

Demographics and practices of dog ownership in a rural Cambodian village adjacent to a wildlife sanctuary

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សត្វឆ្កែស្រុកមានវត្តមាននៅទូទាំងពិភពលោក ហើយពួកវាបង្កការគំរាមកំហែងដល់សត្វព្រៃក៏ដូចជាសុខភាពមនុស្ស។ ការគ្រប់គ្រងសត្វឆ្កែប្រកបដោយប្រសិទ្ធភាពមានការប្រឈមជាច្រើននៅក្នុងប្រព័ន្ធអេកូឡូស៊ីសង្គម។ យើងបានធ្វើប្រជាសាស្ត្រសត្វឆ្កែស្រុក និងទំលាប់នៃការចិញ្ចឹមនៅភូមិជនបទមួយដែលជាប់នឹងដែនជម្រកសត្វព្រៃសៀមប៉ាង។ ការសិក្សានេះមានសារៈប្រយោជន៍សម្រាប់ការរៀបចំយុទ្ធសាស្ត្រគ្រប់គ្រងដើម្បីកាត់បន្ថយហានិភ័យចំពោះសត្វព្រៃដែលបង្កឡើងដោយសត្វឆ្កែស្រុក និងការរៀបចំផែនការដ៏មានសក្តានុពលសម្រាប់បង្ការជម្ងឺឆ្លងក្រៅនិងក្នុងស្រុក។ យើងបានចុះសំភាសន៍ប្រជាជននៅភូមិគោលដៅដោយប្រើកម្រងសំណួរគ្រួសារ ($n=123$) ដើម្បីវាយតម្លៃប្រជាសាស្ត្រសត្វឆ្កែ ទំលាប់នៃការចិញ្ចឹមសត្វឆ្កែ ទំនាក់ទំនងរវាងសត្វឆ្កែជាមួយសត្វព្រៃ និងអាកប្បកិរិយាចំពោះការគ្រប់គ្រងសត្វឆ្កែ។ យើងបានរកឃើញអត្រាសត្វឆ្កែចិញ្ចឹមជាមធ្យមចំនួន 2.41 ក្បាលក្នុងមួយគ្រួសារ ហើយសត្វឆ្កែទាំងអស់ត្រូវបានប្រលែងអោយដើរដោយសេរី។ ម្ចាស់ឆ្កែមួយចំនួនតូច (18%) ដឹងថាឆ្កែរបស់ពួកគាត់ឧស្សាហ៍ចេញទៅក្រៅ ខណៈ 40% នៃម្ចាស់ឆ្កែពេលខ្លះបណ្តើរឆ្កែចូលព្រៃជាមួយពួកគាត់។ មានតែ 10% នៃអ្នកឆ្លើយសំណួរបាននិយាយថាប្រទះឃើញសត្វឆ្កែប្រមាញ់ឬយាយីសត្វព្រៃដោយមិនបានដឹងថាជាសត្វឆ្កែរបស់អ្នកណាទេ។ ការយល់ស្របបឋមលើសេចក្តីទាំងស្រុងទៅលើការគ្រប់គ្រងសត្វឆ្កែនៅមានកម្រិតទាប ដោយប្រជាជនភាគច្រើនបង្ហាញពីភាពនៅកណ្តាល (35–70%) ចំពោះទស្សនៈនៃការគ្រប់គ្រងសត្វឆ្កែចំនួនក្នុងចំណោមពលរដ្ឋ។ លទ្ធផលនៃការសិក្សារបស់យើងបង្ហាញថា ដើម្បីកាត់បន្ថយផលប៉ះពាល់នៃសត្វឆ្កែមកលើសត្វព្រៃវិធីសាស្ត្រដ៏មានប្រសិទ្ធភាពក្នុងការគ្រប់គ្រងសត្វឆ្កែគួរតែគ្របដណ្តប់នៅក្នុងសហគមន៍ទាំងមូល ដោយផ្តោតយ៉ាងសំខាន់ទៅលើសុខភាព អាហារូបត្ថម្ភ និងការចូលមើលជម្រកសត្វព្រៃ។

Abstract

Domestic dogs are abundant worldwide and they pose a threat to wildlife as well as human health. Effective management of dogs is challenged by complex socio-ecological factors. We investigated local dog demographics and cultural practices of dog ownership in a rural Cambodian village adjacent to Siem Pang Wildlife Sanctuary. This knowledge will be useful for preparing a management strategy to mitigate risks posed by dogs to wildlife and potentially contingency planning for exotic and endemic diseases. Household questionnaires ($n=123$) were completed to assess dog demographics, ownership practices, dog-wildlife interactions and attitudes towards dog management. We found a mean ownership rate of 2.41 dogs per household, with all dogs allowed to roam freely. Relatively few owners (18%) were

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aware of their dogs roaming away from their household, while 40% were accompanied by their dogs into the forest at least some of the time. Only 10% of respondents admitted to observing dogs hunting or harassing wildlife without specifying whether they were their own dogs. Strong agreement or disagreement with management statements was low, with respondents commonly indicating that they were neutral (35–70%) on six of seven management statements. Our findings show that a management strategy for dogs will need to target the whole community, and indicate key areas such as health, nutrition and sanctuary visitation, that may be important for reducing the impact of dogs on wildlife.

Keywords Free-roaming dogs, management, protected areas, questionnaires, wildlife conservation.

Introduction

Domestic dogs *Canis familiaris* are abundant world-wide and their management ranges from being owned, fed, sheltered and contained to being feral, where the animal receives no care from humans and they must find their own food (World Health Organization, 1988). Free roaming dogs sit in the middle of this management spectrum, with such animals receiving some care from humans but are largely left to roam freely outside of their homes (Meek, 1999; Hughes & Macdonald, 2013). Such free-roaming dogs are ubiquitous in Southeast Asia and the degree of care they may receive varies depending on location, community and individual ownership.

Domestic dogs can have various impacts on wildlife, from killing (e.g., Kruuk & Snell, 1981; Taborsky, 1988) and harassment (e.g., Banks & Bryant, 2007; Glover *et al.*, 2011; Weston & Stankowich, 2015) to competition (e.g., Butler & Du Toit, 2002; Vanak *et al.*, 2015) and disease transmission (e.g., Scott, 1988; Butler *et al.*, 2004). Dogs have been implicated as having negative impacts, such as predation, disturbance and disease transmission, on a large number of threatened species which can contribute to population declines (Banks *et al.*, 2003; Lessa *et al.*, 2016; Gatti *et al.*, 2018; Augusteyn *et al.*, 2021), with the highest number of species known to be impacted occurring in Southeast Asia (Doherty *et al.*, 2017). The relative significance of dog impacts on threatened species and how they compare to the other threatening processes impacting these species remains unclear, particularly regarding non-consumptive effects (Hughes & Macdonald, 2013; Doherty *et al.*, 2017).

Free-roaming dogs are thought to account for the majority of dogs world-wide (Hughes & Macdonald, 2013) and it is likely that they also hunt and scavenge for food to supplement what is provided to them, particularly in more rural areas where wildlife is typically more abundant. Dogs may target a variety of wildlife species, including large species such as deer, as documented in the United States of America and India (e.g., *Cervus elaphus*, *Odocoileus hemionus*, *Rusa unicolor*) (Bergman *et al.*, 2009; Home *et al.*, 2018). In addition to killing, the

presence of dogs in natural habitats as they hunt and scavenge for food may induce fear-mediated behavioural changes in wildlife, and harassment by dogs may impact survival and fecundity, as found in Ecuador (Zapata-Rios & Branch, 2016).

Dogs are also vectors for diseases affecting wildlife, humans and livestock, with over 40 zoonotic diseases known to be carried and transmitted by dogs (Bergman *et al.*, 2009). Disease transmitted by domestic dogs to wildlife have had serious consequences for some species, such as the decimation of black-footed ferret *Mustela nigripes* populations in the USA due to canine distemper virus (Williams *et al.*, 1988) and the loss of African wild dog *Lycaon pictus* packs through rabies and canine distemper viruses (Kat *et al.*, 1995; Alexander *et al.*, 1996). Some of these diseases can also have significant impacts on human health, such as the rabies virus and hydatidosis.

Hence, there is a need to mitigate negative impacts of free-roaming dogs on wildlife, as well as improving human and animal health. Dog populations that have some degree of dependency on humans present particular management challenges that require effective engagement with the local people (Kennedy *et al.*, 2018). Before implementing interventions to control dogs, it is necessary to understand the local situation, including local people's perceptions and attitudes, their interactions with the dog population as well as its size and condition, so that the management strategy is tailored to local conditions. The role of people's attitudes and practices towards domestic dogs and how dog interactions with humans are perceived is an important consideration, with concepts such as 'food provision', 'dog walking' and even 'ownership' being variable across cultures (Miller *et al.*, 2014). Management decisions need to be developed based on evidence, not assumptions, about community views and practices as this potentially results in ineffective management and may result in conflict (Miller, 2009).

Cambodia supports significant populations of globally threatened vertebrates, including primates (Rawson

et al. 2009; Phan & Gray, 2010a), large ungulates (Maxwell *et al.*, 2007; Phan & Gray, 2010b; O’Kelly & Nut, 2010; Gray *et al.*, 2011), carnivores (Gray *et al.*, 2010, 2012) and large waterbirds (Seng *et al.*, 2003; Wright *et al.*, 2012). Dogs have been identified as a threat to species such as dhole *Canis alpinus* (Kamler *et al.*, 2015) and Eld’s deer *Rucervus eldii* (Gray *et al.*, 2015). Domestic dogs are capable of killing juvenile Eld’s deer, and likely adult females if the dogs are hunting in packs (Gray *et al.*, 2015). The impact of free-roaming dogs on wildlife in Cambodia is largely unknown, with few studies undertaken in the country and these primarily about hunting with people. Coad *et al.* (2019) found that domestic dogs are commonly used to hunt in Cambodia, with just over half of households that reported hunting in the Cardamom Mountains using dogs. This figure was even higher in eastern Cambodia, with 87% of hunters in Keo Seima Wildlife Sanctuary using dogs (Ibbett *et al.*, 2020).

In addition to the impact that free-roaming dogs may have on biodiversity in Cambodia, the impact on human health is also a significant concern. Rabies is endemic in Cambodia, with dogs recognised as the main reservoir for the virus in the country (Ly *et al.*, 2009). Dog bite incidences are an important proxy for rabies incidence estimation and a survey of four villages in the Cambodian province of Siem Reap recorded a high dog attack incidence rate of five attacks per 100 person-years, with most attacks involving a household dog (Ponsich *et al.*, 2016). Parasitic infections are also a concern, with high proportions of Cambodian village dogs found to be infected with hookworm and Echinostomes (Inpankaew *et al.*, 2015). In addition, eight helminths and three protozoan parasite species were recorded in a separate village (Schär *et al.*, 2014) and taken together with reports of hydatid disease (Garjito *et al.*, 2019), dogs pose serious health risks to villagers.

Siem Pang Wildlife Sanctuary (SPWS) in northeast Cambodia is home to a number of threatened species for which dogs have been identified as threats, including Eld’s deer (Gray *et al.*, 2015). The sanctuary is zoned into a multiple use zone, a conservation zone with restricted access and a strictly protected core zone. Dogs are prohibited across the entire sanctuary, including these areas. However, in practice villagers and dogs generally have open access across the sanctuary. This is due to a lack of regard people have for the rules and a lack of enforcement due to insufficient rangers and resources. There is currently no management strategy relating to domestic dogs in the area. Developing management plans for dogs owned by humans is complex and cannot be undertaken without communication and consultation with the owners and the provisioning of general data on owner-

ship (Murray & Penridge, 1997). As such, we aimed to collect baseline information on the demographics of the dog population, roaming behaviours, dog-wildlife interactions, how dogs are cared for and the attitudes of local people regarding the domestic dog population around SPWS.

Methods

Study site

Siem Pang Wildlife Sanctuary is located in Stung Treng Province, Cambodia, next to the Laos border (Fig. 1). The sanctuary is home to a number of Endangered and Critically Endangered species including Eld’s deer and giant ibis *Thaumatibis gigantea*, and is actively managed by Rising Phoenix Co. Ltd., a social enterprise that has absorbed the previous BirdLife International project at the site. Seven villages are located close to or within the wildlife sanctuary and local people from these villages routinely enter the sanctuary to collect non-timber forest products, fish and hunt. These villages are actively engaged with a livelihoods programme designed to benefit local people and encourage sustainable stewardship of the forest (BICP, 2020). We conducted a survey of Khmer families in the village of Khes Svay due to its proximity to the wildlife sanctuary boundary. This village is considered to be largely representative of villages in this area because of its size, industry and use of the forest in the sanctuary, with villagers and dogs regularly observed in the sanctuary. Agriculture is an important economic activity for the villagers and many households have some reliance on non-timber forest products. The village has 233 households, as recorded in 2020 (Siem Pang District Administration Office, unpubl. data).

Ethical considerations

This study received University of Queensland Institutional Human Ethics Research Approval (2019002414). Before speaking to any families, a meeting with the village chief was organised to explain the aims and methods of the research and seek permission to conduct the research. A copy of the survey questions and an explanation of the research, including ethical approval, was provided to him, as well as the commune chief. Prior to any interviews with families, the Khmer interviewers explained the purpose of the survey, risks, benefits and proposed use of the data and verbal consent was sought. All participation was on a voluntary basis, anonymous and no compensation was provided and the survey was undertaken in Khmer by employees of the BirdLife Inter-

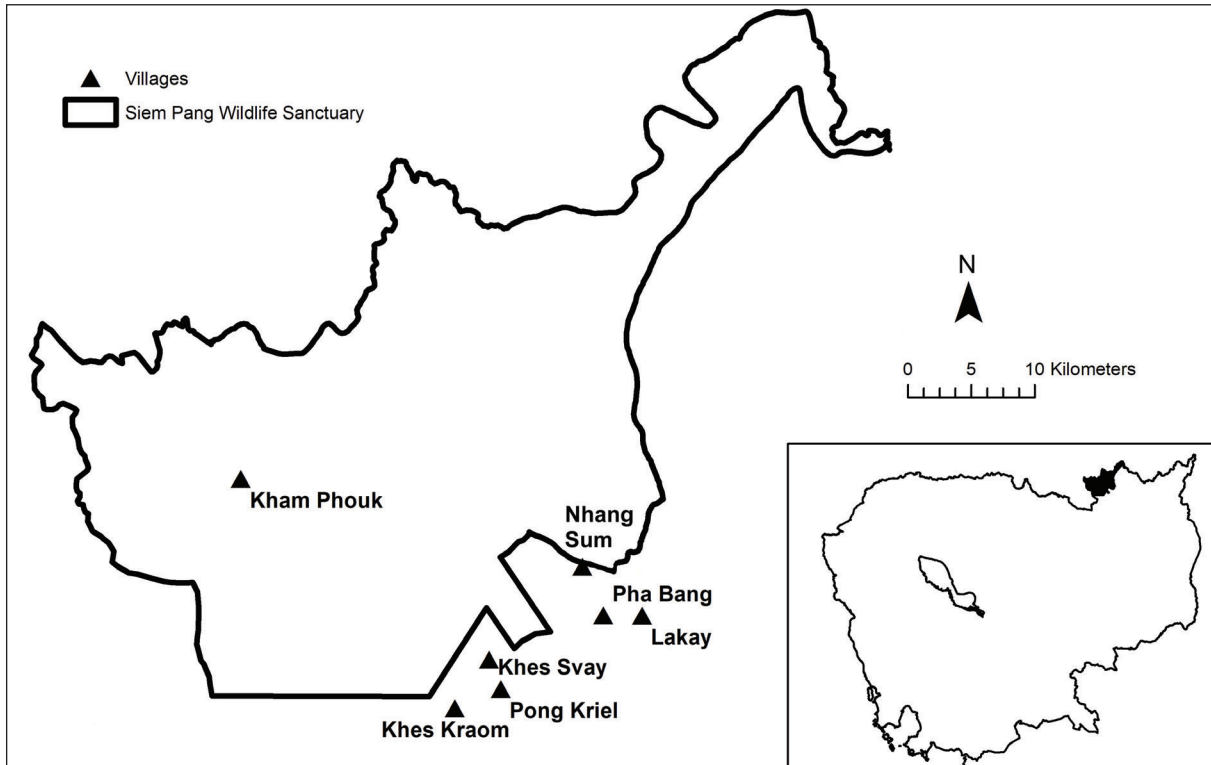


Fig. 1 Location of Siem Pang Wildlife Sanctuary (shaded area of inset map) and surrounding villages in northeast Cambodia. Our survey was conducted in Khes Svay village.

national Cambodia Programme, with nearly all surveys conducted by the same interviewer.

Questionnaire

To ensure that our questions were culturally suitable and relevant, these were developed in consultation with the local BirdLife International team, all of whom are Khmer-speaking Cambodians. The questionnaire included five sections: basic household information, demographics of the dogs owned over the past two years, dog management practices, dog and wildlife interactions, and attitudes on dog management based around the Likert scale. Five points were used on the Likert scale to measure attitudes towards seven statements (Fig. 2), ranging from 'strongly agree' to 'strongly disagree' and included a neutral option (Likert, 1932). There was a total of 36 questions in the survey, eight with additional dependent follow up questions, with each section having between four and 11 questions. The questionnaire was developed in English and then translated into Khmer. The English version is included in Annex 1.

Only one questionnaire was completed per household, with the head of the household being the preferred

respondent. However, any adult member of the household was able to participate, and encouraged to do so if the head of the household was unavailable, which was common. We attempted to visit most households within the village, however some households are not occupied year-round, and there were sometimes difficulties finding an available adult willing and able to participate. The survey commenced in January 2020 to avoid the busiest harvesting and planting periods, with staff visiting households sporadically due to resource constraints. However, the survey was postponed in April 2020 due to Covid-19 concerns. The questionnaire recommenced in January 2021 until May 2021. The recorded responses were then translated into English and entered into a database by one member of the team.

Participant responses were tallied and summarised. These included basic demographic details for the villagers, as well as demographic and reproductive details of the dog population including the sex ratio, mean litter size and mean number of surviving puppies produced per adult female dog each year. To examine the potential for health concerns to motivate changes in attitudes and therefore dog management, we grouped respondents according to their awareness of disease

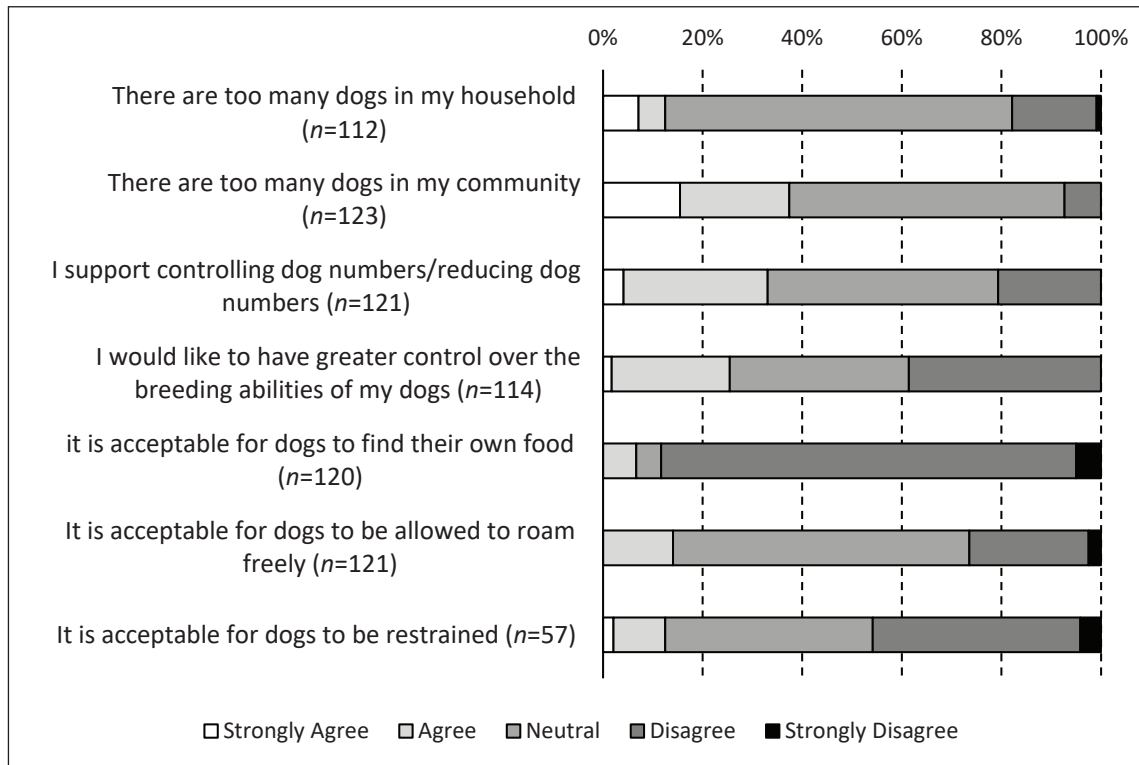


Fig. 2 Proportion of respondents in Khes Svay village who agreed and disagreed with the seven statements regarding dog ownership on a Likert scale.

transmission from dogs to humans (aware or unaware). We used a Mann-Whitney U test in R (R Core Team, 2021) to determine if there were any differences in the attitudes expressed towards the Likert scaled questions and if the mean number of dogs owned differed between these two groups.

Results

We surveyed 123 out of the 233 households (52.8%) in the village (41 of whom were surveyed in 2020). Data from both survey periods was pooled because responses were similar across all categories, except for our question about reasons for owning a dog, with the difference explained below. The response rates for each question were generally high, with fewer than 15 respondents choosing not to answer any given question. Questions that were dependent on preceding questions had smaller sample sizes, however their response rates were similar to independent questions. The exception to the high response rate was in the attitudes section, where 53.7% of respondents did not report their level of agreement regarding the statement about the acceptability of restraining dogs.

A total of 111 households (90.2%) reported owning at least one dog at the time of the survey, with eight households (6.5%) having owned at least one dog in the last two years. One household did not report their dog ownership. The mean number of people per household was 5.3 (range 2–12). The majority of households (82.1%) were involved in raising livestock and growing crops, while some (16.3%) engaged in only one of these activities and two households (1.6%) did not engage in either. Field houses, an additional dwelling of the household located outside of the village at their crop fields, were owned by 89 households (72.4%). When staying at their field houses, 70 households (79%) stated that they took their dogs with them. Nearly all households relied on forest resources to some extent, and mostly on non-timber forest products and fish, but also timber.

Dog demographics

The average rate of dog ownership across the four years discussed in the survey was 2.41 dogs per household (range 1–12), with a dog-to-human ratio of 1:1.8. The average litter size was 3.3 (min=1, max=8), with only one litter produced each year during the dry season or late wet season, most commonly in November or December.

A mean of 1.57 puppies survived per adult female dog in the population per year. The number of dogs taken out of the village, or new dogs brought into the village from elsewhere was not recorded. The sex ratio of the overall dog population was nearly equal with one male to every 1.03 females. However, the adult dog population was skewed towards females, with one male for every 1.5 females. Only five households stated that they attempted to manage their dogs' reproduction, which was achieved by sterilisation in four cases and by euthanasia of puppies in one case.

Dog management

Almost all respondents believed that all dogs in the village were owned, with only one respondent believing that two dogs were unowned. The primary reason for owning dogs in the majority (96.7%) of households was for security. However, only households sampled in 2020 provided multiple reasons for ownership, likely due to misunderstanding about allowing more than one answer to this question when the survey resumed in 2021. It was clear from the respondents in 2020 that multiple reasons for owning a dog is common, with 65.8% of respondents giving two or more reasons. For the 2020 cohort ($n=38$), pest management (34.2%), culture (28.9%) and hunting (26.3%) were also reported, as well as single mentions of breeding to produce puppies for sale and herding livestock. Nearly all households fed their dogs daily, whereas two households fed their dogs 4–6 times per week and three households only 1–3 times per week. All households fed their dogs rice. Aside from one household, all respondents reported that they fed food waste to their animals. None of households kept their dogs restrained or contained at any time.

In response to questions on roaming behaviour, which was defined as wandering unaccompanied from the household area, 82% of households believed their dogs did not roam, while 17% stated their dogs sometimes roamed and 1.8% believed their dogs often roamed. For households that had roaming dogs, the majority thought their dogs roamed for 1–2 hours or for no more than half a day, with only one household believing their dog roamed for a day, two believing their dogs roaming for 2–3 days and one having a dog that roamed for a week or longer. Most households did not see any particular pattern to their dog's roaming.

Only one household reported that at least one of their dogs had been vaccinated, although they did not specify the vaccine or disease. The type of care provided by households when their dog is sick is indicated in Fig. 3, with the majority (51.2%) providing some form of medicine or traditional remedy, and only two house-

holds seeking veterinary care. When asked if they had any awareness of diseases that dogs could transfer to people, 56% of respondents had some level of awareness and 80% of these were concerned with the issue.

Dogs and wildlife

Respondents were asked about their observations of dog-wildlife interactions in the forest. The majority (60%) of respondents reported that they never took their dogs into the forest, whereas 29% stated they sometimes did, 9% said they usually did and 2% always took their dogs with them. Respondents reported seeing other people with dogs in the forest always (5%), usually (16%), sometimes (49%) and never (30%). They also indicated how often the dogs seemed to stay within calling distance of their owners (as estimated by the respondent) while in the forest, with only 15% saying this always seemed to be the case. The number of dogs that respondents took into the forest, or saw other people with, typically ranged from one to five, with two dogs being the most common answer. Only 10% of respondents stated that they had seen dogs hunting or harassing wildlife in the forest, with reptiles and rodents the most common prey, but also birds. Similarly, only 12% of respondents stated that dogs hunted or harassed wildlife around the village and fields and the same prey were specified. Only seven

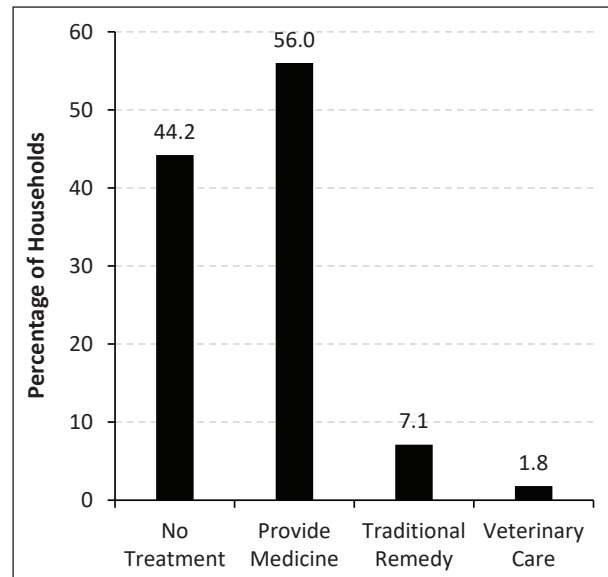


Fig. 3 Percentage of households ($n=113$) providing different treatments to their dogs when sick. The type of medicine was often unspecified although paracetamol was the most commonly specified, despite its toxicity in dogs. Multiple answers were allowed.

respondents (5.7%) gave incomplete or no answers to our hunting related questions.

Dog ownership and Management options

We found owners had a strong preference for female dogs, with 74.6% of respondents preferring females and only 2.5% having no preference. The main reason (73.9%) given for this preference was that female dogs could be used for breeding, with one respondent specifically mentioning doing this for financial gain. In contrast, of owners that preferred male dogs, just under half (48.1%) preferred them because they did not produce puppies. There was also a belief that one sex was less likely to roam and stay at home. However, 24 respondents believed this was true of female dogs, while seven respondents thought it was true of male dogs. Only 4% of respondents preferred male dogs for reasons relating to improved security, with these indicating they believed male dogs to be bigger or stronger.

The results of attitudinal statements measured on the Likert scale indicated that most respondents did not have strong attitudes about most of the issues we raised (Fig. 2). More respondents indicated that they felt the community had too many dogs (37%) and were in support of controlling dog numbers (33%) than those who disagreed with these statements (7% and 21%, respectively). However, respondents were slightly less keen about managing reproduction among their own dogs (with only 25% wanting greater control of their breeding). Of those that were keen, 76% preferred to euthanise puppies, with the

remainder preferring sterilisation. Respondents who felt that they had too many dogs also tended to agree that the community also had too many. In contrast, respondents who did not think they had too many dogs were mixed on whether the community had too many dogs. The majority (88.3%) of respondents did not think it was acceptable for dogs to find their own food. Of the 7% of respondents that thought this was acceptable, three disagreed with allowing dogs to roam, which seems a contradiction in allowing dogs to find their own food. Only 11% of respondents felt it was acceptable to restrain dogs and these respondents also disagreed with or had no opinion about allowing dogs to roam. This disagreement with restraining dogs was confirmed with a follow up question about how often dogs should be restrained, with 84% saying never, and with responses for restraining dogs during the day (7%) only narrowly surpassing restraining dogs only sometimes (5%), or only at night (5%).

Our Mann-Whitney U test did not find any significant differences in opinions between respondents that were aware of disease transmission between humans and dogs (57.5%) and those that were unaware (42.5%), except on whether it was acceptable to restrain a dog (Table 1). In this case, those unaware of disease transmission were more likely to disagree with this statement, while those aware were more likely to be neutral on the matter. The average number of dogs owned by respondents unaware of disease transmission from dogs to humans was higher than those aware of this, although the difference was not statistically significant ($p=0.06814$).

Table 1 Results of Mann-Whitney U comparisons of the attitudes of respondents aware and unaware of disease transmission between humans and dogs.

Statements	Test Statistic	<i>p</i>
There are too many dogs in my household	1517	0.991
There are too many dogs in my community	1947	0.275
I support controlling dog numbers/ reducing dog numbers	1895	0.230
I would like to have greater control over the breeding abilities of my dogs	1731	0.225
It is acceptable for dogs to roam freely	1974	0.130
It is acceptable for dogs to be restrained	249	0.016

Discussion

Our study provides useful knowledge and insights into the domestic dog population around SPWS and practices and attitudes of Cambodian households towards dog ownership. With a mean ownership of 2.41 dogs per household and virtually all households owning at least one dog at the time of the survey or some point in the prior two years, it is clear that any management interventions for dogs will need to be supported by the entire community through engagement. The dog-to-human ratio (1:1.8) we recorded contrasts with the average ratio recorded in the Kandal and Battambang provinces of Cambodia (1:3.8 and 1:3.3 respectively; Chevalier *et al.*, 2021), indicating that rates of dog ownership are lower in our study area. To improve understanding of the dynamics of the dog population, further investigation into the role that in- and out- migration of dogs plays is needed, as well as the causes of and age at death. Given that the rate of puppy survival we recorded per female

per year was less than two, emigration likely plays an important role. A longer-term study would be helpful to understand population fluctuations and determine the possible drivers of these.

We found the adult dog population was slightly skewed towards females, although it was unclear whether the local preference for female dogs played a role in this, and the overall sex ratio was approximately equal. Chevalier *et al.* (2021) also found relatively even sex ratios for dog populations in the Battambang and Kandal provinces, as did Morters *et al.* (2014) in South Africa. This contrasts with the usually male-skewed sex ratios reported for village dog populations around the world (Boitani *et al.*, 2007; Ortolani *et al.*, 2009; Ruiz-Izaguirre *et al.*, 2014; World Health Organization, 1988). The preference for female dogs in Khes Svay also contrasts notably with survey responses in Kandal and Battambang, where male dogs were the clear preference (Chevalier *et al.*, 2021). The importance many owners place on their dog's ability to breed may pose a challenge to controlling reproduction among domestic dogs. While many respondents felt that there were too many dogs in the community, fewer believed that they owned too many dogs, and the preference for female dogs, largely for their ability to breed, suggests this is important to most owners and may be an economic benefit for some. While only a relatively small number of respondents stated a preference for a reproductive control method, the majority preferred euthanasia of puppies, rather than sterilisation, suggesting that they prefer to maintain their dog's fertility. The use of temporary contraceptives might be more palatable for the community; however, achieving reproductively significant uptake may be a challenge. While the barriers to accessing different reproductive control methods could have influenced the respondent's preferences, this was not examined. Reducing the mortality rate of dogs would likely assist in reproductive management, as owners may feel less need for a ready supply of new puppies. Further investigation into the reasons behind the unwillingness of local people to use fertility control should be undertaken.

It was clear from our study that security was the primary purpose for owning a dog. Unfortunately, only the first cohort of respondents gave secondary reasons, but it is still apparent that culture, hunting and pest management are also important reasons for owning a dog. The importance of security, and hence the requirement of constant presence of the dog at the house to provide this service, may encourage owners to consider changes in the way they manage their dogs to prevent roaming. However, with only 18% of respondents believing or admitting that their dogs roam, and the majority of these

for only a few hours, convincing owners to curb roaming behaviour may be challenging. Evidence of the roaming behaviour of dogs from Khes Svay village is available: Ladd *et al.* (2023) determined the activity ranges and patterns of ten dogs from the village and found that half of them entered the wildlife sanctuary on roaming forays. Presenting this information in an appropriate format may be useful for convincing villagers of the problem. The use of dogs for hunting and pest management may conflict with efforts to reduce roaming and the taking of dogs into the forest. While hunting in the wildlife sanctuary is prohibited and ranger patrols attempt to enforce this, it does occur and the areas considered appropriate for pest management by their owners may conflict with wildlife protection. Further investigation is needed to quantify the impact dogs may have on wildlife in Siem Pang Wildlife Sanctuary, as much of the existing evidence has been opportunistically collected by sanctuary rangers when they encounter such events.

Just over half of our respondents had some degree of awareness about diseases that could be transmitted from dogs to humans, and of those that were aware, all were concerned with this issue. However, there was little difference in the attitudes of these two groups towards the management statements and the rate of dog ownership. The depth of knowledge on disease transmission was not investigated, so it is unclear how detailed the knowledge of those aware of the issue was, and whether a deeper understanding might result in changes to attitudes. The integration of human health and animal welfare objectives into dog management programmes has been identified as a useful strategy for increasing community uptake in such programmes, rather than focusing only on conservation (Doherty *et al.*, 2017). Health is a more direct concern to the everyday lives of local people and may provide greater motivation for behavioural changes.

While the response rate to all of our questions was generally high, there are indications that respondents may not have been entirely truthful or may have given answers that they thought we wanted to hear in relation to some topics. This issue was discussed during the development of the survey and the role Rising Phoenix (formerly BirdLife International) plays in the enforcement of protected area laws and regulations was seen as a potential hinderance to receiving honest answers, particularly regarding dog-wildlife interactions. This was apparent with many of the respondents who stated one of their reasons for owning dogs was for hunting, yet contrary to this, they also claimed to have never seen their dog or anyone else's dog hunting or harassing wildlife. While there are forested areas outside of the wildlife sanctuary that could be used for hunting, these areas

are increasingly degraded by logging and clearance for new rice fields. Such discrepancies in the data seem to be largely limited to the questions regarding dog-wildlife interactions, so these responses need to be considered with some scepticism. To better gauge local experiences of dog-wildlife interactions, an alternative method may be needed in future investigations, such as bringing in an unaffiliated team to undertake research, and/or using an unmatched count technique that allows for differences in responses to sensitive questions to be measured (Hinsley *et al.*, 2019; Cerri *et al.*, 2021).

The dearth of strong views on options for dog management suggests that the community may be open to education and behavioural change. However, lack of resources poses a major barrier to effective management of dogs. All households feed their dogs with rice and almost all also feed them with food scraps, however it is unclear how often this occurs, and the frequency, quantity and nutritional value is likely highly variable. Given this information on diet, and the relatively poor body condition of many dogs observed in the community, poor nutrition is likely very common. Cambodia is one of the poorest countries in Southeast Asia and households do not always have the resources to consistently provide their dogs with higher quality and quantities of food, or to construct dog proof fencing, actions which may reduce roaming and hunting. Domestic dogs that are underfed are more likely to prey on wildlife compared to dogs receiving adequate nutrition (Silva-Rodriguez & Sieving, 2011) and if an approach to improve nutrition were to be attempted, food subsidies might be needed in addition to education. Additionally, it would be important to create an appropriate experimental design for any trial to improve dog nutrition to determine that the desired result of reduced wildlife predation occurs without unintended consequences such as producing stronger dogs that are more effective hunters, or increasing the dog population. With 40% of respondents indicating they take their dogs with them to the forest at least sometimes, this issue is a potentially more feasible starting point for reducing the number of dogs in the forest, as it does not require owners to invest any resources in curbing roaming behaviour, such as restraining or containing them. However, it will be necessary to investigate the reasons why people take dogs into the forest, so that they can be appropriately addressed when attempting to change this behaviour. There was also a relatively large group that were against restraining dogs, which would challenge efforts to reduce roaming behaviour.

Our survey provides useful baseline data for developing a management strategy for free-ranging dogs. Although most owners stated they never take their

dogs into the forest, we found that there was still a large proportion of households (40%) that do, and engaging this group to stop this will be important. Further investigation on why villagers take their dogs with them may be needed to develop a targeted education campaign and enforce rules regarding dogs in the wildlife sanctuary. It will also be critical to convince local people that dogs are a problem. This will require the collation of evidence, such as the roaming behaviour of dogs in Khes Svay village documented by Ladd *et al.* (2023) and ranger reports of dog-wildlife interactions, and presenting this in an appropriate format. The relatively poor nutrition of dogs has potential for improvement to reduce their roaming and hunting, however careful consideration on how this could be made to work is needed given the limited resources locally and potential for unintended consequences. The integration of health into a management strategy for dogs appears to be a promising avenue, with awareness on this topic limited. Improving dog health as part of a more comprehensive strategy would not only have benefits for wildlife, but human, dog and livestock health as well.

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Annex 1 Study Questionnaire

Household Information

1. How many people currently live in your household?
Adults Children
2. Do you keep livestock and/or grow crops?
Livestock / Grow crops / Both
a. What livestock do you keep?
Chickens / Ducks / Cows / Buffalo / Pigs / Goats /
Other (specify)
3. Do you have a field house?
Yes / No
a. Do your dogs go with you when you stay there?
Yes / No
4. How do you dispose of food waste?
Give to Animals / Burn / Bury / Other
5. Do you use forest resources?
Non-Timber Forest Products / Fish / Collect Wood /
Other (specify)

Dog Demographics

1. During the past 2 years, how many dogs have you owned, how many died or were given away, and how many do you have now?
2. How many of the following do you have now?
 - a. Male adult dogs
 - b. Female adult dogs
 - c. Male juvenile dogs
 - d. Female juvenile dogs
 - e. Male puppies
 - f. Female puppies
3. How many litters have your female dogs had during the past 12 months?

Dog 1:	Dog 2:	Dog 3:
a. How many puppies in each litter?		
Litter 1:	Litter 2:	Litter 3:
Litter 4:	Litter 5:	
b. How many puppies died, how many lived?		
Litter 1:	Died	Lived
Litter 2:	Died	Lived
Litter 3:	Died	Lived
Litter 4:	Died	Lived
Litter 5:	Died	Lived

c. What times of year were the litters of puppies born?

OR

Wet season / Dry season

d. Are your female dogs currently pregnant or have puppies?

Dog 1: No / Pregnant / Puppies

Dog 2: No / Pregnant / Puppies

Dog 3: No / Pregnant / Puppies

4. Do you try to control your dogs' reproductive output?
Yes / No
a. How, and for which dogs?
Spay or Neuter / Prevent Mating / Euthanise Puppies / Other (specify)

Dog Management

1. Why do you own dogs? (indicate order of importance if multiple reasons)
Security / Pest Management / Hunting / Herding Livestock / Breeding / Cultural / Other (specify)
2. In the last week, how often did you feed your dogs (not leftovers/food waste)?
Daily / 4-6 times / 1-3 times / Never
3. In the last week, what did you feed your dogs?
4. In the last week, on how many occasions was it restrained or contained (i.e. kept from roaming)?
Never / 1-3 days / 4-6 days / Always
a. On these occasions, for how long was it restrained?
All Day & Night / Night Only / Day Only / More than Half the Day / Less than Half the Day
5. How do you restrain or contain your dog?
Tethered / Penned / Dog-Proof Fenced Yard / Other (specify)
6. How often does your dog roam outside of your yard/roam outside of calling distance?
Never / Sometimes / Often / Always
a. When roaming, in general, how long is the dog away before coming back?
1-2 hours / Half a Day / One Day / 2-3 Days / A Week or More
7. What time does your dog start roaming (i.e. not being around the house)?

Morning / Midday / Afternoon / Evening / Night / Anytime

8. When does your dog usually return?

Morning / Midday / Afternoon / Evening / Night / Anytime

9. Has your dog ever been vaccinated?

Yes / No

10. If your dog is sick or injured, what do you do?

Do Nothing / Treat with Traditional Remedies / Seek Veterinary Care / Other (specify)

11. Are you aware of the diseases that dogs can pass on to humans, as well as other dogs, such as rabies and toxocariasis?

Yes / No

- a. Are you concerned about this?

Very concerned / concerned / neutral / unconcerned / very unconcerned

Dogs and Wildlife

1. Do your dogs go with you into the forest?

Never / Sometimes / Usually / Always

2. Do you see other people taking dogs into the forest?

Never / Sometimes / Usually / Always

3. How many dogs usually go with you or do you see with others?

4. Do the dogs stay within calling distance during the trip?

Never / Sometimes / Usually / Always

5. In the last 12 months, have you observed your own or other dogs hunting or harassing wildlife in the forest?

Yes / No

Ungulate / Rodent / Bird / Reptile / Other (specify)

6. In the last 12 months, have you observed your own dogs or other dogs hunting or harassing wildlife around the village, or fields maintained by your village?

Yes / No

Ungulate / Rodent / Bird / Reptile / Other (specify)

Opinions

1. How many unowned dogs do you think live in the village?

2. Do you have a preference for male or female dogs?

Males / Females. Why? Reason:

What is your opinion on the following statements?

1. There are too many dogs in my household.

Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree

2. There are too many dogs in this community.

Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree

3. I support controlling dog numbers/reducing dog numbers.

Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree

4. I would like to have greater control over the breeding abilities of my dogs.

Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree

- a. What are your preferred methods, in order of preference?

Spay and Neuter / Euthanise Adults / Euthanise Pups / Other (specify)

5. It is acceptable for dogs to find their own food.

Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree

6. It is acceptable for dogs to be allowed to roam freely.

Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree

7. It is acceptable for dogs to be restrained.

Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree