can potentially help identify priority areas for in situ conservation where targeted snare removal supports population recovery.

CONCLUSION

This study is the first of its kind in the world to use camera-traps in an innovative context to directly simulate the impact of snare hunting on large mammals. Although the analysis was simple and the sampling period was short, our results yield new insights into the snaring crisis and “empty forest syndrome” especially

highlighting the potential differential vulnerability among species. It is believed that with more replication and analysis of larger datasets based on similar methods, these approaches may offer promising new opportunities to address the snaring crisis. Until such time, greatly enhanced, strategic, and highly focused law enforcement is needed in critical protected areas of Vietnam to effectively mitigate illegal hunting in key locations and ultimately prevent widespread extirpation of many species, but particularly the Annamite endemic species.

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Tóm tắt: Dãy Trường Sơn trên bán đảo Đông Dương có mức độ đặc hữu thú cao nhưng đồng thời cũng đang bị đe dọa tuyệt chủng nghiêm trọng, chủ yếu do săn bắt trái phép bằng bẫy dẫy phan tràn lan. Ở phía nam của dãy Trường Sơn thuộc Việt Nam, Vườn quốc gia Chư Yang Sin là một trong số ít các khu rừng ở nước này được dự đoán vẫn còn sự hiện diện của Mang lớn, một loài thú chỉ được ghi nhận ở dãy Trường Sơn và đang có tình trạng bảo tồn ở mức Cực kỳ Nguy cấp. Mục tiêu của nghiên cứu này là 1/ thực nghiệm điều tra mức độ tác động của bẫy dẫy phan lên các quần thể thú tại vườn bằng phương pháp bẫy ảnh, tập trung vào các loài mang, và 2/ cung cấp một danh lục các loài thú lớn cho vườn. Năm 2020, một khảo sát tiền trạm được tiến hành nhằm xác định địa điểm thực nghiệm trong vườn quốc gia dựa trên việc ghi nhận các dấu vết gọi ý sự hiện diện của các loài thú lớn. Từ tháng 12/2020 đến tháng 02/2021, một tuyến đường bẫy dẫy mô phỏng dài 515 m đã được xây dựng tại địa điểm thực nghiệm bởi năm thợ săn địa phương có kinh nghiệm trong vùng. Các bẫy ảnh được lắp đặt sau đó dọc theo 240 m của tuyến đường bẫy nhằm theo dõi sự di chuyển của động vật. Các bẫy ảnh hoạt động tổng cộng 4.747 đêm đã ghi nhận sự hiện diện của Mang lớn và 10 loài thú lớn khác. Nghiên cứu cho thấy Mang lớn dễ bị dính bẫy dẫy hơn so với các loài thú khác, có xác suất "dính bẫy" cao nhất nếu cá thể gặp phải đường bẫy ($p = 0,67$). Phát hiện này củng cố giả thuyết trước đây rằng việc tiếp xúc kéo dài với tuyến đường bẫy sẽ làm suy giảm mạnh các quần thể thú lớn, vì khi một cá thể nhiều lần tiếp xúc một tuyến đường bẫy, xác suất "dính dẫy" sẽ tăng gần đến $p = 1$. Nghiên cứu này lần đầu tiên cho thấy một cách thực nghiệm rằng các loài khác nhau có mức độ nhạy cảm với bẫy dẫy khác nhau. Dựa trên phương pháp thực nghiệm này, các nghiên cứu trong tương lai có thể mang lại những hiểu biết mới nhằm quản lý hoạt động săn bắt bằng bẫy dẫy phan hiệu quả hơn, thông qua việc kết hợp dữ liệu từ nhiều khu vực khác và tiến hành trong thời gian dài hơn.

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First time in 110 years: sighting of *Gynacantha khasiaca* MacLachlan, 1896 (Odonata: Aeshnidae) in Arunachal Pradesh, India

– R. Mahesh, Rajesh Gopinath, Gaurav Joshi & Roshan Upadhaya, Pp. 28982–28987

Notes

Evidence of Rusty-spotted Cat *Prionailurus rubiginosus* (L. Geoffroy Saint-Hilaire, 1831) (Mammalia: Carnivora: Felidae) in National Chambal Sanctuary, Uttar Pradesh, India

– Anshoo Nishad, Hiyashri Sarma, Rajib Saha, Vijay Pratap Singh, Maneesha Bhatt, Atit Rai, Qamar Qureshi & Vishnupriya Kolipakam, Pp. 28988–28990

First photographic record of Naumann's Thrush *Turdus naumanni* Temminck, 1820 from Assam, India

– Pulakeswar Basumatary, Pp. 28991–28994

New breeding record of Black-headed Ibis *Threskiornis melanocephalus* from Malappuram District, Kerala, India

– K.K. Junaina & A.P. Rashiba, Pp. 28995–28997

From the heart of Urad: records of *Cyrtodactylus bapme* Kamei & Mahony, 2021 (Reptilia: Squamata: Gekkonidae) from Assam, India, with comments on the pre-loocal region in males

– Manmath Bharali, Pranjal Swargiary, Tejas Mariswamy, Madhurima Das, Jayaditya Purkayastha & Sanath Chandra Bohra, Pp. 28998–29002

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