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# 1 Estimating hunting prevalence and wild meat reliance in

# 2 Cambodia's Eastern Plains

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#### 12 Abstract

13 Hunting is a primary driver of biodiversity loss across south-east Asia. Within Cambodia, the use 14 of wire snares to capture wildlife has been highlighted as a severe threat in protected areas; 15 however, few studies document the behaviour of hunters from local communities. Here, we 16 combine the Unmatched Count Technique with direct questioning to estimate the prevalence of 17 different hunting behaviours and wildlife consumption amongst 705 households living in Keo 18 Seima Wildlife Sanctuary, Cambodia. We assessed local communities' knowledge of rules, and 19 their perceptions of patrols responsible for enforcing rules. Estimates of hunting behaviour 20 varied; results from the UCT were inconclusive, while direct questioning revealed 9% of 21 households hunted, and 20% set snares around farms to kill crop raiding wildlife. Domestic dogs 22 were the method most commonly used to catch wildlife, 87% of households owned a mean of 23 2.91 dogs. Wild meat was consumed by 84% of households, and most frequently bought or 24 caught. We detected a high awareness of conservation rules, but low awareness of punishments 25 and penalties, with wildlife depletion, rather than the risk of being caught by patrols, having a 26 greater effect on hunting reduction. Our findings demonstrate the challenges associated with 27 deriving reliable estimates of rule-breaking behaviour and highlight the need to incorporate 28 careful triangulation into study design.

29

30

### 31 Key words

32 Bushmeat, poaching, snares, law enforcement, ranger patrols, protected areas, Unmatched

33 Count Technique

# 34 Introduction

35 Hunting endangers a quarter of terrestrial mammal species worldwide (Ripple et al., 2016), and 36 is estimated to have decreased bird and mammal abundances by 58% and by 83% respectively 37 in some hunted areas in the tropics (Benitez-Lopez et al., 2017). The situation is particularly 38 severe in Southeast Asia, where most large wild vertebrate species have experienced substantial 39 population declines throughout their remaining ranges (Sodhi et al., 2004; Harrison et al., 2016). 40 Here, forests are increasingly considered 'empty'; devoid of all but the smallest or most common 41 of species (Harrison, 2011), with overexploitation facilitated by advancements in hunting 42 technologies, rapid economic growth, and improved access to forested areas (Harrison et al., 43 2016; Hughes, 2017).

44

45 Cambodia is one of the most biodiverse countries in SE Asia (Daltry, 2008) and is legally one of 46 the best protected, with 34% of terrestrial land area afforded protected status (Souter et al., 47 2016). However, in reality protected areas (PAs) are chronically underfunded, overexploitation of 48 natural resources is widespread, and laws are weakly enforced (Souter et al., 2016). Hunting has 49 likely driven species such as the kouprey (Bos sauveli) to extinction, extirpated the Javan rhino 50 (Rhinoceros sondaicus) and tiger (Panthera tigris ssp.) (O'Kelly et al., 2012), and continues to 51 threaten the viability of many others (Starr et al., 2011; O'Kelly et al., 2012; Rostro-garcía et al., 52 2016). According to Nielsen et al. (2018), Cambodia has one of the highest prevalence of hunting 53 and wild meat reliance in the world, with an estimated 83.3% of rural households engaged in 54 some form of harvest of wild animals at least once during the survey year. Snares are widely 55 used; in 2015 alone, 27,714 were removed by patrols in Cambodia's South Cardamoms National 56 Park (Gray et al., 2016), with true snare abundance probably much higher, as experimental 57 studies suggest only a small proportion of the snares that are set, are found by rangers (O'Kelly 58 et al., 2018). Usually made from wire, cable, or nylon, snares are affordable, accessible, and 59 have limited selectivity with respect to animals' species, sex, or age (Noss, 1998). Once set, they 60 can trap a wide range of arboreal and terrestrial species (Borgerson, 2015; Ingram et al., 2017),

and although animals occasionally escape, subsequent nonfatal injuries often jeopardize longterm survival (Yersin et al., 2017).

63

64 While the impact of hunting on Cambodia's fauna is well documented (Harrison, 2016), there is 65 less empirical information about hunters, their hunting methods, and local demand for wildlife 66 products (but see Martin & Phipps, 1996; Loucks et al., 2009; Coad et al., 2019). This information 67 gap may partly occur because gathering robust information about hunting is challenging. 68 especially in contexts where hunting is a restricted or prohibited activity (Nuno & St John, 2015). 69 Hunting in Cambodian PAs is a punishable offence (FA, 2002; MoE, 2008), thus those who 70 violate rules may not wish to identify themselves for fear of sanctions (Solomon et al., 2007). 71 When asked directly, respondents may refuse to participate, provide inaccurate responses, 72 conceal their true attitudes, beliefs or behaviours, or temper their answers so as to appear more 73 socially acceptable ('social desirability bias') (Tourangeau & Yan, 2007; Krumpal, 2013). 74 Acquiring robust and reliable data on hunting prevalence is nonetheless important to ensure 75 conservation interventions are targeted towards the most appropriate groups (St John et al., 76 2013; Jones et al., 2019).

77

78 Here, we quantify the prevalence of hunting amongst rural communities in a Cambodian PA. We 79 use the Unmatched Count Technique (UCT), an indirect questioning approach, to estimate the 80 prevalence of hunting as a subsistence and income-generating livelihood activity. Specialised 81 questioning techniques, such as the UCT, can enable the biases typically associated with direct 82 questioning to be overcome by assuring greater levels of anonymity, although often at the cost of 83 lower precision (Nuno & St John, 2015). We couple this with direct questioning to derive further 84 information about seasonality, methods used, species caught and consumed, and trends in 85 hunting activity. Finally, we assess local communities' knowledge of rules regarding the capture 86 and use of wildlife, alongside their perceptions of the ranger-patrols responsible for enforcing PA 87 rules.

89 Study area

Our study was conducted in Keo Seima Wildlife Sanctuary (KSWS), a 2927km<sup>2</sup> area of protected
mixed deciduous dipterocarp, semi-evergreen, and evergreen forest in Mondulkiri and Kratie
provinces on the eastern border of Cambodia (Fig. 1) (Evans et al., 2012). The PA supports
regionally important populations of Asian elephant (*Elephas maximus*), wild cattle (*Bos* spp.), and
globally important populations of primates (*Nomascus gabriellae, Pygathrix nigripes*) (Griffin,
2019).

96

97 Approximately 32,000 people live within and around KSWS, the majority of whom are Bunong, 98 an animist minority indigenous people who have strong spiritual connections to the forest and its 99 wildlife. Traditionally, the Bunong practised swidden agriculture, and relied heavily on Non-100 Timber Forest Products (NTFPs) such as honey, fish, rattan, wild fruit, vegetables and wildlife for 101 subsistence (Evans et al., 2003). The construction of roads has brought market integration to 102 previously inaccessible villages and strengthened cross-border trade links with Vietnam 103 (Mahanty & Milne, 2016). Many households have abandoned traditional swidden agricultural 104 practices in favour of more profitable cash crops such as cassava and cashew (Travers et al. 105 2015). Villages, particularly those on the periphery, have experienced large influxes of Khmer 106 (the majority ethnic group in Cambodia) families seeking land, and forest cover has declined as a 107 result of subsequent small-scale farm clearance (Mahanty & Milne, 2016; Riggs et al., 2018). In 108 addition, the forest has experienced severe pressure from illegal logging for luxury timber, as well 109 as industrial-scale forest clearance associated with Government granting of Economic Land 110 Concessions within PA boundaries.

111

Prior to 2016, KSWS was managed as a Protection Forest by the Royal Government of Cambodia's Forestry Administration. In 2016 jurisdictional reforms of natural resource management resulted in site transfer to the Ministry of Environment under sub-decree 83, and reclassification as a Wildlife Sanctuary, with the principal objective of preserving and protecting wildlife (MoE, 2016). According to the 2002 Forestry Law, it is strictly prohibited to hunt, harm or harass all wildlife, and under the 2008 Protected Area Law, killing wildlife and releasing hunting

- 118 dogs is strictly forbidden throughout, while regulated extraction of NTFPs and sustainable use is
- allowed in some zones within the PA (MoE, 2008). Hunting occurs throughout KSWS, previous
- 120 research has highlighted the reliance of local communities on wild meat for subsistence
- 121 purposes (Travers, 2014), and to supplement income. Hunting is also undertaken by outsiders
- 122 for sport, commercial purposes and subsistence (Drury, 2005; Evans et al., 2013). Responsibility
- 123 for enforcing rules lies with 40-50 government rangers distributed across 10 patrol stations. The
- 124 government has received financial and technical support for the management of KSWS from
- 125 WCS since 2002.

### 126 Methods

#### 127 Household Questionnaire

Between February and April 2018, we interviewed 705 households in 18 villages (Fig. 1). Between 30-50% of households were surveyed per village, with houses identified using a systematic sampling strategy where interviews were conducted at every *n*<sup>th</sup> house, with *n* inversely related to village size. We surveyed any available respondent above the age of 18 in each household. If respondents declined or were absent, interviews were conducted at the next available house.

134

Interviewers collected data on respondent demographics and household livelihood strategies, household reliance on different wildlife species for meat and medicine, specifically the frequency with which species were consumed, whether wildlife was bought or caught, the meat most preferred to eat. Respondents were also asked about conflict with wildlife on farms, and their perceptions regarding change in hunting levels over the previous five years.

140

#### 141 Measuring hunting prevalence

142 To reduce social desirability and non-response biases, we used the UCT to investigate the 143 proportion of households that collected wild meat, took snares to the forest to hunt, and hunted 144 to generate income in the previous year. Half the sample were randomly allocated to a 'control' 145 group who received a list of non-sensitive items, while the 'treatment' group received a list which 146 included the same non-sensitive items, plus an additional sensitive item (Nuno & St John, 2015). 147 Respondents were asked to report only the *number* of items applicable to them, never which 148 items. Item scores were averaged across groups, and the prevalence of the sensitive item was 149 estimated from the difference between the means. UCT requires large sample sizes, and 150 estimates can have wide standard errors (Hinsley et al., 2019); to mitigate against this, we 151 employed a double-list UCT, whereby participants simultaneously act as control and treatment 152 groups by answering two different lists for each question, one of which always contains the 153 sensitive item (Droitcour et al., 1991). Prevalence is derived by calculating the mean score

across the paired lists (Glynn, 2013). Due to high illiteracy levels, pictorial lists were used, and
items were verbally described to participants. A practice question on fruit consumption was used
to introduce the method to respondents, and follow-up questions were asked to assess
respondents' understanding. At the end of the questionnaire, respondents were asked directly
whether they currently or had ever hunted, the species they caught, how often they hunted, the
methods used, and their reasons for hunting.

160

#### 161 *Knowledge of conservation rules*

We assessed knowledge of rules pertaining to hunting activity, and the perceived likelihood of a) a neighbour knowing if someone had caught wildlife, b) being caught by a patrol when hunting, c) receiving a penalty if caught. We measured social acceptability by asking respondents whether they would approve if a friend or family member went hunting. Finally, we asked households whether they had ever been caught by a patrol in possession of wildlife, and if so what happened.

168

#### 169 Ethical Considerations

170 Upon arrival in each village, we met the village chief to explain research aims and seek 171 permission to work in the community. Before each interview the research purpose, risks, benefits, 172 and proposed data-use were explained to participants before verbal consent was sought 173 (Appendix S2). All interviews were voluntary, anonymous, and conducted in Khmer or Bunong by 174 independent enumerators, unassociated with WCS. Hunting is illegal, to protect participants 175 against reprisals questions on hunting were targeted at the household rather than individual 176 level, and village names have been anonymised to offer additional protection. All methods were 177 piloted before data collection (n=33 households).

178

#### 179 UCT analysis

180 Prior to analysis, UCT data were tested to determine whether individual responses to the non-

181 sensitive item changed depending upon the respondents' treatment status (design effects). This

182 test was conducted using the *ict.test* function in the *list* package of R (Blair et al. 2016; R Core

- 183 Team 2017). A Bonferroni-corrected p-value of less than >0.05 was interpreted as evidence for
- the presence of design effects, which were detected for one list (Appendix S2). In addition, both
- 185 floor and ceiling effects were detected for all lists, suggesting the method may not have worked
- 186 as expected. Prevalence estimates were calculated by combining the scores from list pairs using
- 187 the *ictreg* function.

## 188 **Results**

#### 189 Sample characteristics

- 190 In total, 56% of respondents were men, 44% were women. Respondents were Bunong (66%),
- 191 Khmer (31%), or from other indigenous groups (e.g. Stieng, Laotian, Cham; 3%). Respondents
- had lived in their village for a mean of 17 years ( $\pm$  SD 12.8), with 3 years ( $\pm$  SD 3.5) of formal
- education. The main sources of household income were farming (66% of households), shops or
- businesses (11%), resin collection (9%), opportunistic paid labour (7%), salaried work (5%) or
- 195 illegal logging (2%). Eighty-four percent of households collected NTFPs, and 23% collected
- 196 resin.
- 197

### 198 Wildlife hunting

199 Hunting prevalence, frequency & seasonality

200 When directly questioned, 9% of households reported hunting, whilst 27% of households 201 reported that they used to hunt, but no longer did. Respondents were asked to provide the year 202 they ceased hunting (Fig. 2), results show 82% of ex-hunters retired after 2009. Reasons 203 included increased difficulty in catching wildlife (43% of retired hunters), reduced time available 204 for hunting (35%), lack of dogs to hunt with (8%), old age (7%) and concern about meeting law 205 enforcement patrols (5%). The UCT warm-up question regarding fruit consumption appeared to 206 work as expected, providing an estimate of 25% (± 9%), but the UCT question on hunting 207 provided a negative prevalence estimate (Fig. 3). Ideally, no respondent should report 208 undertaking all activities, however, responses to the UCT question were subject to ceiling effects, 209 meaning more respondents than expected reported undertaking all activities. While this 210 undermines assurances of anonymity (because the interviewer knows the sensitive answer 211 applies to the respondent), it provides a direct count of households who reported hunting (n=63, 212 9%) (Fig. 3). UCT estimates for taking snares to the forest & hunting for income were again 213 unreliable and did not significantly differ from zero (Appendix S2).

215 Households that reported hunting (9% of all respondents) undertook a mean of 4.31 hunting trips 216 per month, almost double the effort reported by retired hunters (27% of respondents, 2.45 trips 217 per month). When asked what they would do if hunting became harder (i.e. wildlife was caught 218 less frequently), 52% of current hunters said they would stop, 27% said they would seek new 219 hunting grounds, and 17% said they would continue to collect other NTFPs, hunting if the 220 opportunity arose, 2% would change method and 2% didn't know what they would do. Seventy-221 seven percent of all respondents thought more hunting occurred in the wet season when the 222 absence of leaf litter on the forest floor made it easier to walk quietly in the forest, snares could 223 be set around fruiting trees such as wild almond (Irvingia malayana), and wildlife is easier to 224 catch as animals are distracted while foraging on new-growth. In addition, it was reported that 225 lulls in agriculture and logging meant people had more time to allocate to hunting, and poor road 226 conditions reduced the chance of encountering ranger patrols. Six percent of respondents said 227 hunting was more frequent in dry season when the absence of foliage made it easier for dogs to 228 run unhindered, and when water scarcity meant efforts could be targeted around water sources. 229 Seventeen percent of respondents did not know when hunting occurred most.

230

#### 231 Hunting methods

Dogs were the most commonly reported hunting method (87% of current hunters, n = 60),
followed by slingshot (47%), snares (13%) and crossbow (3%) (Table 1). Only 7% of all
respondents reported ever having set snares in the forest, and only eight households reported
currently doing so (1%). These eight households set a mean of 46 snares, although one
household reported maintaining 500 snares.

237

Thirty-five percent of current hunting households reported using more than one method to catch
wildlife. Dogs and slingshots were reported more frequently by current hunters than retired
hunters, with snares, crossbows and guns reported less frequently by current hunters (Table 1).
Respondents often said that guns were only used by outsiders or authorities, such as police or
the military. Several respondents reported seeing soldiers hunting primates with guns, whilst
another said they had seen men with rifles come in 4x4s with cool-boxes to take meat away. One

respondent said they had borrowed a gun from the police to shoot black-shanked douc langur (*P. nigripes*).

246

247 Of those households that reported hunting, 68% said they did so only for subsistence, 28% 248 hunted for food and income, while only one household reported hunting for income only. One 249 individual said that, if successful, they could earn \$250-500/month by selling meat to villagers or 250 external traders. This is significantly more than the monthly earnings of a casual laborer, which 251 ranges from 15,000-30,000 KHR a day (4000KHR = USD\$1, which equates to approximately 252 USD\$80-150/month). The most commonly caught species were monitor lizard (Varanus spp., 253 71% of current hunters), wild pig (Sus scrofa, 28%), chevrotain (Tragulus spp., 13%) and civets 254 (Paradoxurus hermaphroditus, Viverra zibetha, 12%) (Table 2). Other species caught included 255 northern red muntjac (Muntiacus vaginalis), sambar (Rusa unicolor), long and pig-tailed 256 macaque (Macaca spp.), black-shanked douc langur, southern yellow-cheeked crested gibbon 257 (N. gabriellae), Sunda colugo (Galeopterus variegatus), red jungle fowl (Gallus gallus), and 258 various tortoise, turtle and squirrel species. Compared to retired hunters, a greater proportion of 259 current hunters reported catching monitor lizard and civet, and fewer reported catching wild pig, 260 muntjac and chevrotain (Table 2).

261

262 Protecting Crops

263 Alongside killing wildlife for food, medicine and income, respondents reported killing wildlife to 264 protect crops. Seventy-one percent of all households reported crop raiding, and 20% of all 265 households reported setting snares (mean 20 snares per HH) around farms to protect crops. 266 Four percent of households reported setting between 100 and 300 snares. The main pest 267 species reported were wild pig (85% of respondents with wildlife problems), long-tailed macaque 268 (52%), elephant (32%) and green peafowl (Pavo muticus, 24%). Other species mentioned 269 included East Asian porcupine (Hystrix brachyura), red muntjac, jungle fowl and bamboo rat 270 (Rhizomyini spp.).

271

272 Hunting by dogs

273 Seventy-nine percent of households owned dogs, and 45% of those who went to the forest took 274 dogs with them for companionship and to protect against wildlife encounters. While a few 275 respondents reported actively using dogs to hunt species such as muntiac and sambar, many of 276 those who reported dogs killing wildlife said it was unintentional. When accompanying owners to 277 the forest, dogs would chase wildlife scents, owners also reported dogs roaming away from 278 home to go and hunt, catching species such as monitor lizard, chevrotain, turtle and tortoise. 279 Excluding puppies, for which survival rates were unknown, we recorded a total of 1633 dogs. The 280 mean number of dogs owned across all households (n=705) was 2.31 (a mean of 2.91 dogs per 281 dog owning household (n = 557)). Approximately 40% of households were surveyed, suggesting 282 the total number of domestic dogs living within KSWS could exceed 4000, or 1.36 per km<sup>2</sup>, a 283 density comparatively higher than many species of conservation interest.

284

#### 285 Wildlife use and consumption

Eighty-five percent of all households consumed wild meat, and 45% used wildlife products for
medicinal purposes. Overall, 70% of respondents preferred eating wild meat to domestic
alternatives, mostly because wild meat was believed to be healthier, free from chemicals, and *'chnganh'* (delicious) (Table 3).

290

291 Of the 24% of households who preferred domestic meat, accessibility was the main reason 292 given. Domestic meat was reportedly more widely sold, and easier to buy in smaller quantities, 293 than wild meat, which was usually only sold by the kilogram. Several respondents said wild meat 294 could unknowingly be bought, as it is difficult to differentiate meat once butchered. Only 4% of 295 respondents who preferred domestic meat cited affordability, and prices often overlapped. Wild 296 pig, for example, ranged from US\$3.75 to \$6.25/kg in villages, while domestic pork in the district 297 town (which is usually cheaper for commodities in general than villages) was US\$3-4.5/kg. 298 Muntjac and sambar meat was less available, therefore more expensive than wild pig meat 299 (village price = US\$5-8.75/kg).

300

301 Households typically accessed wild meat in several different ways. Wild meat was most 302 commonly bought (78%) from villagers, or motorcycle traders from the district town. Some said 303 traders hid meat in secret compartments under the seats of their motorbikes. Thirty-three percent 304 of households reported catching wild meat to eat themselves, which is surprising considering 305 only a small proportion of the households reported hunting. 20% of households reported being 306 given wild meat by family or neighbours. More households ate wild meat in wet season (90% of 307 consumers) than dry season (73%), with wild meat also consumed more frequently in wet 308 season (mean 1.79 times per month) than dry season (mean 0.95 times per month). This agrees 309 with reportedly higher frequency of wildlife conflict in wet season, when wildlife could be caught 310 around rice crops. In addition, domestic alternatives were reportedly less available during wet 311 season, as rain restricts traders' access, and villagers had less income to purchase domestic 312 meat.

313

314 The species most commonly reported as eaten were wild pig (79%), monitor lizard (30%), 315 muntjac (22%), chevrotain (11%), monkey (4%), civet (3%), sambar (3%), tortoises and turtles 316 (3%) and jungle fowl (2%). Snakes, porcupine and other rodents accounted for less than 1% 317 each. Species most likely to be bought were wild pig, monitor lizard and red muntjac. Species 318 most likely to be caught were monitor lizard, wild pig, chevrotain and muntjac, while monitor 319 lizard was most likely to be gifted (Table 4). The most common species used for medicine were 320 slow loris (Nycticebus pygmaeus, 83% of households) and porcupine (77%). In some villages, 321 slow loris could be ordered from local hunters, who caught them at night using spotlights and 322 slingshots. Others bought slow loris or porcupine from neighbours or traders when available. 323 One respondent reported that the tonic could be purchased pre-made at one of the provincial 324 markets. Other species mentioned more than once for medicinal purposes included chevrotain 325 (12% of households), cobra (Naja spp.) (4%), flying squirrel (4%), muntjac (2%), civet (2%), 326 black-shanked douc (2%), Sunda pangolin (1%) and hornbill (Bucerotidae spp.) (<1%). 327

#### 328 Temporal changes in hunting & wildlife consumption

329 When asked about temporal changes in hunting levels and wildlife consumption, the majority of 330 households believed that, since 2013, levels of hunting (82% of all households), wildlife 331 consumption (90%) and sale of wildlife by villagers (89%) had decreased. Fifty-four percent of 332 respondents believed that hunting levels had declined because wildlife was scarcer and 333 therefore harder to catch, 13% thought patrols deterred people, 10% said forest loss meant there 334 was nowhere to hunt, and 9% said livelihood changes meant people were now too busy farming 335 cash crops to hunt. Reasons freely given by respondents for these changes included growing 336 village populations which had increased demand for wildlife, and because hunters secretly sold 337 wildlife to traders. Others suggested that growing village populations meant people were less 338 inclined to share wild meat with neighbours, to avoid having to share wild meat with lots of 339 people. Fifty-two percent of respondents believed that hunting by outsiders had decreased, 38% 340 of respondents did not know or thought hunting was not undertaken by outsiders, while 9% 341 thought hunting by outsiders had increased. Outsiders were typically regarded as people from 342 outside the commune. Some respondents stated that declines in hunting by local people had 343 meant there was more wildlife, which attracted outsiders to hunt.

344

#### 345 Law enforcement

#### 346 Knowledge of rules

When asked if they were aware of any rules about catching wildlife, 71% of respondents said that they were. Of these, 26% attributed knowing rules to WCS (e.g. 'WCS said we cannot catch wildlife'). Twenty-seven percent did not know if there were rules, and 2% believed there to be none. When asked specifically about setting snares around farms, 26% of respondents incorrectly believed it was legal, 45% correctly said it wasn't and 29% did not know.

352

353 The majority of respondents (78%) thought that if a member of their household went hunting,

their friends and/or family would disapprove. However, some respondents explained that it

depended on what was caught; taking 'small' animals, such as monitor lizard or turtle, caught

with dogs for food, was considered acceptable, whilst shooting 'big' animals, such as elephant,

was not. Twelve percent of respondents thought others would approve of hunting, whilst 10% did
not know or had no opinion. If someone in the village caught wildlife, 76% of respondents
thought it likely that neighbours would know (Fig. 4). Some respondents said it was difficult to
keep it secret because children would spread the news, although secrecy would allow people to
avoid sharing their catch, and to reduce the risk of being reported.

362

#### 363 Perceptions of law enforcement effectiveness

364 If a villager hunted, only 40% of respondents thought it likely that a patrol would catch them, but 365 if caught, 64% thought it likely a hunter would receive a penalty (Fig. 4). Expected penalties 366 listed by respondents included arrest (45% of respondents), warning (16%), fine (15%), and 367 confiscation of meat and/or snares (13%). Twenty-four percent of respondents did not know what 368 the penalty would be. Respondents often stated that the type of penalty received depended on 369 the severity of the crime, and whether the hunter had previously been caught. Some reported 370 that if they were only hunting for food, and had caught only 'small' animals such as wild pig, 371 monitor or tortoise, patrols may show leniency. However, if caught hunting 'big animals' such as 372 elephant, sambar or gaur, punishment could be a fine of up to \$2000, or imprisonment.

373

Despite the villagers saying that there was a 40% probability of being caught when hunting, overall, just 13 respondents (7% of all those who reported ever hunting) had been caught by a patrol when hunting, and only once did a household report severe punishment. In this incident, the respondent's son had been lent a gun by the police to shoot sambar. After his arrest by rangers, the police reportedly intervened and, rather than being prosecuted, the son was released with a fine of two million riels (USD \$500). Mostly, respondents reported receiving warnings or having meat confiscated.

381

### 382 Perceptions of patrols

383 Sixty-two percent of respondents reported that they were not worried about encountering patrols 384 in the forest. The majority said that since they did not hunt or partake in any illegal activities they 385 had nothing to fear, although a small number of respondents expressed concern that patrols

386 might prevent or punish the legal collection of NTFPs, such as rattan. Others reported adapting 387 their behaviour to avoid patrols, for example by waiting until patrols had passed. Some said 388 friends and family would call to warn them if patrols passed through the village towards the 389 forest. One respondent said when hunting in a group, each would travel individually to reduce the 390 chance of being spotted by a patrol, and meat would be shared in the forest before leaving to 391 reduce punishment if caught. In total, 37% of respondents expressed concern about meeting 392 patrols, of which 21% said that this was because a member of their household was engaged in 393 illegal logging. A further 25% of respondents said they were worried that rangers would punish 394 them if their dogs caught wildlife. Several respondents believed that camera traps set by WCS to 395 monitor wildlife populations were actually set to photograph people hunting.

396

#### 397 Corruption

398 We frequently found that respondents associated patrols with corruption. One individual stated 399 "patrols only come to catch the money, not to stop people", whilst another stated "patrols only 400 use laws for villagers, they have different rules for outsiders or people with power". One 401 respondent, who was a commercial hunter, reported that they avoided punishment because they 402 were on friendly terms with rangers, whilst other respondents reported that if caught, rangers 403 would ask for (or accept) a bribe. Others believed that when rangers confiscated meat, they ate it 404 themselves instead of destroying it. After one interview a respondent reported they had found a 405 muntiac fawn in the forest, but when urged to take it to the nearest patrol station, they refused, 406 as they believed that the rangers may eat it. No-one explicitly reported having paid a bribe when 407 caught hunting, but two respondents said they'd paid bribes to patrols when transporting wood, 408 whilst others reported that they had heard that other villagers paid bribes to release confiscated 409 motorbikes. One respondent said that bribery occurs because the low-paid rangers have to pay 410 their superiors in order to maintain their positions.

# 411 **Discussion**

412 Hunting is widely cited as a cause of Cambodia's biodiversity loss (Harrison et al., 2016; Gray et 413 al., 2017). Here, we confirmed that local communities living in KSWS do hunt, although 414 uncertainty remains regarding prevalence. Direct questioning and ceiling counts from the UCT 415 suggest a prevalence of 9%, but the UCT estimate itself did not significantly differ from zero. This 416 is probably the result of floor and ceiling effects, which reduce precision (as well as anonymity) 417 (Blair et al., 2016). Findings also highlighted ambiguity regarding the definition of hunting; a fifth 418 of respondents reported setting snares around farms, which was considered a legitimate crop 419 protection activity, and when people were asked about how they accessed wild meat to eat, 420 nearly a third said that they caught their own wild meat, presumably from snares set around 421 farms. Yet, few households stated they hunted. Our results suggest questions about the 422 intentional killing of wildlife in the forest were likely subject to bias, while responses about wildlife 423 killed opportunistically (e.g. by dogs) or coincidentally (e.g. to protect crops) were less likely to be 424 censored, a trend also documented elsewhere in Cambodia (Coad et al. 2019). Our findings 425 highlight the need to consider survey questions carefully, and to triangulate by asking questions 426 in multiple ways, particularly if surveying on sensitive topics. During our research, some 427 respondents were hushed by fellow family members when discussing hunting, and others failed 428 to mention information they later provided after questionnaires were completed (e.g. borrowing 429 guns). Overall, it is likely our findings underestimate hunting prevalence.

430

431 While specialised methods such as UCT can be useful for reducing biases associated with 432 sensitive topics, they require careful design, extensive piloting and are not suitable for all contexts 433 (Hinsley et al., 2018). Greater understanding about the reliability of these methods to provide 434 robust estimates of rule-breaking behaviour is urgently needed. Typically, estimates derived from 435 Specialised Questioning Techniques are validated by comparing them to those obtained from 436 direct questioning; if prevalence estimates from the specialised method are higher, the method is 437 perceived as more successful. Aside from undermining the anonymity of the method (lbbett & 438 Brittain, 2019), this validation approach fails to inform researchers whether respondents actually

439 understood the method and felt sufficiently protected to accurately report their behaviour.

440 Typically, conservation research focuses on obtaining data to answer urgent conservation

441 questions, rather than testing methods *per se*. Yet, experimental studies that explicitly assess

442 methods such as UCT would not only enhance research practice, but also improve the reliability

443 of data used to inform conservation interventions.

444

445 In recent years, snaring has been identified as a specific threat to Cambodia's wildlife (Harrison 446 et al., 2016; O'Kelly et al., 2018). While snares were widely used to protect crops, few 447 households reported setting snares to hunt wildlife in the forest. Snaring levels amongst retired 448 hunters, who theoretically have less incentive to misreport behaviour, were also low. We suspect 449 that a handful of individuals per village hunt for commercial purposes and are probably facilitated 450 by 'middlemen', who may place orders, purchase catch, and in some cases supply equipment -451 a trend documented elsewhere in Cambodia (Gray et al., 2017; Coad et al., 2019). One limitation 452 of our research is that our study was restricted to the hunting activity of local communities, when 453 hunting is thought to also be undertaken by Vietnamese nationals near the international border 454 (O'Kelly et al., 2018), by logging gangs who stay for extended periods in the forest (HI, pers. 455 obs), and by military or police personnel with high-powered rifles (Drury 2005; Evans et al. 2013). 456 Gathering information on prevalence amongst these different groups should be a research 457 priority, though to do so may pose significant risk to researchers; as often these groups are 458 armed, dangerous, and well-connected.

459

460 Our findings highlight a threat to wildlife from hunting by domestic dogs, an issue identified 461 elsewhere in Cambodia (Heng et al. 2016; Loveridge et al. 2018). The scattered distribution of 462 villages, combined with the frequent accompaniment of hunters by dogs during forest forays, 463 means that interactions between dogs and wildlife are likely to occur with considerable regularity 464 throughout the PA. Canine presence in the landscape can also have indirect impacts on wildlife, 465 for example by inducing fear, increasing competition for resources, and transmitting disease 466 (Gompper, 2014). To better understand the potential threats that dogs pose to wildlife, more 467 information on dogs' ranging and hunting behaviour (e.g. faecal analysis, GPS tracking) is

needed, alongside socially-acceptable interventions that promote responsible dog ownership.
For example, preliminary surveys suggest communities are concerned about excessive dog
populations but lack the means to deliver humane sterilisation. A free, voluntary dog sterilisation
programme could offer a win-win solution, although recent research suggests a considerable
proportion of dogs would need to be sterialised in order to achieve a sufficient reduction in
population (O. Griffin, pers comms).

474

475 Traditionally, hunting in KSWS was conducted alongside resin collection (Drury, 2005). However, 476 over the past 10 years resin collection has significant declined (Cheetham, 2014), partly due to 477 reduced profitability, but also due to the loss of resin trees to illegal logging and industrial-scale 478 land clearance, which intensified around 2013. Cash cropping has emerged as the primary form 479 of income generation (Travers et al., 2015; Mahanty & Milne, 2016), meaning many have less 480 time, fewer skills to hunt as well as more income to buy wild meat (Coad et al., 2019). Looking 481 ahead, infrastructural improvements, such as paved roads and improved cellular networks may 482 further enhance the market integration of villages situated within the PA (Riggs et al., 2018), 483 boosting the prevalence of cash cropping and reducing economic reliance on traditional 484 livelihood activities.

485

486 Fluctuations in cash crop prices, declining soil fertility, high input costs associated with fertilisers, 487 pesticides and land rents, has contributed to increasing debt burdens within local communities 488 (Mahanty & Milne, 2016). Results suggest consumption of wild meat is wide-spread, but low level 489 - constituiting only a few meals per month. Historically, forest products such as wildlife have 490 provided communities with vital safety nets in times of hardship (Milner-Gulland et al., 2003) -491 economic vulnerability associated with growing debt may result in increased pressure on natural 492 resources including wildlife. This could be exacarbated by infrastructual improvements, which 493 may enhance local, provincial and regional access to wildlife trade. Intelligence-gathering 494 operations that assess commodity chains would be beneficial to understanding demand 495 dynamics, but in-depth understanding of the norms and attitudes driving consumption is also

required. To be effective, any behaviour change intervention must be informed by robust
evidence, and include appropriate monitoring and impact evaluation (Veríssimo & Wan, 2019).

499 Central to the success of PAs is that rules governing natural resource use are widely known 500 (Keane et al., 2011) and, once known, adhered to (Arias, 2015). Patrols are deployed to catch 501 those who commit offences and to act as deterrent to potential offenders (Dobson et al. 2018). 502 Regardless of whether law enforcement is effective, if the perceived likelihood and cost of being 503 caught are high, offenders should be less likely to offend. According to our findings, the 504 effectiveness of patrols as a strategy to reduce hunting varied. The perceived likelihood of getting 505 caught was low, but the perceived likelihood of incurring a punishment if caught was high - these 506 factors combined were sufficient to deter some individuals from hunting (and caused others to 507 develop patrol-avoidance strategies). Yet, rangers were also perceived to unjustly punish local 508 people, although some considered rangers' malleability - in particular their willingness to 509 allegedly accept a bribe - to be advantageous. While we reinforce the recommendations of 510 others (that more efficient and intelligence-led patrolling is needed, legislation that criminalises 511 hunting and possession of technologies such as snares is required, and all aspects of judiciary 512 systems must be strengthened (Gray et al., 2017)), we believe that conservation success is 513 unlikely to be achieved by strengthened law enforcement alone (Travers et al., 2016). Any 514 approach, must be informed by adequate understanding of the drivers of non-compliant 515 behaviour, alongside clear recognition of the incentives most likely to encourage positive 516 behavioural change.

# 517 Author Contributions

- 518 The research was led by HI. All authors contributed to the research conception and study design.
- 519 HI collected and analysed the data and led the writing of the manuscript. All authors contributed
- 520 critically to the drafts and granted final approval for publication.

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- 526 Silhouettes used in Table 4 are from <u>www.phylopic.org</u>.
- 527

# 528 Conflicts of Interest

- 529 None
- 530

# 531 Ethical Standards

- 532 Research permission was granted from the Royal Government of Cambodia, with ethics
- 533 clearance approved by the University of Oxford's Social Sciences & Humanities Interdivisional
- 534 Research Ethics Committee (Ref No: R43030/RE004).

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666 Figure 1. Keo Seima Wildlife Sanctuary, Mondulkiri Province. All settlements located within and

667 close to the protected area are shown, but specific study villages (n=18) are not identified, to

668

665

ensure anonymity.



669

670 Figure 2. Temporal change in the prevalence of hunting reported by households (n=705) in Keo

671 Seima Wildlife Sanctuary, Cambodia, 2018.



Figure 3. Estimates of hunting prevalence in Keo Seima Wildlife Sanctuary, Cambodia captured
through different questions, showing 95% confidence intervals in 2018 HH = household. \* indicates questions where respondents where asked about hunting directly (n=705). UCT =
Unmatched Count Technique (n=702).



If someone in the village caught wildlife, how likely is it that....

679 Figure 4. Respondents' perceived probability of neighbours knowing about a villagers' hunting

- 680 activity, of a villager being caught by a patrol if hunting, and of a villager receiving a penalty if
- 681 caught by a patrol (n=705) in Keo Siema Wildlife Sanctuary, Cambodia.

Table 1. Hunting methods reported by current and retired hunters in Keo Seima Wildlife

		Sanctuary, Cambodia in 2018.				
	Method		Retired hunters (%)	Current hu (%)	Inters	
	Dogs		155 (81)	52 (87	<u>')</u>	
	Slingshot		73 (38)	28 (47	<b>'</b> )	
	Snares		40 (21)	8 (13	)	
	Crossbow		12 (6)	2 (3)		
	Gun		5 (3)	0		
	Total number	of households	192 (27)	60 (8	)	
Table 2	2. Species most cor	nmonly caught re Wildlife Sanctua	ported by current a ary, Cambodia, in 2	and retired hur 2018.	nters in Keo Seima	
Speci	ies	National statu	ıs	Retired	Current hunters	
		(IUCN status)	)	hunters (%)	(%)	
Monit	or lizard	Common (LC	:)	116 (60)	43 (71)	
Wild p	pig	Common (LC	:)	78 (41)	17 (28)	
Chev	rotain	Unclassified (	(LC)	46 (24)	8 (13)	
North	ern red muntjac	Common (LC	3)	26 (15)	2 (3)	
Civet		Common (LC	/EN)	9 (5)	7 (12)	
Prima	ate*	Common/Rar	e (LC/EN)	11 (6)	3 (6)	
Samb		Common ()/I	D	2 (1)	• (•)	
Total	bar		,	( )	1 (<1)	
LC = L	oar number of househol	Ids	·)	192 (27)	1 (<1) 60 (8)	
	oar number of househol .east concern, VN =	lds Vulnerable, EN =	= Endangered. * =	192 (27) Species depe	1 (<1) 60 (8) endent. Long tailed	
mad	oar number of househol ₋east concern, VN = caque = Common/Lu	Vulnerable, EN =	= Endangered. * = douc langur & yel	192 (27) Species depe low cheeked c	1 (<1) 60 (8) endent. Long tailed crested gibbon =	
mao	oar number of househol east concern, VN = caque = Common/Lu	Vulnerable, EN = C, black-shanked	= Endangered. * = douc langur & yel Rare/EN	192 (27) Species depe low cheeked c	1 (<1) 60 (8) endent. Long tailed crested gibbon =	

Table 3. Reasons given by respondents living in Keo Seima Wildlife Sanctuary when asked

Reason	Like	Wild meat	Domestic
	equally %	%	meat %
It is better for your health		42%	2%
It has no chemicals		33%	<1%
It is tastier		30%	3%
It is natural		8%	-
It is more affordable		<1%	<1%
It is easier to buy		-	17%
	6%	70%	24%

about their preference for different types of meat in 2018 (8 respondents gave no answer, n=705)

700

Table 4. Chi-square tests for association with 1 degrees of freedom, between species consumed
by households in Keo Seima Wildlife Sanctuary, and the ways in which meat was accessed. All
species reported as eaten by communities were tested, but only species for which positive
associations with access type are reported.

How household accessed wild meat	Species household reported consuming	χ²	p-value
	Wild pig	58.266	<0.001
Bought	Monitor lizard	19.338	<0.001
	Muntjac	18.362	<0.001
	Monitor lizard	121.02	<0.001
Coucht	Wild pig	40.765	<0.001
Caught	Chevrotain	20.410	<0.001
	Muntjac	7.271	0.007
Gifted	Monitor lizard	4.941	0.026