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# Hunting Pressure on Primates in Veun Sai-Siem Pang National Park, Cambodia

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## Abstract

Approximately 60% of primate species are threatened with extinction, primarily due to hunting and habitat loss. To alleviate primate hunting pressure an understanding of human–nonhuman primate interactions is required. Six confirmed primate species inhabit Veun Sai-Siem Pang National Park (VSSP) in Cambodia, a part of the Indo-Burma hotspot. Local people in the surrounding villages rely on the national park for food, traditional medicine, and income. Illegal logging frequently occurs in the park and in recent years there has been an increase in the use of homemade guns for hunting; however, the hunting pressure on primates remains unknown. We investigated the current hunting pressure on primate species within the park using semi-structured interviews with local people in five villages adjacent to VSSP. All participants were 18 yr or older and identified as the head of the family and/or the primary resource collector. Of the 96 participants we interviewed, 64% were current hunters with 38% of these targeting primates. The pygmy slow loris (*Nycticebus pygmaeus*) is the most frequently hunted, sold and sought-after primate species in VSSP and is used in traditional medicine. The most wanted primate for a pet is the northern yellow-cheeked crested gibbon (*Nomascus annamensis*). Despite this, *N. annamensis* is rarely hunted in VSSP, reportedly due to a lack of suitable hunting equipment. We suggest that the importance of hunting primates for local communities and the potential impacts on these communities from conservation actions must be understood, and the potential impacts mitigated, for primate conservation plans to be effective.

**Keywords** Bushmeat · Ethnoprimatology · Hunting · Primate conservation · Traditional medicine

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## Introduction

Overexploitation is one of the largest drivers of biodiversity loss, with human activities such as hunting, logging, and the pet trade impacting thousands of threatened and near-threatened species worldwide (Maxwell *et al.* 2016). While forest resources are exported to wealthy nations from poorer nations (Shandra *et al.* 2009), millions of people living in poverty rely on forest resources for their livelihoods (Kim *et al.* 2008; MEA 2005). This includes hunting for bushmeat, a valuable protein source (Nasi *et al.* 2008) that is often cheaper than domestic meat (SCBD 2011), and hunting for income and for traditional medicine (Corlett 2007; Fa and Brown 2009; Nasi *et al.* 2008), which is often but not exclusively used (Ashwell and Walston 2008) by those living in poverty who have limited access to health services (OECD and WHO 2003; Peters *et al.* 2008).

In the tropics, where the hunting of wildlife is of cultural significance to many forest peoples (Bennett and Robinson 2000; Nasi *et al.* 2008), the sustainability of hunting practices is reduced by numerous factors including habitat loss and more effective transport and hunting equipment (Bennett and Robinson 2000). The creation of roads and subsequent increase in access to tropical forests (Bennett and Robinson 2000; Corlett 2007; Peres and Lake 2003), such as roads created for logging (Bennett and Gumal 2001; Blake *et al.* 2007; Laurance *et al.* 2009; Wilkie *et al.* 2000), further exacerbate the hunting pressure on wildlife therein (Bennett and Robinson 2000; Laurance *et al.* 2009). This has been illustrated in the Congo Basin (Blake *et al.* 2007; Wilkie *et al.* 2000), the Amazon (Laurance and Balmford 2013; Peres and Lake 2003), and Southeast Asia (Bennett and Gumal 2001; Clements *et al.* 2014).

Owing to unsustainable practices by humans, approximately 60% of primate species are threatened by extinction (Estrada *et al.* 2017). The two key threats to primates are hunting and habitat loss (Estrada *et al.* 2017), primarily due to conversion to agricultural lands (Gibbs *et al.* 2010) and logging (Estrada *et al.* 2017). While land conversion increases hunting rates as primates enter nearby villages to forage on crops (Meijaard *et al.* 2011), primates are also hunted for use in traditional medicine and for income (Meijaard *et al.* 2011; Starr *et al.* 2010) and food (Chapman *et al.* 2006; Fa and Brown 2009; Fa *et al.* 2006). The primate trade occurs domestically and internationally (Nijman *et al.* 2011; Shepherd 2010) and every year millions of primates are killed in addition to the tens of thousands, if not more, that enter the live trade (Nijman *et al.* 2011) for use as pets and for entertainment and biomedical research (Eudey 2008; Nekaris and Bergin 2017; Nijman 2005).

In Southeast Asia, a region of high biodiversity, hunting is considered the greatest threat to wildlife (Gray *et al.* 2018). Roads (Bennett and Gumal 2001; Clements *et al.* 2014), human population growth, habitat loss (Harrison *et al.* 2016; Sodhi *et al.* 2004), and Southeast Asia's large involvement in the wildlife trade continue to increase the hunting pressure on wildlife (Gray *et al.* 2018; Sodhi *et al.* 2004). As seen in other regions such as Africa (Lindsey *et al.* 2013), the severity of hunting varies throughout Southeast Asia due to differences in hunting practices, access to markets, demand, hunting and gun laws, and law enforcement (Harrison *et al.* 2016). Primates are traded legally and illegally in Asia and the severity of trade varies significantly between countries (Nekaris and Bergin 2017). Southeast Asia is a hotspot for the trade in the region, with Malaysia, Indonesia, Laos, and Cambodia among the largest exporters of primates (Nekaris and Bergin 2017).

Cambodia is part of the Indo-Burma hotspot (Myers *et al.* 2000) and lost 21,700 km$^2$ of tree cover between 2001 and 2018, including 1090 km$^2$ of natural forests in 2018 (GFW 2018) due to illegal logging and conversion of forests to agricultural land (Turreira-García *et al.* 2018). Hunting is also a significant factor in the decline of forest biodiversity in the country (Loucks *et al.* 2009). Between 1998 and 2018, Cambodia maintained an average economic growth rate of 8% and poverty rates decreased from 47.8% in 2007 to 13.5% in 2014 (The World Bank 2020). However, approximately 90% of the poor reside in rural areas (The World Bank 2020), and rely on nontimber forest products for their survival (Kim *et al.* 2008). In Cambodia during the Khmer Rouge regime (1975–1979), only traditional medicine was permitted (Ashwell and Walston 2008), as biomedical practices were prohibited (Ashwell and Walston 2008) and health professionals were scarce (Liverani *et al.* 2020). There have been ongoing efforts to better the national health system (Liverani *et al.* 2020), yet despite substantial improvements made over the past 20 yr (Asante *et al.* 2019), many people in Cambodia, especially those living in poverty and rural areas, have limited access to health services (Asante *et al.* 2019; Liverani *et al.* 2017). In both rural and urban areas of Cambodia, traditional medicine is in high demand and provides a trusted, cheaper and more readily available alternative to biomedicine, further increasing the hunting pressure on certain wildlife species (Ashwell and Walston 2008).

In 2016, the Royal Government of Cambodia announced five new protected areas (Souter *et al.* 2016), one of which was Veun Sai-Siem Pang National Park (VSSP), a former Conservation Area consisting primarily of semievergreen and evergreen forests stretching *ca.* 550 km$^2$ (Kibria *et al.* 2017; King *et al.* 2016). The park has a high level of biodiversity, including 6 of the 12 primate species (Table I) that inhabit Cambodia (González Monge 2016; Rawson 2010; Rawson *et al.* 2012; Rawson and Roos 2008; Thinh *et al.* 2010). According to local people, a seventh primate species, the Bengal slow loris (*Nycticebus bengalensis*) may also inhabit VSSP; however this is yet to be confirmed by field surveys (Iseborn 2011; Rawson *et al.* 2012). Despite the change in protection status, illegal logging and hunting in the park still occurs (Kibria *et al.* 2017).

In 2011, the pygmy slow loris (*Nycticebus pygmaeus*) was targeted in VSSP for traditional medicine (Iseborn 2011) and the northern yellow-cheeked crested gibbon (*Nomascus annamensis*) and the long-tailed macaque (*Macaca fascicularis*) were most frequently targeted for the pet trade (Hill 2011). At that time, hunting with guns in VSSP was not common practice (Iseborn 2011). Unfortunately, since that time homemade gun use for hunting has increased (J. Frechette, *pers. comm*., February 16, 2021) while illegal logging continues to occur, but no further assessments on the hunting pressure on the primates in VSSP have been conducted. Understanding why and how frequently human–nonhuman primate interactions in VSSP occur is essential for developing effective conservation plans to both meet human needs and decrease the hunting pressure on primates in the park.

We had four aims in this study: 1) to determine the prevalence of hunting in VSSP, the species that are most targeted and the importance of hunting for local communities surrounding the park; 2) to assess the hunting pressure on nonhuman primates in VSSP by determining the percentage of hunters that target primates, which primates are hunted most frequently and why, the methods used to capture primates, including the prevalence of gun use to hunt primates, and how primate hunting practices may have changed over time; 3) to identify the most traded and sought-after primate species in the

**Table I** Primate species found in Cambodia and Veun Sai-Siem Pang National Park (VSSP) in northeastern Cambodia

| Primates in Cambodia | Common name | IUCN Red List of Threatened Species status | VSSP |
|---|---|---|---|
| *Nomascus annamensis* | Northern yellow-cheeked crested gibbon | Endangered | Present |
| *Macaca leonina* | Northern pig-tailed macaque | Vulnerable | Present |
| *Macaca fascicularis* | Long-tailed macaque | Vulnerable | Present |
| *Trachypithecus margarita* | Annamese silvered langur | Endangered[a] | Present |
| *Nycticebus pygmaeus* | Pygmy slow loris | Endangered | Present |
| *Pygathrix nemaeus* | Red-shanked douc langur | Critically Endangered | Present |
| *Nycticebus bengalensis* | Bengal slow loris | Endangered | Absent |
| *Macaca arctoides* | Stump-tailed macaque | Vulnerable | Absent |
| *Trachypithecus germaini* | Indochinese silvered langur | Endangered | Absent |
| *Pygathrix nigripes* | Black-shanked douc langur | Critically Endangered | Absent |
| *Nomascus gabriellae* | Southern yellow-cheeked crested gibbon | Endangered | Absent |
| *Hylobates pileatus* | Pileated gibbon | Endangered | Absent |

[a] *Trachypithecus margarita* is currently included as part of the assessment for Endangered *Trachypithecus germaini.*

Data from González Monge (2016); IUCN (2020); Rawson (2010); Rawson *et al.* (2012); Rawson and Roos (2008); Thinh *et al.* (2010).

villages surrounding VSSP; and 4) to understand the perceived risks of encountering law enforcement while hunting in the park.

## Methods

### Study Site

VSSP (14°01′N 106°44′E) is contiguous to Virachey National Park (3200 km$^2$) (King *et al.* 2016) and is managed by the Ministry of Environment, Cambodia in collaboration with Conservation International (Fig. 1). The park is located in northeastern Cambodia in Siem Pang District of Stung Treng Province and Veun Sai District of Ratanakiri Province. These two provinces have a population size of 159,565 people (Stung Treng) and 204,027 people (Ratanakiri) (NIS 2019) and are among the poorest provinces in Cambodia (ADB 2014). We conducted interviews in five villages ($N = 3$ in Ratanakiri; $N = 2$ in Stung Treng) within 10 km of VSSP (Fig. 1). These villages are I Tub, Kang Nuok, Backae, Kapin, and Talae. Numerous ethnic minorities reside in these rural areas, but I Tub and Backae consist predominately of Lao community members, whereas Kapin, Talae, and Kang Nuok villages consist predominately of Kavet community members.

Local people in these villages rely on VSSP for hunting wildlife and collecting timber and other forest products from the park for personal use and income (Iseborn

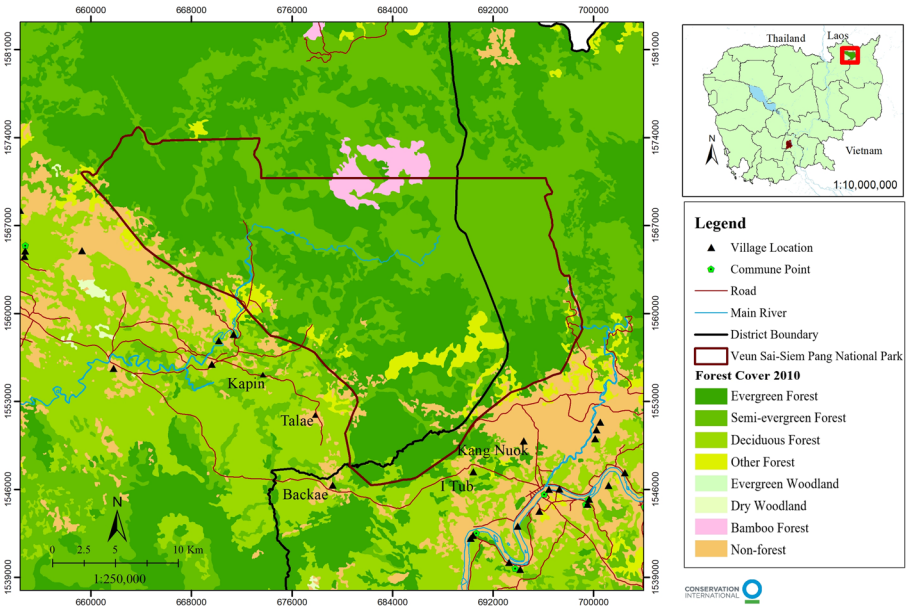


**Fig. 1** Veun Sai-Siem Pang National Park boundary and surrounding villages. Source: Conservation International.

2011; Kibria *et al.* 2017; Rawson *et al.* 2012). Bushmeat from the park and fish from its rivers are crucial food sources for the local people, in addition to domestic livestock (Iseborn 2011; Rawson *et al.* 2012). These communities implement slash and burn agriculture, primarily for rice cultivation (Iseborn 2011). This practice, coupled with increases in human population size in the area and a decrease in soil fertility, is expected to increase deforestation in VSSP (Rawson *et al.* 2012).

## Participant Selection

Researchers from the Australian National University have been studying primates in VSSP since 2012 and have worked with local research guides from the study villages. Each village has been interviewed in previous studies, either by researchers from the Australian National University (Kibria *et al.* 2017) or other organisations (Hill 2011; Iseborn 2011). This research was facilitated by staff at Conservation International, who have conducted studies in the area and have worked with a number of these communities as part of a community-based ecotourism program. We conducted interviews between December 2 and 20, 2017. When we arrived in each village with a Khmer–English translator, we met with the chief or deputy chief of the village and provided details of the project and a letter of permission from the Ministry of Environment, Cambodia. We subsequently selected a local guide/translator for Khmer–Lao or Khmer–Kavet translation as not all participants spoke Khmer. We trained translators in interview techniques and all translators signed confidentiality agreements.

We conducted four trial interviews in Backae on December 2, 2017 and then revised the questionnaire. For example, this led to the inclusion of *Nycticebus bengalensis*, as participants had referred to seeing two loris species in VSSP. Following the trial

interviews, we selected participants for the study using snowball sampling to maximise the number of interviews completed over 3–4 days in each village. The local guide/translator in each village recommended people for the study, and many participants also voluntarily recommended other people. When we first approached potential participants, we provided them with the details of the study and informed them that it was confidential, voluntary and that they could withdraw from the study at any time until the work was prepared for publication. We answered any questions, confirmed the person was 18 yr or older and the head of household and/or primary resource collector and obtained informed consent before proceeding.

## Interviews

We conducted 96 interviews (20–80 min each): 16 interviews in Backae and 20 interviews each in I Tub, Kapin, Talae, and Kang Nuok villages. We interviewed participants in an area of their choosing and with other community members present if desired. We did not ask for any identifiable information but obtained the age range (e.g., 20–29 yr old), gender, ethnicity, and nationality of each participant (Table II). Interviews were semistructured and consisted of a maximum of 38 questions (a mix of open-ended, closed-ended, and multiple-choice questions), some of which had multiple components. The series of questions we asked varied depending on if the participant currently hunts, was a retired hunter or had never hunted. We asked questions on numerous topics including general hunting practices, bushmeat consumption, the use of equipment, selling and hunting of primates, and the perceived risks of hunting in VSSP.

**Table II** The number, gender, age, and ethnicity of participants interviewed ($N$ = 96) in five villages in Cambodia

| Participants | Village | | | | | |
|---|---|---|---|---|---|---|
| | Backae | Kang Nuok | I Tub | Kapin | Talae | Total |
| Men | 16 | 20 | 17 | 20 | 19 | 92 |
| Women | 0 | 0 | 3 | 0 | 1 | 4 |
| Ethnicity | | | | | | |
| Kavet | 0 | 20 | 0 | 20 | 19 | 59 |
| Lao | 14 | 0 | 20 | 0 | 0 | 34 |
| Other | 2 | 0 | 0 | 0 | 1 | 3 |
| Age (yr) | | | | | | |
| <20 | 0 | 1 | 0 | 0 | 0 | 1 |
| 20–29 | 4 | 7 | 5 | 1 | 4 | 21 |
| 30–39 | 6 | 4 | 3 | 9 | 4 | 26 |
| 40–49 | 2 | 3 | 4 | 4 | 7 | 20 |
| 50–59 | 4 | 3 | 3 | 4 | 3 | 17 |
| 60–69 | 0 | 2 | 4 | 1 | 1 | 8 |
| 70–79 | 0 | 0 | 1 | 1 | 1 | 3 |

We conducted interviews from December 2, 2017 to December 20, 2017.

Additionally, we asked participants if they preferred domestic meat or bushmeat (Velho and Laurance 2013). For comparison to previous studies conducted in the area (Hill 2011; Iseborn 2011), we included a number of questions and topics from those studies, such as the use of primates as pets (Hill 2011) and willingness of hunters to cease hunting if provided with an alternative income (Iseborn 2011). We showed participants images of each primate species to facilitate accurate identification. However, as we could not access an image of *Nycticebus bengalensis* following the trial interviews, we described the morphological differences between *N. bengalensis* and *Nycticebus pygmaeus* when showing the image of *N. pygmaeus*.

### Statistical Analysis

We first entered the interview transcripts into Microsoft® Excel and subsequently sorted and open-coded responses. We did so by allocating specific phrases from each response into distinct categories, which we selected based on the range of answers given for a specific question. We created frequency tables and calculated percentages for each category using SPSS version 26 for Windows® (IBM Corp. 2019), shown as "*a%, b/c*" where "*b*" is the number of participants that provided the answer, and "*c*" is the number of participants that were asked the question and responded (Starr *et al.* 2010). As the data were categorical, we analysed the relationships between variables using chi-square tests ($\alpha = 0.05$) in SPSS version 26 for Windows® (IBM Corp. 2019).

## Ethical Note

We obtained approval for this research from the Australian National University Human Research Ethics Committee (Protocol 2017/738). We received permission to conduct this research from the General Department of Administration for Nature Conservation and Protection, Ministry of Environment, Cambodia (Letter number 409). The authors declare that they have no conflict of interest.

**Data Availability** The data sets analysed during the current study are available from the corresponding author on reasonable request.

## Results

### General Hunting Practices

Of the 96 participants, 64% (61/96) currently hunt, 30% (29/96) hunted in the past only and 6% (6/96) have never hunted (Table III). VSSP is a hunting area solely for or in addition to other areas nearby for 69% (42/61) of current hunters. Most hunters, past and current, were solely or in part taught to hunt by their parents (89%, 79/89), 53% (47/89) plan to teach their own children to hunt in the future and 6% (5/89) are unsure if they will teach their children to hunt. While almost all participants consume bushmeat (98%, 94/96), only 57% (53/93), prefer bushmeat to domestic meat, and 28% (26/93) prefer to consume both domestic meat and bushmeat. The most frequently hunted

**Table III** Number of participants that identified as current hunters, ex-hunters, and nonhunters in five villages in Cambodia

| Province | Village | Ethnicity | Current hunters | Ex-hunters | Non-hunters | Total |
|---|---|---|---|---|---|---|
| Ratanakiri | Backae | Lao | 10 | 3 | 3 | 16 |
| | Kang Nuok | Kavet | 16 | 4 | 0 | 20 |
| | I Tub | Lao | 15 | 5 | 0 | 20 |
| Stung Treng | Kapin | Kavet | 7 | 12 | 1 | 20 |
| | Talae | Kavet | 13 | 5 | 2 | 20 |

We conducted interviews from December 2, 2017 to December 20, 2017.

animal by current hunters is the Bengal monitor (59%, 35/59; Fig. 2a), and the most frequently consumed animal by participants is wild boar (80%, 72/90; Fig. 2b). If current hunters were to stop hunting, 78% (46/59) believe that their livelihood would be negatively affected. However, 58% (35/60) would stop hunting if they obtained an alternative income, with a significantly greater number of Kavet current hunters willing to stop hunting than Lao current hunters [$\chi^2$ (1, $N$ = 60) = 7.14, $P$ < 0.01].

## Hunting of Primates: Past vs Present

Of current hunters, 38% (23/61) currently hunt primates, with a significantly greater number of Kavet current hunters hunting primates [$\chi^2$ (1, $N$ = 60) = 18.19, $P$ < 0.001] than Lao current hunters (Table IV). All but one current primate hunter targets *Nycticebus pygmaeus* (96%, 22/23). An additional 23 current hunters and ex-hunters hunted primates in the past only and 4 current primate hunters hunted additional primate species in the past only ($N$ = 27). More than half of these participants targeted both *N. pygmaeus* (56%, 15/27) and *Macaca fascicularis* (56%, 15/27; Fig. 3) in the past.

Current hunters use a variety of methods to capture primates (Table V), and methods vary between species. For example, hunters use slingshots, crossbows, or their hands to capture lorises but not three species of monkey or *Nomascus annamensis*. While 26% (6/23) of current primate hunters use homemade guns, none use commercially produced guns to capture primates. Twenty-six percent of past primate hunters (6/23) reported using commercial guns to hunt monkeys and *N. annamensis* in VSSP and 9% (2/23) of past primate hunters reported using homemade guns to capture at least one primate species in VSSP. *N. annamensis* and the monkeys of VSSP are most frequently hunted by current primate hunters for food, whereas *Nycticebus pygmaeus* and *Nycticebus bengalensis* are most frequently hunted as a source of income (Table V). More than half (56%, 54/96) of all participants said they would be willing to keep a primate as a pet, but only 14% (13/96) of participants had kept a primate as a pet (Fig. 4). Currently, of all the primates, *N. annamensis* is most wanted as a pet (44%, 42/96; Fig. 4), although it is rarely hunted (Fig. 3). All current hunters of *N. pygmaeus* (100%, 22/22) and *N. bengalensis* (100%, 6/6) hunt them during the night, whereas they hunt all other primates during the day. For current *N. pygmaeus* hunters, the median offtake is two individuals per year ($N$ = 20).

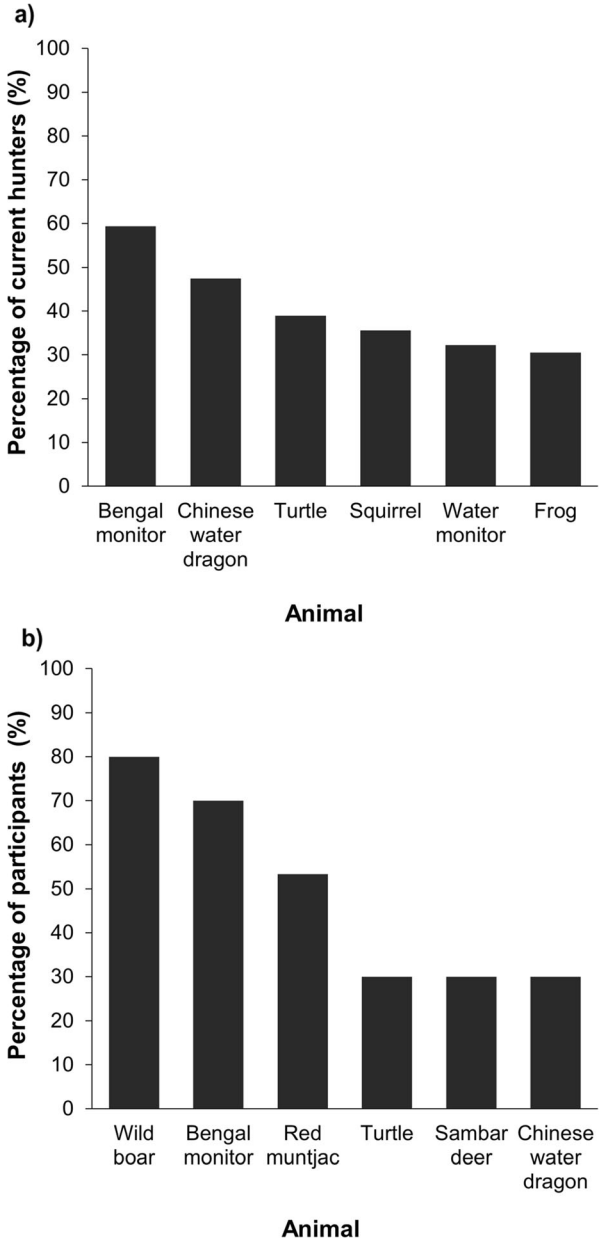


**Fig. 2** (**a**) The six animals most frequently hunted by current hunters ($N = 59$) and (**b**) the six wild animals most frequently consumed by participants ($N = 90$). We interviewed participants from five villages surrounding Veun Sai-Siem Pang National Park, Cambodia, from December 2, 2017 to December 20, 2017.

**Table IV** Number of current hunters ($N$ = 61) that currently hunt primates in each of the five villages surrounding Veun Sai-Siem Pang National Park in Cambodia

| Province | Village | Ethnicity | Current hunters | Hunts primates | Does not hunt primates |
|---|---|---|---|---|---|
| Ratanakiri | Backae | Lao | 10 | 2 | 8 |
| | Kang Nuok | Kavet | 16 | 10 | 6 |
| | I Tub | Lao | 15 | 0 | 15 |
| Stung Treng | Kapin | Kavet | 7 | 2 | 5 |
| | Talae | Kavet | 13 | 9 | 4 |

We conducted interviews from December 2, 2017 to December 20, 2017.

Primates have been consumed by 39% (37/95) of participants, with a significantly greater number of Kavet participants having done than Lao participants [$\chi^2$ (1, $N$ = 92) = 13.45, $P$ < 0.001]. When we asked all participants if other people hunt primates in their village, 42% (40/96) said yes, with a significantly greater number of Kavet participants giving this response than Lao participants [$\chi^2$ (1, $N$ = 87) = 10.24, $P$ = 0.001]. The greatest number of participants said that others hunt *Nycticebus pygmaeus* (75%, 30/40), followed by *Macaca fascicularis* (40%, 16/40; Fig. 5). An additional three participants thought others currently hunt loris but were unsure of which species.

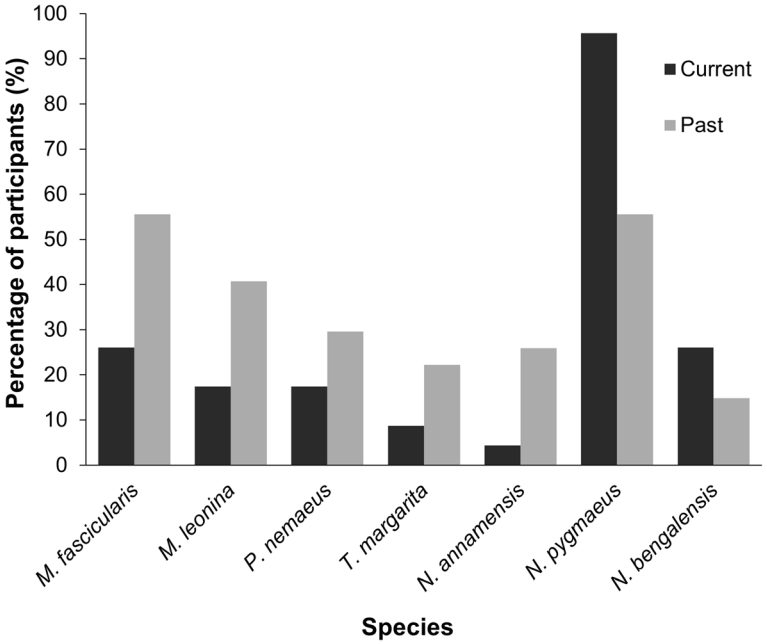


**Fig. 3** Percentage of primate hunters that currently hunt each primate ($N$ = 23) or has hunted each primate in the past ($N$ = 27). We interviewed participants from five villages surrounding Veun Sai-Siem Pang National Park, Cambodia, from December 2, 2017 to December 20, 2017.

**Table V** Number of current primate hunters ($N = 23$) that hunt different primate species in each season and location, with methods used, the reasons for hunting, and how long they have been doing so

| Species | *M. fascicularis* | *M. leonina* | *P. nemaeus* | *T. margarita* | *N. annamensis* | *N. pygmaeus* | *N. bengalensis* |
|---|---|---|---|---|---|---|---|
| *N* | 6 | 4 | 4 | 2 | 1 | 22 | 6 |
| Location[a] | | | | | | | |
| VSSP | 5 | 3 | 3 | 1 | 1 | 19 | 6 |
| Farm | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| Virachey NP | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| Methods | | | | | | | |
| Dog | 4 | 2 | 4 | 2 | 1 | 0 | 0 |
| Trap | 4 | 2 | 0 | 1 | 0 | 5 | 3 |
| Knife | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| Homemade gun | 0 | 1 | 0 | 0 | 0 | 5 | 1 |
| Commercial gun | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Slingshot | 0 | 0 | 0 | 0 | 0 | 4 | 2 |
| Crossbow | 0 | 0 | 0 | 0 | 0 | 9 | 1 |
| By hand | 1 | 0 | 0 | 0 | 0 | 7 | 3 |
| Other | 1 | 1 | 3 | 2 | 1 | 2 | 0 |
| Reason | | | | | | | |
| Income | 1 | 0 | 0 | 0 | 0 | 20 | 6 |
| Food | 5 | 4 | 4 | 2 | 1 | 0 | 1 |
| Pet | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Traditional medicine | 0 | 0 | 0 | 0 | 0 | 5 | 1 |

**Table V** (continued)

| Species | *M. fascicularis* | *M. leonina* | *P. nemaeus* | *T. margarita* | *N. annamensis* | *N. pygmaeus* | *N. bengalensis* |
|---|---|---|---|---|---|---|---|
| Years hunted | | | | | | | |
| <1–4 | 4 | 2 | 2 | 0 | 0 | 4 | 1 |
| 5–9 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| 10–19 | 1 | 1 | 1 | 1 | 0 | 10 | 1 |
| 20+ | 1 | 1 | 1 | 1 | 1 | 6 | 4 |
| Season | | | | | | | |
| Wet | 2 | 2 | 2 | 1 | 1 | 20 | 6 |
| Dry | 5 | 4 | 3 | 2 | 1 | 9 | 1 |

We accepted more than one answer for all questions except years hunted. We interviewed participants from five villages surrounding Veun Sai-Siem Pang National Park, Cambodia, from December 2, 2017 to December 20, 2017.

[a] For *M. fascicularis*, *M. leonina*, *P. nemaeus*, *T. margarita*, and *N. pygmaeus*, the value of *N* for Location is one less than the listed *N* value because one current primate hunter did not provide an answer.

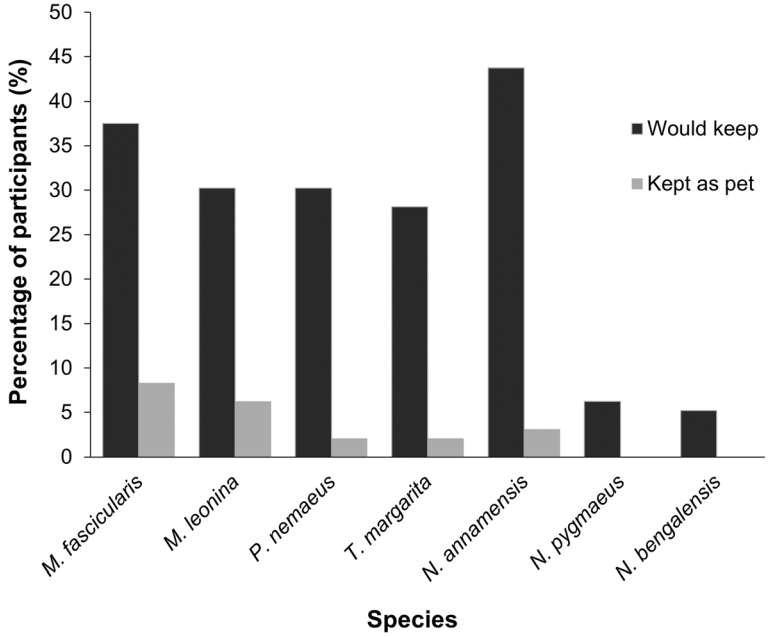


**Fig. 4** Percentage of participants ($N = 96$) that would keep each of the seven primates as a pet and the percentage of participants ($N = 96$) that has kept each species as a pet. We interviewed participants from five villages surrounding Veun Sai-Siem Pang National Park, Cambodia, from December 2, 2017 to December 20, 2017.

Three of the 17 participants who believe others hunt monkeys or small apes in VSSP reported that commercial guns are one of the methods used.

Of all primate species, the highest number of participants said that the *Nycticebus pygmaeus* population has decreased compared to 5 yr ago (35%, 29/82; Table VI). If they encountered lorises, 45% (41/92) of participants would hunt *N. pygmaeus* and 41% (37/91) would hunt *Nycticebus bengalensis*. When we asked current hunters why they do not hunt primate species other than those they currently hunt, the four most frequent responses, given solely or together with other reasons, were because they do not have equipment (44%, 24/54), they do not eat primates (30%, 16/54), they do not know how to catch the primates (20%, 11/54), and tradition (15 %, 8/54).

## Primate Trade

Many participants (59%, 57/96) have seen primates sold in their village, with a significantly greater number of Kavet participants seeing them sold in their village than Lao participants [$\chi^2$ (1, $N = 93$) = 12.61, $P < 0.001$]. The greatest number of participants had seen *Nycticebus pygmaeus* sold (47/96), and 49% (23/47) of these participants had seen this species sold within the previous year. According to participants, who could select more than one primate species, people most want to buy *N. pygmaeus* (51%, 44/86), followed by *Nycticebus bengalensis* (23%, 20/86) and *Macaca fascicularis* (3%, 3/86), and 40% (34/86) were unsure. Nearly all current primate hunters have sold primates before (96%; 22/23) including *N. pygmaeus*

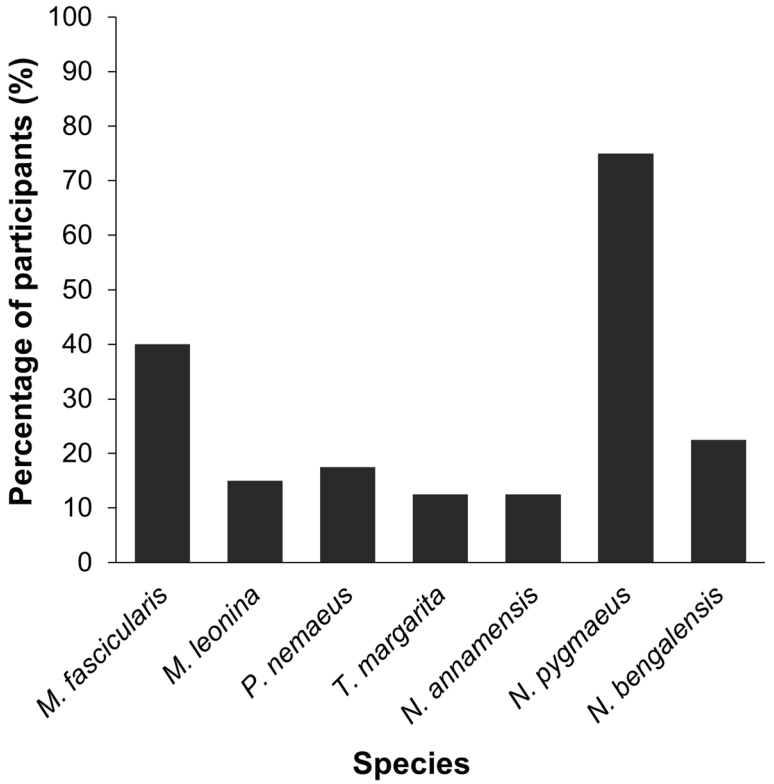


**Fig. 5** Percentage of participants that believe others are hunting each primate species in their village ($N = 40$). We interviewed participants from five villages surrounding Veun Sai-Siem Pang National Park, Cambodia, from December 2, 2017 to December 20, 2017.

(95%, 21/22), with 57% (12/21) having sold at least one *N. pygmaeus* individual in the past year (Table VII). When we asked current and past primate hunters that have sold *N. pygmaeus* before ($N = 31$) where people come from to purchase *N. pygmaeus* (solely or in combination with other locations), the most frequent response given was Veun Sai (47%, 14/30) and/or Ban Lung (40%, 12/30). When we asked why people bought it from them (with more than one response accepted), 48% (15/31) said it was for traditional medicine, and 52% (16/31) were not aware of the reason.

## Law Enforcement

The risk of getting caught hunting in VSSP by a ranger is considered low by 63% (60/96) of all participants, medium or high by 14% (13/96), while 24% (23/96) of participants were unsure of the risk. Only 3% of participants (3/95) knew anyone that had been caught hunting by a ranger and 2% (2/95) of participants were aware of anyone that had been caught selling wildlife by a ranger. The penalty when caught hunting in VSSP by rangers was unknown by 47% (45/96) of participants (Fig. 6a); similarly, 56% (54/96) did not know the penalty for selling wildlife (Fig. 6b).

**Table VI** The number (percentage) of participants that believe the population size of each primate species in Veun Sai-Siem Pang National Park (VSSP), Cambodia, has remained the same, increased or decreased compared to 5 yr ago, and the number (percentage) of participants who would ignore or hunt each species if encountered in VSSP

| Species | *M. fascicularis* | *M. leonina* | *P. nemaeus* | *T. margarita* | *N. annamensis* | *N. pygmaeus* | *N. bengalensis* |
|---|---|---|---|---|---|---|---|
| Population trend | | | | | | | |
| *N* | 83 | 82 | 82 | 83 | 83 | 82 | 80 |
| Increase | 64 (77%) | 60 (73%) | 56 (68%) | 55 (66%) | 57 (69%) | 21 (26%) | 15 (19%) |
| Same | 3 (4%) | 5 (6%) | 4 (5%) | 6 (7%) | 8 (10%) | 3 (4%) | 1 (1%) |
| Decrease | 8 (10%) | 4 (5%) | 5 (6%) | 2 (2%) | 4 (5%) | 29 (35%) | 12 (15%) |
| Unknown | 8 (10%) | 13 (16%) | 17 (21%) | 20 (24%) | 14 (17%) | 29 (35%) | 52 (65%) |
| Action | | | | | | | |
| *N* | 93 | 94 | 94 | 94 | 94 | 92 | 91 |
| Ignore | 89 (96%) | 91 (97%) | 91 (97%) | 91 (97%) | 91 (97%) | 51 (55%) | 52 (57%) |
| Hunt | 4 (4%) | 3 (3%) | 3 (3%) | 3 (3%) | 3 (3%) | 41 (45%) | 37 (41%) |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 2 (2%) |

We interviewed participants from five villages surrounding VSSP from December 2, 2017 to December 20, 2017.

**Table VII** The number of years since participants ($N = 57$) have seen each primate species sold in their village and the number of years since current primate hunters have sold each primate species ($N = 22$)

| Species | *M. fascicularis* | *M. leonina* | *P. nemaeus* | *T. margarita* | *N. annamensis* | *N. pygmaeus* | *N. bengalensis* |
|---|---|---|---|---|---|---|---|
| All participants | | | | | | | |
| *N* | 11 | 3 | 3 | 1 | 3 | 47 | 7 |
| >1 yr | 0 | 0 | 0 | 0 | 0 | 23 | 2 |
| 1–2 yr | 4 | 0 | 1 | 0 | 0 | 11 | 3 |
| 3–5 yr | 1 | 0 | 0 | 0 | 0 | 8 | 1 |
| 6–10 yr | 2 | 1 | 0 | 0 | 1 | 2 | 1 |
| 11+ yr | 4 | 2 | 2 | 1 | 2 | 1 | 0 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| Current primate hunters | | | | | | | |
| *N* | 2 | 0 | 0 | 0 | 2 | 21 | 3 |
| >1 yr | 0 | — | — | — | 0 | 12 | 1 |
| 1–2 yr | 1 | — | — | — | 1 | 8 | 2 |
| 3–5 yr | 0 | — | — | — | 0 | 1 | 0 |
| 6–10 yr | 0 | — | — | — | 0 | 0 | 0 |
| 11+ yr | 1 | — | — | — | 1 | 0 | 0 |
| Unknown | 0 | — | — | — | 0 | 0 | 0 |

We interviewed participants from five villages surrounding Veun Sai-Siem Pang National Park, Cambodia, from December 2, 2017 to December 20, 2017.

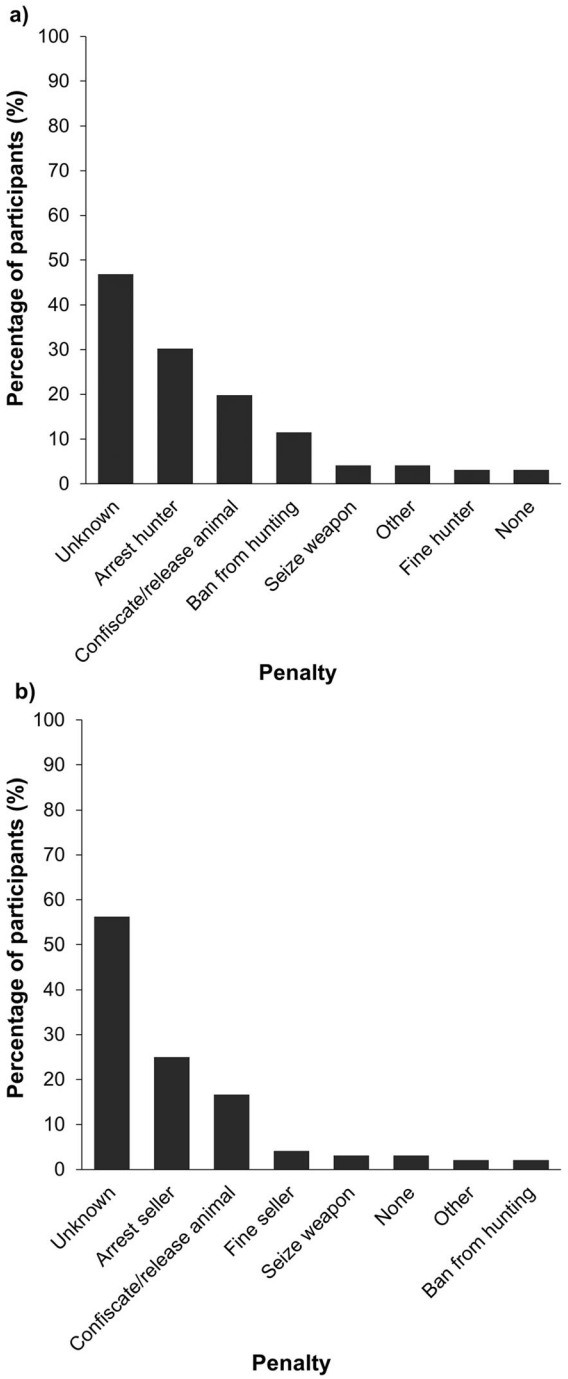


**Fig. 6** Percentage of participants ($N$ = 96) that anticipated each penalty if a person is caught (**a**) hunting wildlife in Veun Sai-Siem Pang National Park (VSSP), Cambodia, and (**b**) selling wildlife by a ranger. More than one response was accepted per participant. We interviewed participants from five villages surrounding VSSP from December 2, 2017 to December 20, 2017.

## Discussion

This study demonstrates that hunting is an important activity for local people in the villages surrounding VSSP. In these communities, hunting supports the livelihoods of local people, is culturally significant and is a skill that is passed down through generations. Many current hunters hunt solely in VSSP or in combination with other areas. Additionally, many local people consume bushmeat, with participants reporting they consume numerous animals including wild boar, red muntjac, and the Bengal monitor. These findings indicate that the illegality of hunting in VSSP has not been a deterrent. While our results reveal that primates are targeted, they are not the most frequently hunted or consumed wildlife in the park. Furthermore, our results indicate that the current hunting pressure on the four monkey species and *Nomascus annamensis* populations in VSSP may be lower than in the past. Almost all participants stated that they would not hunt these species if encountered in the forest and 66–77% of participants thought populations of these species in VSSP had increased in the last 5 yr. The hunting pressure on *Nycticebus pygmaeus* in the park, however, is high.

The Endangered *Nycticebus pygmaeus* is the most frequently hunted, sold, and sought-after primate in VSSP according to current primate hunters and nonprimate hunters. All but one current primate hunter targets this species, with an average offtake of two lorises per year each, while >70% of current *N. pygmaeus* hunters have targeted the species for 10 yr or more. Once found, *N. pygmaeus* is easy to capture by hand, slingshot, and crossbow, supporting the results of previous studies in the area (Iseborn 2011) and nearby Mondulkiri Province (Starr *et al.* 2011). Unlike *Nomascus annamensis* and the four monkey species of VSSP, *N. pygmaeus* is hunted primarily as a source of income, as the individuals are sold for use in traditional medicine, which continues to be a popular and trusted practice in Cambodia (Ashwell and Walston 2008; Ros *et al.* 2018). Most current primate hunters have sold *N. pygmaeus* before and almost half of all participants reported seeing *N. pygmaeus* being sold in their village, primarily to local people from two known wildlife trade areas (Hill 2011), the nearby village Veun Sai or the Ratanakiri Province capital Ban Lung. *N. pygmaeus* is sold dried on bamboo sticks (Rawson 2007) and used to treat wounds, stomach issues, and women following childbirth (Hill 2011; Iseborn 2011; Starr *et al.* 2010).

Between 2010 and 2012 there was a decrease in the average encounter rates for *Nycticebus pygmaeus* in VSSP (Eam 2012; Iseborn 2011; Streicher 2010), which may indicate a decline in population size. Of all primates in VSSP, the highest number of participants in our study believe the *N. pygmaeus* population is declining. No field surveys have been conducted since 2012, but severe population declines of this species due to a high hunting pressure have been reported by local people and field surveys in the nearby Mondulkiri Province (Starr *et al.* 2011). Reductions in the populations sizes of *N. pygmaeus* in Cambodia have resulted in price increases in the past (Starr *et al.* 2010) so the incentives to capture individuals in VSSP as the population size declines will likely remain high. This loris has also been captured unsustainably in Vietnam for use in the pet trade and traditional medicine (Nadler *et al.* 2007). The species may take a long time to recover from a reduction in population size due to its long gestation of 187–203 days (Jurke *et al.* 1998) and seasonal reproductive cycle (Streicher 2004). These factors, together with the ease of capture once seen, and demand for and willingness of participants to capture *N. pygmaeus* if encountered in VSSP are alarming

for the conservation of the species and may indicate a high and unsustainable hunting pressure.

In accordance with previous studies (Iseborn 2011; Rawson *et al.* 2012), we found current hunters target the Endangered *Nycticebus bengalensis* in VSSP. However, many participants did not know the state of the current population of *N. bengalensis*, frequently commenting this was because they had never seen the species. As with *Nycticebus pygmaeus*, this species is hunted primarily for income and 41% of participants would capture *N. bengalensis* if they encountered it in the park. While the 2007 market value of both loris species in Cambodia was more than twice the 1997 market value, *N. bengalensis* had a lower market value than *N. pygmaeus* (Starr *et al.* 2010). The use of lorises for traditional medicine in these communities is consistent with other parts of Cambodia (Starr *et al.* 2010). In Vietnam, *N. bengalensis* is rare and populations across much of species' range have likely significantly reduced due to hunting pressure (Nadler *et al.* 2007). The presence of this species in VSSP has not been confirmed by field surveys (Iseborn 2011; Rawson *et al.* 2012), which may indicate that the species is not abundant in the area and if present, has a smaller population size than *N. pygmaeus* (Rawson *et al.* 2012). In VSSP, further research is urgently needed to confirm the presence and size of any population of *N. bengalensis*.

In addition to the threat to *Nycticebus* species in VSSP, other primates were noted to be potential targets in our survey. This is of conservation importance, as the park is the only known location of the Critically Endangered *Pygathrix nemaeus* in Cambodia, with a population size that could be in the thousands (Rawson *et al.* 2012). As with other sites in Cambodia where *Trachypithecus germaini* and *Trachypithecus margarita* are found, the density of *T. margarita* in VSSP is not known (Moody *et al.* 2011; Rawson *et al.* 2012). Currently, *T. margarita* is still combined with the Endangered *T. germaini* on the IUCN Red List of Threatened Species, as additional taxonomic work is required to determine whether they are separate species (Duc *et al.* 2020). Genetic evidence suggests that populations found east of the Mekong River, including VSSP, are of a separate species called *T. margarita* (Roos *et al.* 2008), hence our use of this nomenclature. There was no known hunting pressure on this species in the park in 2012 (Rawson *et al.* 2012), but hunting pressure on *T. germaini* populations (including *T. margarita*) across Cambodia is still poorly understood (Moody *et al.* 2011). *T. germaini* has experienced drastic reductions in population sizes in both Laos (Timmins *et al.* 2013) and Vietnam (Nadler *et al.* 2007) due to human activities. Cambodia is considered a global stronghold for *T. germaini* (Moody *et al.* 2011), giving the VSSP population even greater conservation importance as the populations in Cambodia may be split into two distinct species and consequently have smaller populations.

VSSP contains one of the largest known populations of the recently described Endangered gibbon *Nomascus annamensis* (Rawson *et al.* 2012). While this species had previously been targeted in the park for use as pets, in 2007 it was reported that the species had not been hunted in VSSP in recent years (Rawson 2007). However, in 2011 *N. annamensis* and *Macaca fascicularis* were the most targeted primates in VSSP for the pet trade (Hill 2011). Our results show that *N. annamensis* is still the most desired primate in VSSP for use as a pet and that *N. annamensis* and the four monkey species are being targeted by up to approximately a quarter of current primate hunters primarily for food, in addition to being wanted by participants for personal use as pets. Our

results reveal that *M. fascicularis* is the second most in demand primate species for personal use as a pet, although the pet trade for the species in Cambodia is thought to be largely local and therefore less of a conservation threat (Rawson 2010).

Unfortunately, along with other *Macaca fascicularis* populations in Cambodia (Eudey 2008), this Vulnerable species' population in VSSP has declined greatly (Rawson 2007), as it was targeted for captive breeding programs for export largely to China and the USA for biomedical research and testing (Eudey 2008). Our study shows that of the four monkey species and *Nomascus annamensis*, *M. fascicularis* was hunted the most in VSSP in the past by primate hunters. However, fewer than 5% of participants stated that *M. fascicularis* is the most in demand primate for purchase and none of the participants had seen the species sold in their village in the previous 12 mo. Furthermore, although participants believed this species is the second most hunted primate in VSSP following *Nycticebus pygmaeus*, most participants thought that the population size of *M. fascicularis* had increased and said they would ignore the animals if they encountered them in the forest. This finding is positive as local people said that the size of all six confirmed primate populations in VSSP had declined over 5 yr during a previous study in 2011, with *M. fascicularis* and *N. pygmaeus* populations declining the most (Hill 2011). These findings indicate that *M. fascicularis* may be hunted less frequently currently than in the past, but further research is needed to determine the population size of *M. fascicularis* in VSSP.

Camera traps indicate that the Vulnerable *Macaca leonina* is abundant in the park (Rawson *et al.* 2012) and in 2007 it was reported that there was no hunting or trade of *M. leonina* in VSSP (Rawson 2007). Our study shows that the species is targeted by some current primate hunters, as are all other primates, but there is less hunting pressure and demand for this species than for other primates in the park. During the study we encountered two captive *M. leonina* individuals in different villages but we were told this was not intentional as they were caught in traps set to capture wild boar or squirrels. Some current primate hunters also reported they had captured *M. fascicularis* individuals accidentally in the same manner.

Approximately a quarter of past primate hunters reported using commercial guns to hunt and almost 40% of participants have eaten primates before. Many stated they consumed primates many years ago and several participants commented that this was before guns were confiscated in the area in the early 1990s. These findings, together with the lower percentage of current primate hunters targeting the four monkey species and *Nomascus annamensis* than the percentage of participants targeting these species in the past only, may be due primarily to the temporarily increased availability of commercial guns following the Khmer Rouge (1975–1979) (Loucks *et al.* 2009). From 1993 onward, guns were confiscated and destroyed around the country and the number of legal firearms was limited (Loucks *et al.* 2009). Currently, the use of weapons to trap animals and the use of hunting dogs in protected areas in Cambodia such as VSSP is prohibited (CDC 2011). However, a greater percentage of current primate hunters use homemade guns than past primate hunters did, primarily to hunt *Nycticebus pygmaeus*. No current primate hunters stated they personally use commercial guns, yet a small number of participants believe others in their village use this method to hunt primates.

Our findings indicate that the use of commercial guns to hunt primates is likely occurring at lower rates following the confiscation of guns from 1993.

When we asked current hunters why they do not hunt primate species other than those they currently hunt, the most frequent response given solely or together with other reasons was because they do not have equipment. Given the past primate hunting practices and the high demand for *Nomascus annamensis*, *Pygathrix nemaeus*, *Trachypithecus margarita*, *Macaca leonina*, and *Macaca fascicularis* as pets, the hunting pressure on these species may increase in the future if access to commercial guns increases. While species such as *M. leonina* and *M. fascicularis* do get caught in traps, commercial guns would be an easier method to capture primates in VSSP, and they are also more powerful than other methods including homemade guns. Gibbon populations have declined primarily due to hunting with guns in Vietnam (Rawson *et al.* 2011), and gun use is considered a major threat to gibbons in Laos (MAF 2011). If commercial guns become prevalent in VSSP, *N. annamensis* would become easier to hunt, particularly as their morning vocalisations reveal their location, which would be easy to access via tracks created for illegal logging. Ongoing monitoring of the hunting pressure on all primates and of primate population sizes in VSSP is needed to detect changes in population size, demand, and availability of equipment.

Understanding local people's attitudes and the reasons why people hunt wildlife and the perception of associated risks and alternatives is needed for more effective conservation policies to decrease hunting pressure on wildlife (Borgerson *et al.* 2016). The change in protection status of VSSP in 2016 was a step in the right direction but did not mean the reliance of local communities on forest resources suddenly ceased. Without additional measures including the creation of alternative income sources and improved access to medical care and food resources, hunting behaviors will not change. Law enforcement is a crucial component of conservation plans to reduce hunting (Harrison *et al.* 2016), but it will have greater impact when part of a multipronged strategy, involving awareness and education programs (Corlett 2007). Some of these programs have been conducted in these communities and we recommend additional programs in the future that illustrate the current threats to VSSP and the benefits of protecting the park in addition to programs that provide details of the protected areas law and conservation policies in the area. Our study shows that the perceived risk of being discovered by law enforcement while hunting in VSSP is low. Very few participants knew of anyone caught hunting in VSSP or selling wildlife and many did not know the penalties incurred. This highlights the need to increase awareness of the penalties for hunting and selling wildlife and the frequency of patrols in VSSP and known wildlife trade areas, including nighttime patrols in VSSP to reduce hunting of *Nycticebus pygmaeus*.

For greater success, primate conservation policies need to be developed based on ethnoprimatological studies, incorporating both qualitative and quantitative research that considers both human and animal perspectives (Parathian and Maldonado 2010; Shaffer *et al.* 2018). When areas become protected, those living nearby are often negatively affected, and it is vital to understand the impacts of conservation plans on these neighbouring communities (Hill 2002). By understanding the reasons behind human-nonhuman primate interactions, conservation plans can include strategies that

address the needs of local communities and decrease their reliance on primates. However, local communities need to be involved in the decision making process, such as through comanagement with the government (Bennett and Robinson 2000). It is crucial that these communities know that they can benefit from protecting these forest lands and primates therein (Estrada *et al.* 2017). This may also increase support and compliance from local people (Ellwanger *et al.* 2015). Hunting is a major part of the culture of these communities and is unlikely to stop entirely, as this skill is passed on through each generation and hunters said their livelihoods would be negatively affected if they were to stop hunting. However, if hunters were to obtain an alternative source of income, approximately 60% would stop hunting, with more Kavet hunters willing to stop than Lao hunters, which is an encouraging finding for primate conservation in VSSP.

Common strategies to reduce bushmeat consumption and trade of wildlife provide alternative sources of protein and income (SCBD 2011). Potential alternative sources of income for the communities surrounding VSSP could include employing additional research guides and rangers, the implementation of carbon payments (Dinerstein *et al.* 2013), and payment for ecosystem services schemes (Tuanmu *et al.* 2016), including those that protect specific wildlife populations (Clements *et al.* 2013; Dinerstein *et al.* 2013) and additional community-based ecotourism programs. Moreover, programs that provide domestic meat to decrease the need for bushmeat by rural people may reduce the hunting pressure on wildlife (Bennett and Robinson 2000). These programs could benefit people in these communities, and primates and other wildlife in VSSP as approximately 40% of participants did not prefer bushmeat to domestic meat. An alternative strategy is to allow local communities to hunt specific, more resilient species so people can still obtain income and protein from bushmeat (Nasi *et al.* 2011). However, this strategy is met with additional challenges and would require strong enforcement and compliance to ensure prohibited threatened species are not targeted (Harrison *et al.* 2016). For VSSP, this strategy would require a substantial increase in law enforcement activity and number of rangers in the park. We will communicate our findings and recommendations to Conservation International to assist with park management. By understanding the role that primate species play in the lives of local people and the potential negative impacts on local communities resulting from not hunting these species, conservation policies can be developed that provide alternatives to hunting primates, ensuring that the needs of the local people are met.

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