Assessing the dog-wildlife interface in Mudumalai Tiger Reserve, Tamil Nadu

by

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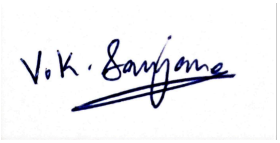
June 2024

DECLARATION

I hereby declare that the work conducted under the thesis entitled **"Assessing the dog-wildlife interface in Mudumalai Tiger Reserve, Tamil Nadu",** is a record of original and independent research work done by me and subsequently submitted for the award of the degree of **Master's in Wildlife Science** at the **Academy of Scientific and Innovative Research**. This research work has been carried out under the guidance and supervision of **Dr. K. Ramesh, Scientist F**, and co-supervision of **Shri Varun Kher, Scientist C** of Wildlife Institute of India, Dehradun. The work has not formed the basis for the award of any other degree, diploma, or any other qualification. I also declare that the thesis embodies my own work, analysis, observation, understanding and the particulars given in it are true to the best of my knowledge.



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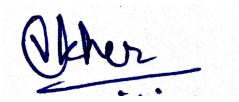

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CERTIFICATE

This is to certify that the thesis by **Sanjana Vadakke Kuruppath** entitled "**Assessing the dog-wildlife interface in Mudumalai Tiger Reserve, Tamil Nadu**" is an original and independent research work submitted to the **Academy of Scientific and Innovative Research**, for the award of the degree of **Master's in Wildlife Science**.

Sanjana Vadakke Kuruppath has put one semester of research work embodied in this thesis under my guidance and supervision. The work presented in this thesis has not been submitted to any other University or Institute for the award of any degree, diploma or distinction.

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I discussed my ideas with many people before this study was in shape. I thank Pallavi Ghaskabi, Aishwarya Bhandari, Rajat Rastogi, Sutirtha Lahiri, Dr. Abi Vanak, Dr. Arjun Srivathsa, Dr Ilona Otter, and all the faculty at WII who took the time to speak with me and help me clarify my thoughts. I thank Dr Ilona and Mr. Nigel Otter for meeting me as well, for allowing me to tag along on a vaccination drive, and for explaining the ABC programme in Mudumalai to me with such kindness. Everyone in Masinagudi was welcoming and friendly, and made my first taste of small town life a memorable one. Sudha akka in particular deserves all the praise possible for cooking such healthy, delicious food every single day.

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To the anxious and hopeful future MSc students reading this: don't hesitate to speak to every possible person who might be able to help clarify your ideas, and don't worry, it'll all work out.

To other curious readers: please note that submission does not equal completion, and this study is still a work in progress!

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EXECUTIVE SUMMARY

Dogs are generally considered to be detrimental to wildlife, primarily as hyper-abundant predators and vectors of disease. However, studies on the impact of dogs are often a by-product of research on a wild species or anecdotal accounts of predation. Among studies where the focus is on dogs, quantified reports of impacts are rare compared to studies based on social surveys; very few such studies have been produced from India. This study aims to produce such a report from Mudumalai Tiger Reserve in the Nilgiri landscape.

The objectives of this study were to quantify the dog population and its demographic parameters, assess spatio-temporal overlap with wildlife, and carry out a survey to understand human attitudes towards dog management. Population and human attitude assessment are critical to monitoring long-term dog presence in the region as well as to successfully implement management strategies. To accomplish this, I carried out photographic sight-resight surveys, a questionnaire survey, and boundary camera trapping in five villages in MTR, and also utilized secondary camera trap forest data. My results indicate that:

1. The dog population is approximately 1300 across all villages, with a distinct population towards the village center and another roaming population of stray/farm dogs at the wildlife interface. If current levels of sterilization are maintained, the population will drop to around 600 within 20 years. Heterogeneity capture-recapture models in Program MARK provide fairly reliable estimates that improve with higher recapture rates.
2. Spatio-temporal overlap of wildlife with dogs is relatively high in forest areas, indicating little segregation and therefore little negative impact on wildlife behavior. In village areas, temporal segregation was present while spatial segregation was not, indicating that

further fine-scale research at the boundaries is required. Chital is the prey species at highest risk of predation, while dholes show moderate overlap with dogs at village boundaries. Levels of overlap are specific to villages as well as dog pack activity patterns and local context should be considered at the village scale while planning management strategies.

3. Local residents have strong ties to their dogs, which primarily protect their owners and assets such as livestock, and are broadly in favor of ABC programmes. Outreach and education to improve awareness and goodwill will be crucial to successfully managing the dog population in the future.

1. INTRODUCTION

The domestic dog (*Canis lupus familiaris*) is considered to be the first animal to be domesticated by humans, and has a long history of close association with human settlements and livelihoods (Miller et al., 2014). This bond extends to the emotional as well, and dogs are often portrayed in popular media as protective, loyal, and courageous companions. Commonly kept as pets or used as guard or sniffer dogs, they are the most common member of the order Carnivora on the planet, with an estimated population of approximately 1 billion worldwide as of 2014 (Gompper, 2014b). A separate population of 100 million is estimated to be free-ranging (Gompper, 2014b); that is, free to roam without constraint, whether entirely feral, community-owned, or partially owned by individuals. The threat posed to wildlife by free-ranging dogs is therefore one that has attracted increasing attention in recent years (Bryce et al., 2021; Gompper, 2021)..

Studies from across the world have validated different dimensions of this threat. Dogs have been implicated in the extinction of eleven species and threaten nearly 200 species worldwide (Doherty et al., 2017). They are known vectors of multiple diseases and there is documented evidence of dogs exposing co-occurring wildlife to pathogens. Examples of such transmission include rabies in African wild dogs and Ethiopian wolves (Woodroffe, 1999), and, notoriously, canine distemper in lions in the Serengeti, resulting in a 33% decrease in the estimated population (Roelke-Parker et al., 1996). Dogs also impact prey species through direct predation, sometimes far above their energetic requirements, and may also induce fear through chasing and harassment (Ritchie. et al., 2014; Young et al., 2011). Overall, they have been shown to pose a threat as hyper predators or competitors with native predators, as carriers of disease, as prey that

may subsidize predators and bring them into conflict with humans, and as sources of interbreeding with wild *Canis* species (Gompper, 2021). These threats are amplified by the high population density of dogs in many parts of the world, sustained by provisioning from humans (Gompper, 2014a). They are considered an invasive threat to native wildlife, negatively affecting threatened species across regions and taxa (Doherty et al., 2016, 2017).

However, this may not always be the case. For example, though dogs were found to be a significant threat to vulnerable pudu in Chile (Silva-Rodríguez & Sieving, 2012), they were only a minor management problem for widespread white-tailed deer in the USA, though they preyed on both deer species (Gompper, 2021; Parsons et al., 2016). Additionally, it is reasonable to suppose that in areas where dogs have been long established, native wildlife is likely to have adapted to coexist with them and sustain the effects of the dog population, whether as predators, prey, or carriers of disease (Gompper, 2021). Wild canid populations may, for instance, already have several strains of pathogens circulating amongst them that exist in nearby dog populations as well, but these need not have been transmitted by dogs or be sustained by interaction with dogs. Hybridisation may also be specific to populations where wild canids have restricted mating opportunities and need not have large-scale, drastic impacts on their populations (Bryce et al., 2021). As such, dog-wildlife dynamics are not invariably generalizable as severely harmful to wildlife (Bryce et al., 2021). They are likely to be specific to the region's environmental and ecological context, with possible negative impacts occurring on a local - and therefore manageable - scale (Gompper, 2021). In this context, critical assessment of the various aspects of possible dog impact on wildlife is necessary to substantiate the need for dog management in a given area and design effective, scientific management strategies where required.

The need for such studies is most pressing in India, which has one of the highest populations of dogs in the world, estimated at 58.5 million in 2014 (Gompper, 2014b), supported by the high human population, poor pet ownership laws, and lack of waste management (Home et al., 2018). A dog population boom may also have been facilitated in the previous century by the vulture poisoning crisis in India, as the free-ranging dog population is likely to have successfully occupied the suddenly empty niche of carcass scavenger (Frank & Sudarshan, 2023). Current Indian laws do not allow euthanasia for dog management; the only permitted recourse is animal birth control, commonly known as ABC, to sterilize dogs and limit population growth, which in itself is plagued by several issues (Warden, 2014).

A large free-ranging dog population with limited avenues for management results in added pressure on India's natural ecosystems, which are already under threat across the country. Given the country's rich and varied wildlife, there is an abundance of situations where studies on dog-wildlife dynamics may not only be fruitful but urgently necessary. Of the many aspects of these dynamics that may be investigated, one of the most fundamental is the demography of free-ranging dog populations. Quantifying the nature of a particular dog population is the first step to understanding its impact on wildlife, as well as to tracking population trends in the future. I therefore characterized the dog population in the study area in demographic terms. I also investigated dog-wildlife spatio-temporal overlap at village boundaries to assess the probability of encounter between dogs and wild mammal species of interest. Finally, I carried out a questionnaire survey across the study area to investigate human attitudes relevant to dog-keeping, a factor which will inform future management strategies.

1.1. Study aims

1.1.1. Objectives

1. To quantify the dog population's abundance and demographic parameters.
2. To record human attitudes towards dogs and understand why and how they are kept.
3. To quantify spatio-temporal overlap between dogs and mammal wildlife.

1.1.2. Questions

1. How many dogs are present in the area, and how many are male, female, and sterilized? What could their population growth look like in the long term?
2. How do local residents feel about dogs in general, and why and how do they care for them? What are their attitudes towards ongoing dog management strategies, and are they aware of conflict between dogs and wildlife?
3. How does dogs' use of space and time overlap with mammal wildlife, and which wildlife species might they come into contact with most often?

2. LITERATURE REVIEW

Despite dogs being a popular companion as well as working animal across the globe, and despite the fact that its effects on wildlife as an invasive species are fairly tangible compared to smaller animals, they receive surprisingly little attention and have fewer studies focused on them than feral domestic cats (Hughes & Macdonald, 2013; Young et al., 2011), possibly the only other animal that acts similarly as a human companion. A 2013 literature review (Hughes & Macdonald, 2013) reported 69 studies on dog-wildlife interactions, of which the majority were from North or South America, followed by Africa, Asia, Europe and Australsia. These studies reported all the well-known detrimental effects of dog presence, including predation, competition with wild carnivores, disease transmission, and behavioral modification of wild species. However, the majority of these studies consisted of anecdotal evidence or records of incidents without any quantification of the overall impact on prey species, failing to provide conclusive evidence as to the detrimental impacts of dog presence. This is likely due to the fact that such studies are often a byproduct of research focused on the ecology of a wild species, rather than the dogs themselves (Hughes & Macdonald, 2013; Young et al., 2011). Additionally, studies may use sociological methods to estimate impact and/or population and demographics, such as online or field questionnaire surveys (Butler & Bingham, 2000; Home et al., 2018; Orozco et al., 2022; Sogliani et al., 2023; Zamora-Nasca & Lambertucci, 2022). While this provides valuable information as to the role that dogs play in the community and the demographics of the owned dog population, it should ideally not be used as the sole method of dog-related impact assessment as it may be biased by error of memory or emotional/social reasons to respond untruthfully (for example, fear of harm to an owned dog if the researchers report that it has killed wildlife). This

method is also not dependable for information about free-ranging dogs which may come into limited contact with humans, as the study must necessarily be restricted to using data about owned, easily controlled household dogs that are less likely to roam (Belsare & Gompper, 2013).

Studies that did directly assess dog impacts on wildlife have discussed several different impacts, such as altering activity patterns and reducing habitat use by wildlife in areas with dog activity (Lenth et al., 2008), suppressing population growth and limiting kid/female ratio of mountain gazelles (Manor & Saltz, 2004), altering landscape-level distribution of ungulates (Silva-Rodríguez & Sieving, 2012), interfering with native carnivores by altering their space use (Silva-Rodríguez et al., 2010; Vanak & Gompper, 2010), and increasing the exposure of wild canids to pathogens (Woodroffe et al., 2012). Such research is still lacking in India. While there are several studies focusing on dog demography, population estimation and epidemiology from both rural and urban areas (Belsare & Gompper, 2015b; Hiby et al., 2011; Reece et al., 2008; Totton et al., 2010), published studies specifically on dog impacts on wildlife numbered only six ((Belsare et al., 2014; Belsare & Gompper, 2015a; Mahar et al., 2023; Vanak et al., 2009; Vanak & Gompper, 2009, 2010)). While these studies indicate severe impacts such as predation, interference competition, and potential disease transmission, they are located in only two regions - Central India (Maharashtra) and the Trans-Himalayas (Ladakh), a poor sampling of the wide range of landscapes that contain India's biodiversity. There is thus a large gap in research on this topic that urgently needs to be addressed, given the myriad of negative impacts dogs have been shown to cause across the globe.

With respect to the specific objectives of this study, while quantifying spatio-temporal overlap between dogs and wildlife needs little explanation as to its importance, the dog demography and population assessment objective provides perhaps the greatest scope for long term population management. Hughes & Macdonald, 2013, mention several parameters that should ideally be recorded in every dog-related study to assess the scale of the issue, model the growth trend of the population, illuminate future research directions, and provide a standard by which to compare multiple such studies and determine the magnitude of intervention required. For short term research, these include population size and density along with the size of the study area, population age-sex class sizes, and the size of impacted wildlife populations (Hughes & Macdonald, 2013). This study also mentions that "establishing the local attitudes towards dogs (and) their purpose and value in the community" would contribute to creating effective management strategies, as well as understanding the nature of conflict in the system, as multiple studies have shown (Butler & Bingham, 2000; Orozco et al., 2022; Warembourg et al., 2021). Undertaking a questionnaire survey, while not sufficient to establish dog impacts on its own, is necessary to address the uniquely socio-ecological nature of dog-wildlife interface issues, providing important supportive context for future policies that may be developed (Miller et al., 2014).

3. METHODS

3.1. STUDY AREA

Mudumalai Tiger Reserve (11°29'9.36"N to 11°42'15.18"N to and 76°21'26.58"E to 77° 0'34.31"E) is a protected area covering 688.59 sq km in the Nilgiri district of the state of Tamil Nadu, Southern India. MTR is situated at the tri-junction of Tamil Nadu, Karnataka and Kerala, and is contiguous with Bandipur Tiger Reserve to the north and Wayanad Wildlife Sanctuary to the east, as well as Sigur Reserve Forest and Singara Reserve Forest to the west and south respectively. It is part of the Nilgiri Biosphere Reserve, which provides Indian wildlife with critical refuge and facilitates connectivity for one of the largest tiger and elephant populations in the country (Puyravaud et al., 2016).

The terrain is undulating, with elevation ranging from approximately 300 m to 1200 m (H. Suresh et al., 1996). Rainfall is received from both the southwest (June-September) and northeast (October-November) monsoons. Apart from this, MTR experiences two distinct seasons: summer from March to mid-May and winter from November to February. As part of MTR lies east of the Western Ghats, in a rain shadow area, it experiences a decreasing rainfall gradient from the west and south to the east and north (ranging from 1800mm to 600mm). Consequently, there is a vegetation gradient from tropical moist deciduous forest and patches of semi-evergreen forest, to dry deciduous forest, to tropical dry thorn forest towards the east (H. Suresh et al., 1996; H. S. Suresh et al., 2010). Flora across these vegetation types include *Toona ciliata*, *Viburnum punctatum*, *Tectona grandis*, *Lannea coromendalica*, *Terminalia bellarica*, *Anogeissus latifolia*, *Cassia fistula*, *Themeda cymbaria*, *Imperata cylindrica*, *Albizia spp.*, and *Acacia spp.* (H. Suresh et al., 1996). MTR contains a diverse mammalian assemblage, including chital (*Axis*

axis), sambar (*Rusa unicolor*), barking deer (*Muntiacus muntjak*), tiger (*Panthera tigris*), leopard (*Panthera pardus*), bonnet macaque (*Macaca radiata*), black-footed grey langur (*Semnopithecus hypoleucos*), Asian elephant (*Elephas maximus*), gaur (*Bos gaurus*), dhole (*Cuon alpinus*), sloth bear (*Melursus ursinus*), wild pig (*Sus scrofa*), and blackbuck (*Antilope cervicapra*) (H. Suresh et al., 1996).

MTR is an ideal location for a dog-wildlife study as it contains several human settlements in scattered enclaves, in the core as well as buffer zones. This population includes several tribal communities, such as the Soligas, Irulas, and Betta Kurubas (Enters, 2000), and dog-keeping is a common practice. The intensive study area includes five settlements in the center of the Reserve. This area includes part of the core and a large part of the buffer, where dry deciduous and/or dry thorn forest is present. It is situated in a relatively narrow east-west corridor approximately 11 km in width, bordered by the Moyar River to the north and Nilgiri hills to the south (Silori & Mishra, 2001). The five villages included in the study area are Bokkapuram, Masinagudi, Mavanalla, Moyar, and Vazhaithottam, all of which have unique local contexts. Bokkapuram consists of multiple small settlements with a sizable tribal population, and includes several private resorts and estates (many of which are currently closed) because of which it covers a large area. Masinagudi has the highest human population within an area of about 2.2 sq km, making it the most densely populated of all five villages. It has several facilities not available elsewhere (such as hardware shops, medical shops, and a petrol pump), and many people living there depend on tourism for their livelihoods. Mavanalla has the smallest human population and has two distinct settled areas, one with more dense settlements and one with more agricultural fields. Moyar and Vazhaithottam are both larger villages with smaller human populations and a

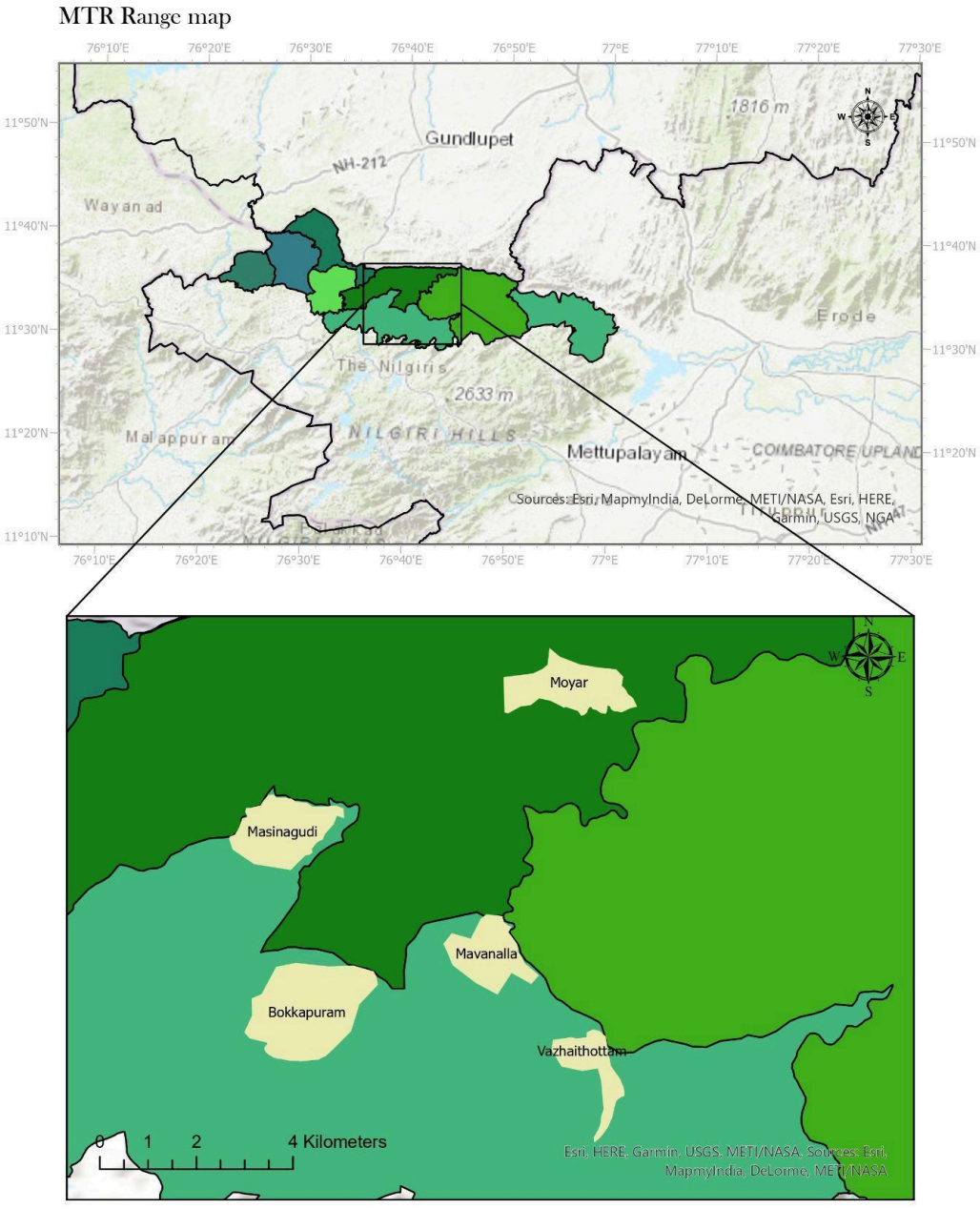
large forest-facing perimeter, and a majority of the area in both villages is under cultivation. The area of each village is presented in table 3.1-1 as calculated using Google Earth Pro, along with the population and household numbers (as provided by the Masinagudi panchayat; however, these numbers are from the 2011 national census and have not been updated since). The population information for Bokkapuram is an estimate provided by a local informant as it is part of a different panchayat and the recorded population was not accessible at the time of this study.

Village name	**Area**	**Human Population**	**Households**
Bokkapuram	3.82	1120	400
Masinagudi	2.23	4588	1641
Mavanalla	1.67	765	255
Moyar	2.1	1458	486
Vazhaithottam	1.17	830	310
Total	13.39	8761	3092

Table 3.1-1: Village area, population and number of households

It is important to note that MTR already has active dog management undertaken by the Worldwide Veterinary Service, which carries out vaccination and sterilization drives in Mudumalai as well as the Ooty-Coonoor-Mettupalayam area. Another NGO in MTR, India Project for Animals and Nature, is an animal rescue and care facility located in Mavanalla. It caters to several domestic animals including dogs, cats, cows, and horses, and also provides veterinary care for pet animals on request. As such, the dog-wildlife interface in MTR provides scope for a valuable, informative case study in a wildlife diverse region where dog management is already in practice.

Study area: Mudumalai Tiger Reserve



Intensive study area - Masinagudi range (including Moyar) and Singara range (including Masinagudi, Bokkapuram, Mavanalla, and Vazhaithottam)

Figure 3.1-1: Study area, including range map and village locations

3.2. FIELD METHODS

The field method employed for each objective was as follows:

3.2.1. Dog demography and population estimation:

A photographic sight-resight method was employed to assess dog population and demographic parameters. Here, all sighted dogs were assumed to be part of the free roaming population as owned dogs were rarely confined to homes or kennels, unless they were of certain valuable breeds, where they were unlikely to be sighted in any case. Owned dogs also rarely wore collars; they were therefore difficult to distinguish from truly stray dogs and, on the whole, had equal opportunity to travel within the study area. Fur patterns and other morphological characteristics (eg. injuries, sex, ear notch) were used to individually identify dogs from photographs. Each village was surveyed a minimum of four times, twice in the morning (9:30 AM onwards) and twice in the evening (4:30 PM onwards). While Belsare et al., 2013 found that the optimal morning time for dog surveys was between 7-9 AM, dog sightings were fairly low during pilot surveys in Masinagudi in January, presumably due to low temperatures causing dogs to become active later in the day. Additionally, safety concerns due to elephant movement prohibited movement to villages for early morning sampling, particularly since the vehicle being used was a two-wheeler. Sampling therefore began at 9:30 AM. Surveys were time bound and were completed within approximately two hours. Each survey consisted of two observers traversing village roads in a single direction on a two-wheeled motor vehicle. In the scenario where using a road that had already been surveyed was unavoidable, observations were not recorded for the length of that road to avoid double-counting. Survey routes were recorded using Locus Map 4.22.2 and are shown for Vazhaithottam in figure 3.2.1-1.

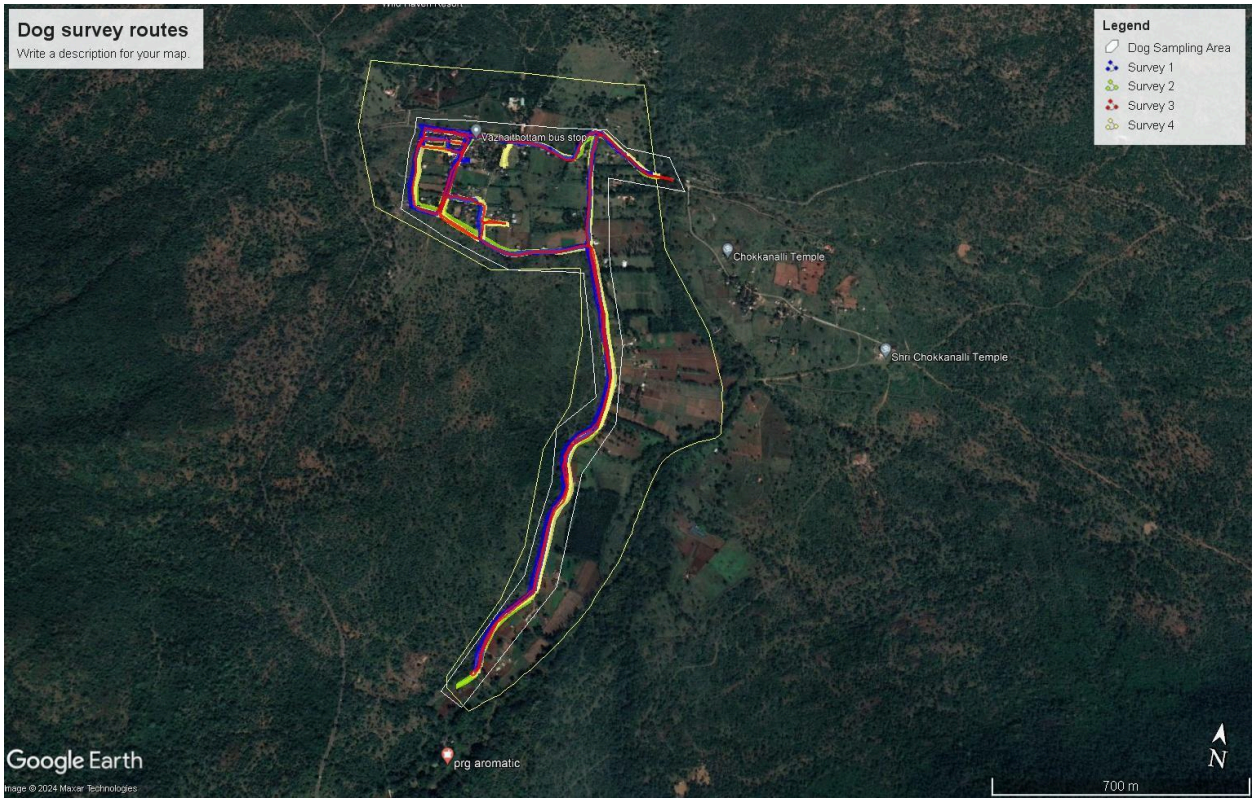


Fig 3.2.1-1: Mapped dog sampling survey routes in Vazhaithottam (village 5).

Survey routes were not predetermined; rather, as many of the village's main roads that could be covered once within the time limit were traversed. This sampling strategy meant that a village's entire area was often not covered, particularly the edges of the village, but the most densely populated areas with the most dogs and best road accessibility were covered multiple times. In order to account for differences in capture probability due to the time of day (that is, due to increased heat towards the end of the morning period, and nightfall towards the end of the evening period), each village was surveyed in the reverse direction upon each successive occasion. For example, if a village was surveyed from south to north during one occasion, it would be surveyed from north to south during the next. Where it was not possible to use a vehicle, both observers surveyed certain roads on foot. However, it is worth noting that this

applies only to major roads and many smaller footpaths were not included. Additionally, most farms kept multiple dogs which could not be observed from the main road and could only have been recorded with a door-to-door approach. Out of the five villages, two (Bokkapuram and Masinagudi) were surveyed more than four times as they had larger dog populations and the recapture rate was therefore lower; Bokkapuram was surveyed five times in total and Masinagudi was surveyed six times. The average number of observations per survey across all villages was 52.4. Apart from the extra survey rounds for Bokkapuram and Masinagudi, which took place in April, surveys were completed between January 5th, 2024 and February 5th, 2024 to maintain demographic closure.

During the survey, one observer recorded the time, GPS coordinates, and demographic data (age class (puppy/juvenile/adult), sex, ear notch presence or absence[1], skin condition score (SCS) and body condition score (BCS) as well as a single representative photo of each dog. The second observer took multiple photos of each dog to assist in individual identification during analysis. Photographs were taken using mobile phone cameras. For females, pregnancy or lactation was also recorded based on the presence of distended belly and/or swollen nipples. Age class was determined based on observation of body size (adult height or not), allometry (large head size and leg length relative to body size), and behavior (habitually accompanying an adult female). The age class ‘Puppy’ indicated a dog under the age of 6 months, ‘Juvenile’ indicated a dog between 6 months to 1 year old, and ‘Adult’ indicated a dog over one year old. Sex was determined based on visible genitalia. SCS was scored from 0-3, with 0 indicating no marks on the dog’s body, 1 indicating a few minor marks such as small scars or elbow hyperkeratosis, 2

[1] Ear notch was used to estimate numbers of vaccinated, sterilized dogs; however, some owners of sterilized dogs requested that their dogs’ ears not be notched. The percentage of sterilized dogs is therefore slightly underestimated.

indicating a few large marks or patches of fur loss, and 3 indicating severe scars, fur loss or mange. BCS was scored from 1-5 following Totton et al., (2011), with 1 indicating emaciation with visible ribs and pelvic bones, 3 indicating a normal body type with visible waist and non-visible ribs and pelvis, and 5 indicating obesity with no visible waist. Since it was difficult to distinguish between owned and unowned dogs as collars were not in common use and most dogs were left to roam free, the presence or absence of a collar and the state of confinement of the dogs (cage/tied/inside house or compound) was also recorded where applicable. Baiting was not routinely used, but biscuits were given to ensure that skittish dogs stayed still long enough for data collection. When dogs moved away too quickly to capture clear photos or to record more than one or two demographic data points, the dog was excluded from the dataset. Between 1-5 dogs were excluded in this way on each occasion, depending on the size of the population.

3.2.2. Human attitudes towards dogs:

A socio-ecological questionnaire survey regarding dog-keeping was conducted in all villages with a two-person team (one speaker and one recorder). The questionnaire was developed with reference to a similar study carried out in Chile (Sepúlveda et al., 2014). Attitudes towards dog keeping included questions pertaining to sterilization, reasons for dog keeping, veterinary care for dogs, and interactions with wildlife. The full questionnaire is available in the Appendix. The total number of respondents was 112, with 19 respondents from Bokkapuram, 24 from Masinagudi, 22 from Mavanalla, 29 from Moyar, and 18 from Vazhaithottam. Random sampling was conducted within each locality in a village as the two-person team traveled on foot, and respondents included households as well as shopkeepers. Dogs hunting wildlife are commonly considered to be a problem in Mudumalai (Premkumar, 2024), and a few respondents also

mentioned Forest Department staff shooting dogs seen on forest land. In general, therefore, respondents had reason to respond positively to questions about dog management and to deny any dog-wildlife interaction, which may have biased the results of the survey.

3.2.3. Dog-wildlife interface:

To quantify the dog-wildlife interface in terms of spatial overlap between dogs and wild mammal species, camera traps (Cuddeback C1) were placed along the periphery of each village boundary. Each camera site was approximately 500m apart, though this varied from 400m up to 1000m depending on land type (such as the presence of private homes or impassable bamboo brakes). Where there was sufficient distance between the settled area and the village boundary to allow for multiple cameras, two cameras were stationed 50m-100m apart from each other in order to increase the sample size per site. All sites are shown in figure 3.2.3-1. Cameras were mostly placed on animal trails to maximize the likelihood of both dog and wild animal capture, and were placed for 15 days in each village. They were set to be triggered by motion and capture images with no delay, apart from cameras with high captures of livestock or blanks, which were set to a five or ten minute delay to prolong battery life. All sites were checked every three days to swap out SD cards and batteries if necessary. On average, one set of eight batteries allowed for around 4000 images. All cameras were installed using safety cages, which prevented the loss of 29 out of 30 cameras. Cameras were placed in two villages simultaneously for each 15 day phase; trapping began on the 26th of February, 2024 and concluded on the 17th of March, 2024. Between 6 to 9 sites were present in each village, resulting in a total of 37 sites across all villages.

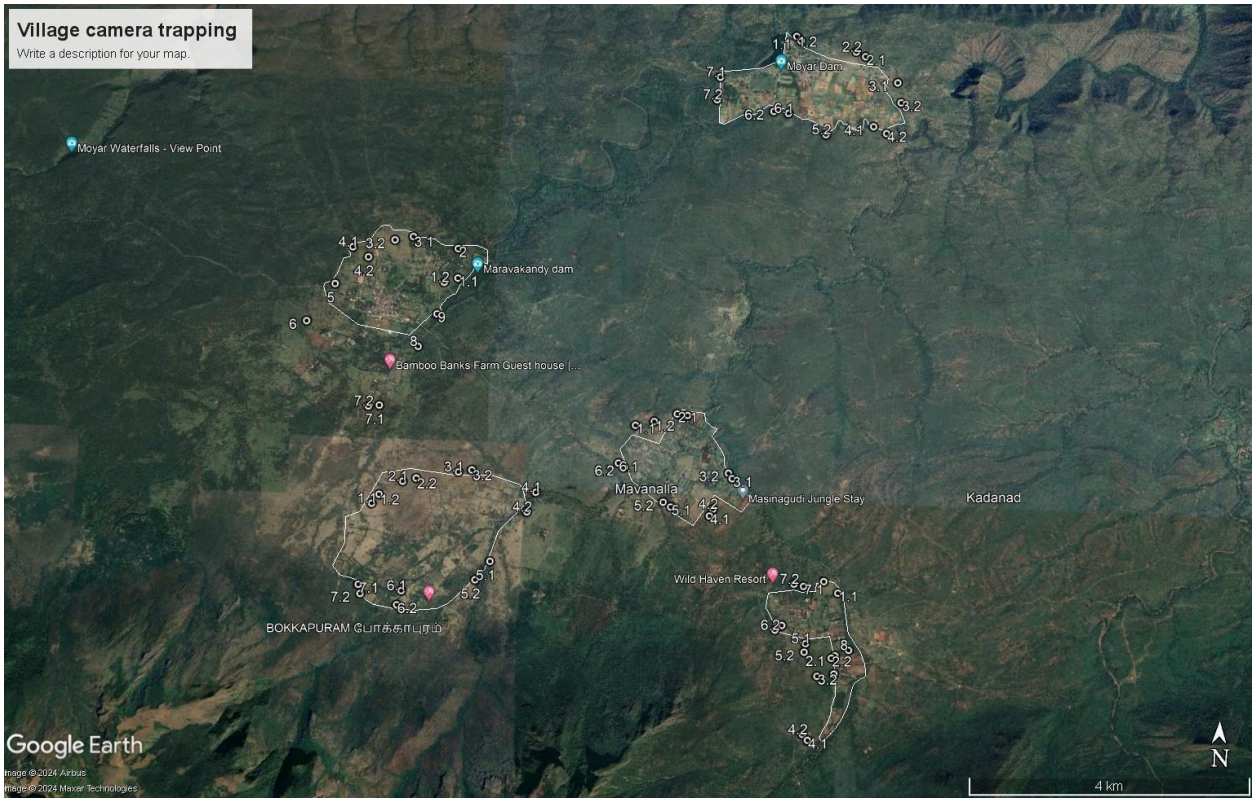


Fig. 3.2.3-1: Mapped camera trap locations at the boundaries of all villages

3.3. ANALYTICAL METHODS

The analytical method employed for each method is as follows:

3.3.1. Dog demography and population estimation:

All dog photographs were sorted by village and visually inspected to record recaptures. Where dog coat color posed any difficulty (eg. uniform tan or black fur) other distinguishing marks were used to uniquely identify each dog and assign them an ID number. If a dog could not be identified as a recapture with 100% certainty, it was considered to be a new capture and assigned a new ID number. The strong territoriality and sociality of dogs was valuable during identification as dogs were nearly always photographed again in the same location and with the same conspecifics as when it was first encountered. The exception to this was dogs that accompanied humans or livestock, which moved longer distances and displayed roaming tendencies. If a dog's photograph was too blurry or indistinct to be of use, the observation was discarded.

After all recaptures were recorded, SCS, BCS age, and sex entries were rechecked and separately recorded for each identified dog, as dogs were sometimes recorded with different demographic data during successive sampling rounds. Dogs that could not be identified as male or female in the field or from photographs were marked as being of 'Unknown' sex. A high percentage of sterilized dogs meant that sterilized male dogs could be mistaken for females if the penis was not clearly visible as testicles were no longer present. It should also be noted the BCS and SCS scoring as mentioned in Totton et al., 2011 was originally used for sedated dogs that could be physically examined, and is more suited for such a study than one with conscious, moving dogs

as marks or rashes on the skin may be hidden underneath the body and BCS can be difficult to score if the dog has a medium to long fur coat. These scores may therefore not be entirely accurate based solely on a cursory visual inspection. Where discrepancies were found in demographic data for the same dog from multiple survey rounds, the observation that was recorded most often was considered to be true. For example, if a dog was recorded as male twice and female once, it was considered to be male. If it was recorded as each sex only once, its photographs were inspected again. If the photographs did not conclusively support either sex, the first recorded sex was considered to be true. The same procedure was followed to resolve discrepancies in SCS and BCS scoring. Finally, the percentage of each class for each demographic variable as well as the recapture rate for each occasion for each village was calculated in Microsoft Excel 2016. 698 dogs were individually identified in total. Recapture rates were of two types - the occasion recapture rate (the number of individuals re-sighted in an occasion divided by the total number of dogs seen during that occasion) and the total recapture rate (the number of individuals re-sighted in an occasion divided by the total number of dogs individually identified across all occasions in that village).

Population estimation was done in Program MARK. Though the sampling framework was a sight-resight one, the data type used during analysis was closed captures (Huggins heterogeneity pi, p and c) since the primary goal was to estimate abundance rather than other parameters that are generally of interest in population ecology (rates of immigration, emigration, survival and recruitment). Additionally, mark-resight models are meant to allow for unmarked individuals as well (Cooch & White, 2009), which were not present in this study as every individual had a unique coat and body type that served as a natural mark. ‘Unmarked’ individuals that were

difficult to distinguish were very few (between one to three individuals per village) and were discarded from the dataset if identification was completely impossible. Regarding closure, the dog population of each village is geographically closed as the villages are present as a matrix within forest land, and connectivity between villages is only available through several kilometers of highway. Dogs have little incentive to travel beyond the village where they have established territory and sources of food, either using highways with traffic or forest land with wild animals that can pose a severe physical threat. While long-term observation would be needed to confirm that dogs are in fact restricted to a single village, no dog was photographed in multiple villages during the sampling period. Demographic closure is also maintained for this reason, as well as the fact that the sampling period was limited to one month in one season. Therefore, the closed captures data type was employed as all the necessary conditions were met. Two types of abundance were estimated: total abundance across villages and total abundance across villages with 'village' as a covariate (that is, pooling all data but retaining the village as a covariate to obtain village-specific estimates). Models included pi, p and c varying with 'village' and time of sampling, and the best model was selected through an information theoretic approach using AIC scores.

Finally, information pertaining to dog population growth, such as the sex ratio and the proportion of sterilized males and females, was used in Program Vortex (Vortex: A Stochastic Simulation of the Extinction Process, Version 10.5.5) to simulate population growth and trends for the next 100 years. Previous studies have estimated that the fecundity of free-ranging dogs is around 50% in any given year for female dogs over the age of one year, and the survival is below 25% for the first year and between 60%-77% for adults (Reece et al., 2008). These survival estimates are

from urban studies, where disease transmission from garbage or sewers and injury due to vehicular accidents are more likely. Therefore, while the fecundity rate was retained at 50% of the unsterilized female population (with all breeding females birthing at least one litter), survival was set to 50% with a standard deviation of 10% in the first year and 90% with a standard deviation of 3% for adults. The sex ratio was set at 50% , given the results from demographic sampling. The reproductive system parameters were set such that breeding was allowed between the ages of 1 to 12, with a maximum of one litter a year consisting of five puppies or fewer. The total population size was set to 1350 (see Results, Dog Demography and Population), with 45-80 individuals in each age class with a peak of 80 at ages 4, 5, 6 and 7 years old, decreasing to 10 for the last age class of 12 years old for each sex. Three scenarios were simulated: population growth with zero sterilization, population growth at half the level of current sterilization, and population growth at the current level of sterilization, where half the population of fertile females produced litters (standard deviation set to five for all). A supplemented version of each model was also run where five males and five females were added every year from year 1 to year 100, to account for people bringing in dogs from other areas. Each simulation was run for 50 iterations, and the carrying capacity was set to 2500.

3.3.2. Human attitudes towards dogs:

Results were collated across villages, classified into broader response categories and tabulated. For each question, the percentage of each type of response was calculated using Microsoft Excel, 2016.

3.3.3. Dog-wildlife interface:

The total number of photographs obtained across all villages was 34,127. An interval of 30 minutes between consecutive photographs was used to ensure independence of captures. Dog photographs from each capture were visually inspected to count the number of individual dogs, and captures were also compared with previous and following captures to enumerate how many captures took place independently of humans and/or livestock.

For temporal analysis, kernel density estimation was used to determine activity patterns and quantify overlap. All times were first converted into radians using the *gettime* function from the *activity* package (Rowcliffe, 2023) in R (R Core Team, 2021). Temporal overlap between dogs and wild species was calculated using the *overlapEst* function from the *overlap* package (Meredith et al., 2024), using Dhat1 as the estimator of overlap value when captures were below 50 and Dhat4 when captures were above fifty, as recommended by the package documentation. Only the wild species that had more than ten captures were included. Confidence intervals were calculated by bootstrapping the Dhat1 or Dhat4 estimates for each species combination 5000 times, then using the function *bootCI* to estimate the 95% confidence interval. Domestic animals and humans were also included in the analysis since dogs accompany humans and livestock into forest areas, in which case the likelihood of negative impact on wildlife decreases as they do not roam freely.

For spatial overlap, naive occupancy estimates were used to estimate overlap between different species and dogs (the number of sites where both dogs and the second species were present, divided by the total number of sites where dogs were present). More robust models of occupancy

were not appropriate to use with these data due to the relatively short distance between sites and the small sample size, which would have introduced bias (Mckann et al., 2013). A simple composite spatio-temporal score was calculated by averaging the spatial and temporal scores for each species (that is, (spatial overlap + temporal overlap)/2). While previous studies have used different composite scores, such as spatial adjusted or prey mass adjusted scores to look at prey selection (Allen et al., 2021), these were not used here as dogs are subsidized, domestic predators and their movement and hunting behavior is unlikely to conform to traditional models of niche overlap in the wild.

These procedures were also followed to estimate spatial and temporal overlap from 2021 camera trapping data from the relevant ranges (Masinagudi and Singara), which were obtained during the most recent cycle of tiger estimation (Tiger Cell, WII). These data, from 110 sites across the two ranges, were analyzed to estimate spatio-temporal overlap in the forest to compare to village boundary areas. Additionally, two occupancy models were run for dogs and dholes using the *unmarked* package in R (Chandler et al., 2024). The Royle/Nichols model was implemented for both species using the function *occuRN* to run a null model as well as a model using distance from settled areas as a covariate, which was calculated using the *Near* function in ArcGIS. Dholes were chosen as the most relevant wild species as they are the only wild canid currently present in Mudumalai.

4. RESULTS

4.1. DOG DEMOGRAPHY AND POPULATION ESTIMATION:

In total, 698 dogs were individually identified across all villages. The demographic variable results are presented in table 4.1-1. The male:female sex ratio is nearly 1:1, and nearly 90% of the population are adults (>1 year old). 63% of the total population is vaccinated and sterilized, as is 63% of the male population; the proportion for females is higher at 69%. This tallies with sterilization data provided by WVS (provided in Appendix). Assuming that the records are consistently accurate, this indicates that a general sterilization coverage of around 60% has been achieved with sterilization efforts since 1997. On average, 61% of the population had a healthy body score of 3 and 68% of the population had a skin condition score of 0. Out of a total of 336 females, 14 were lactating (4.17%) and 2 were pregnant (0.59%).

The average occasion recapture rate ranged from 39%-66%, while the average total recapture rate ranged from 15%-25% (excluding sampling rounds after four, as only two villages were sampled more than four times). These statistics indicate that between 49%- 77% of the population was sighted at least once by the end of four sampling occasions (occasion resight rate from round 4), while between 10%-36% of the population was sighted in a given village during a given sampling occasion, indicating that at least four sampling rounds are required to sight above 80% of the total population at least once. It is worth noting that the village with the highest recapture rates had the smallest dog population (Vazhaithottam), while the village with the lowest recapture rates had the largest dog population (Masinagudi).

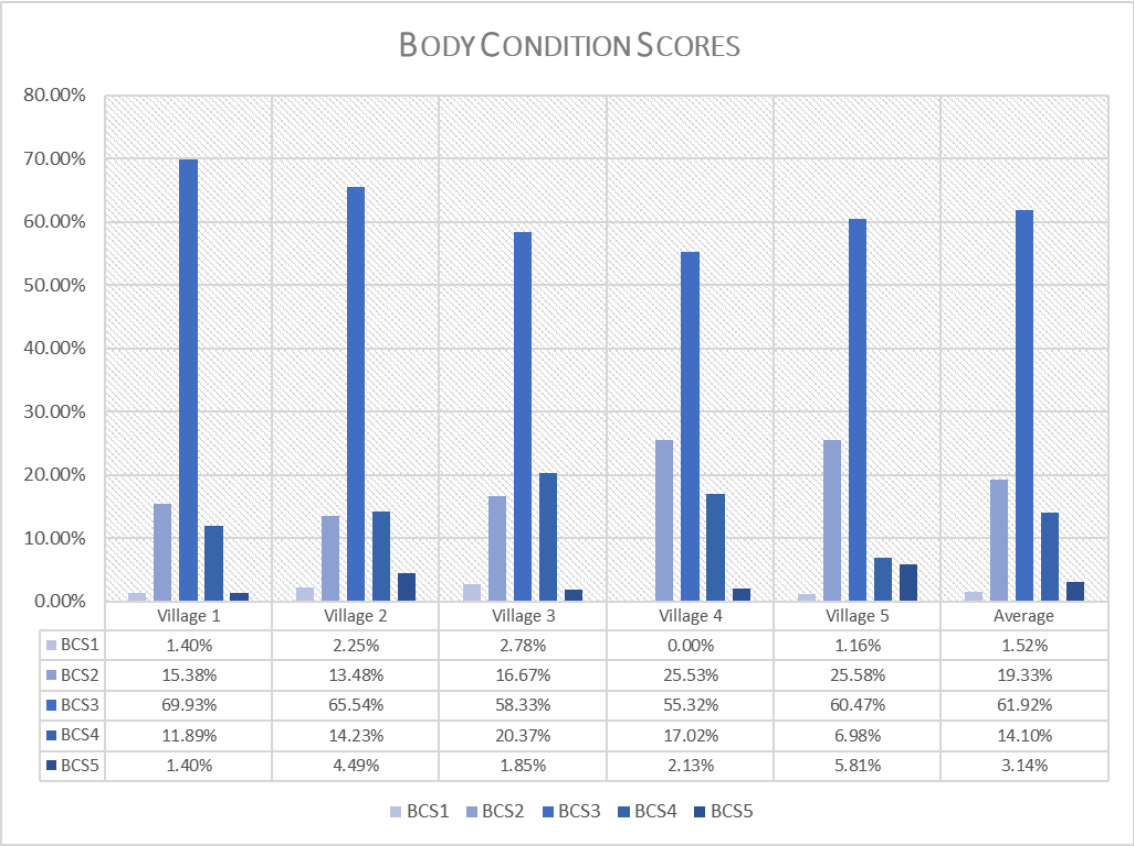
	Village 1 Bokkapuram	**Village 2 Masinagudi**	**Village 3 Mavanalla**	**Village 4 Moyar**	**Village 5 Vazhaithottam**	**Average**
Male	44.44%	42.32%	38.89%	55.32%	47.67%	45.73%
Female	47.92%	50.56%	52.78%	37.23%	46.51%	47.00%
Puppy	5.56%	3.75%	4.63%	4.26%	2.33%	4.10%
Juvenile	5.56%	5.62%	7.41%	1.06%	10.47%	6.02%
Adult	88.19%	90.64%	87.04%	94.68%	87.21%	89.55%

Table 4.1-1: Dog age and sex classes across all villages

Table 4.1-2: Dog sterilization proportions, overall, male-specific and female-specific (below)

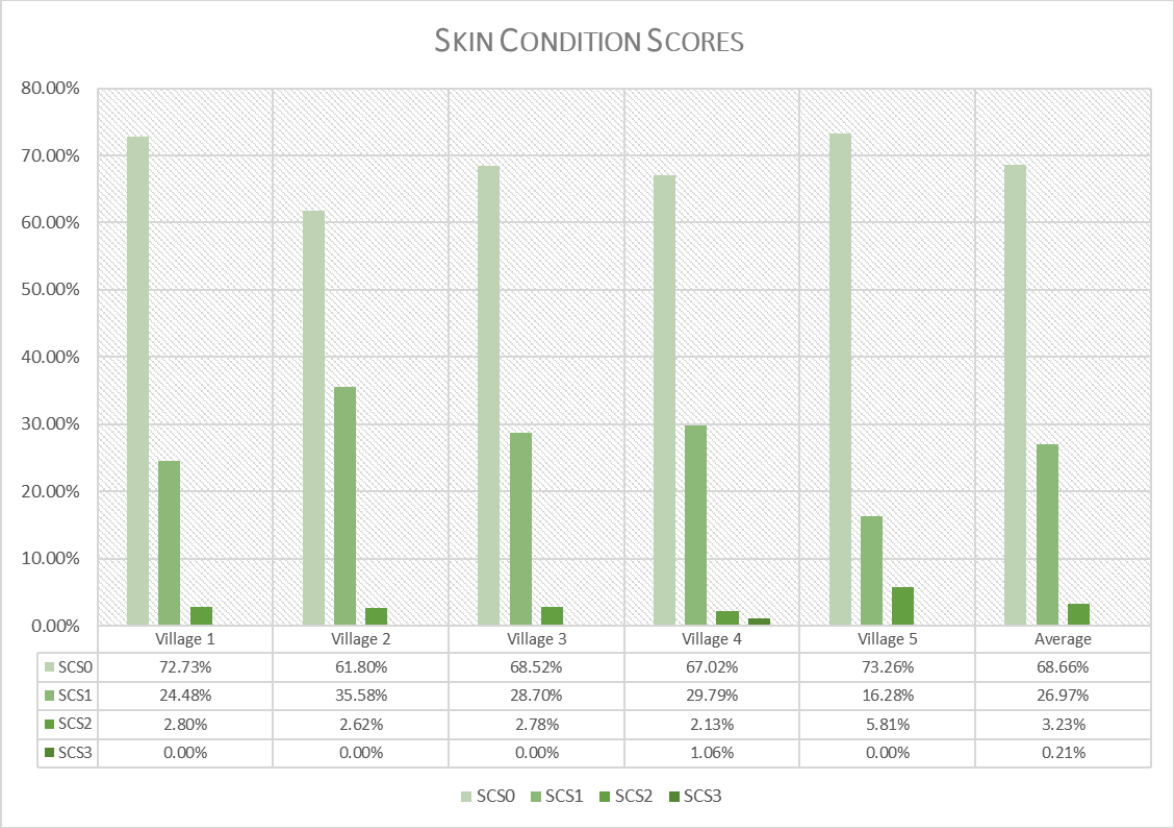
	Village 1 Bokkapuram	**Village 2 Masinagudi**	**Village 3 Mavanalla**	**Village 4 Moyar**	**Village 5 Vazhaithottam**	**Average**
Notched	68.75%	64.04%	65.74%	57.45%	59.30%	63.06%
Male notched/total males	76.56%	68.14%	59.52%	59.62%	53.66%	63.50%

Female notched/total females	72.46%	65.93%	77.19%	62.86%	67.50%	69.19%



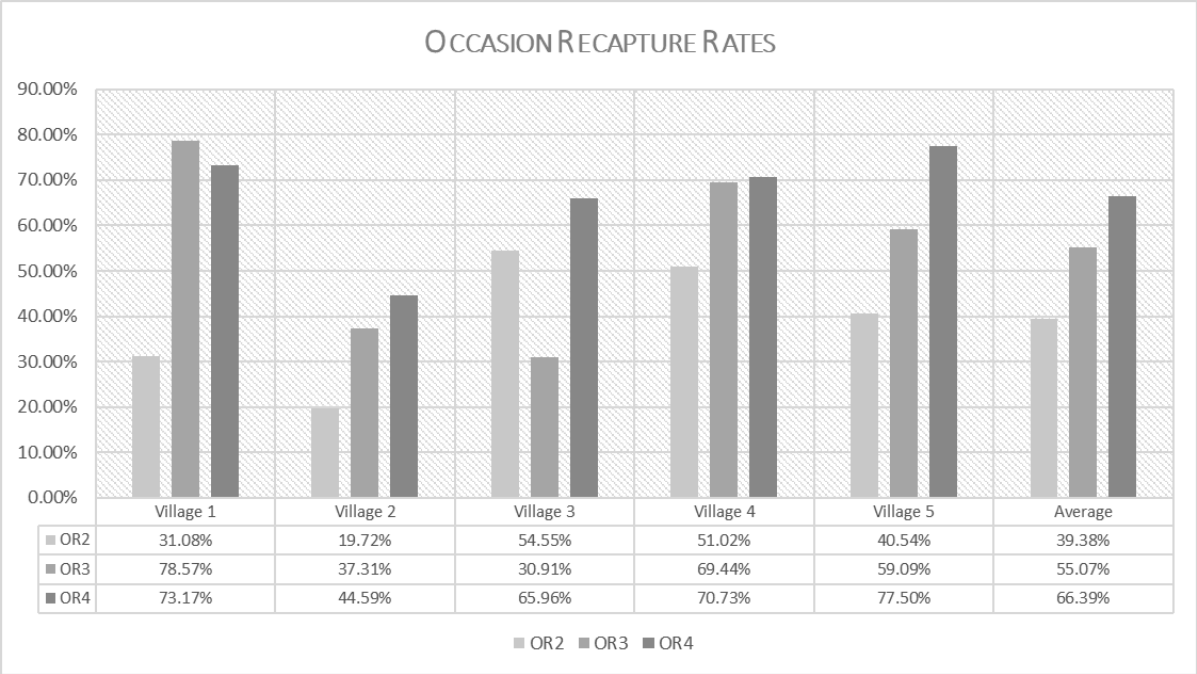
	Village 1	Village 2	Village 3	Village 4	Village 5	Average
BCS1	1.40%	2.25%	2.78%	0.00%	1.16%	1.52%
BCS2	15.38%	13.48%	16.67%	25.53%	25.58%	19.33%
BCS3	69.93%	65.54%	58.33%	55.32%	60.47%	61.92%
BCS4	11.89%	14.23%	20.37%	17.02%	6.98%	14.10%
BCS5	1.40%	4.49%	1.85%	2.13%	5.81%	3.14%

Figure 4.1-1: Body condition scores across all villages



	Village 1	Village 2	Village 3	Village 4	Village 5	Average
SCS0	72.73%	61.80%	68.52%	67.02%	73.26%	68.66%
SCS1	24.48%	35.58%	28.70%	29.79%	16.28%	26.97%
SCS2	2.80%	2.62%	2.78%	2.13%	5.81%	3.23%
SCS3	0.00%	0.00%	0.00%	1.06%	0.00%	0.21%

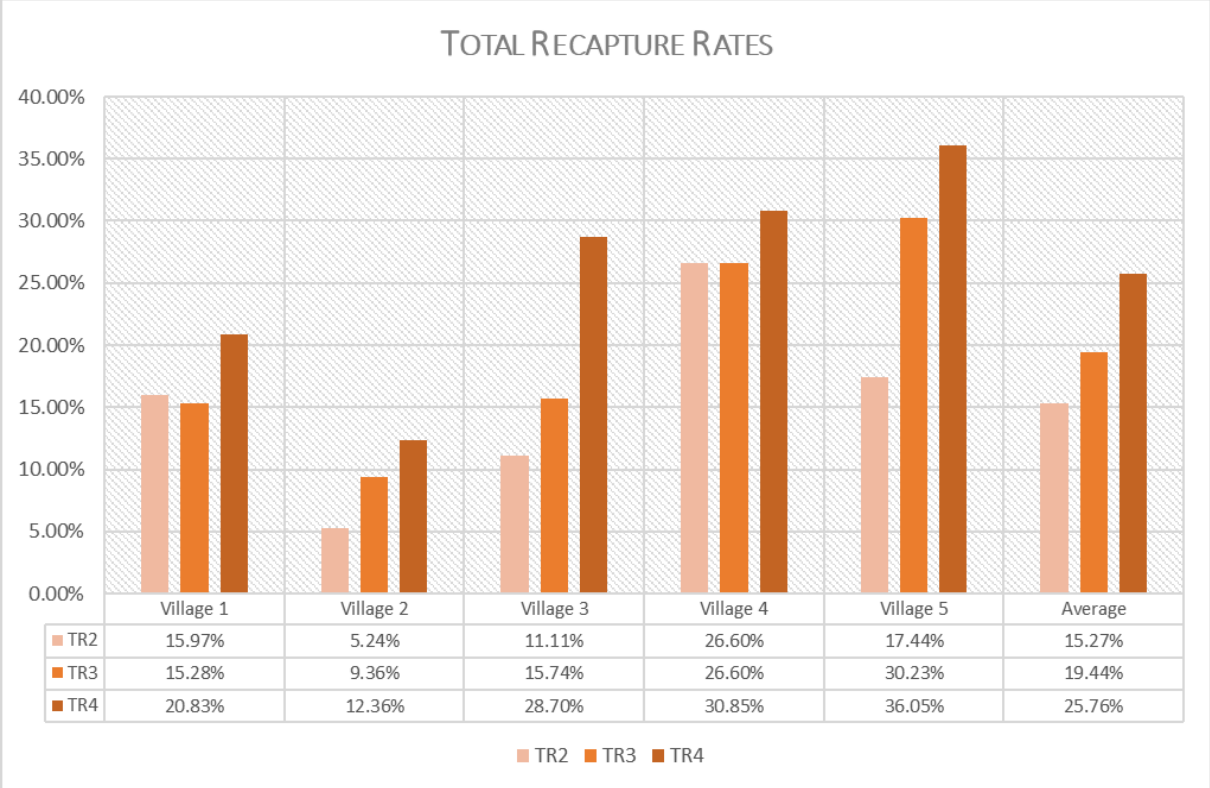
Figure 4.1-2: Skin condition scores across all villages



	Village 1	Village 2	Village 3	Village 4	Village 5	Average
OR2	31.08%	19.72%	54.55%	51.02%	40.54%	39.38%
OR3	78.57%	37.31%	30.91%	69.44%	59.09%	55.07%
OR4	73.17%	44.59%	65.96%	70.73%	77.50%	66.39%

Figure 4.1-3: Occasion recapture rates across all villages

Figure 4.1-4: Total recapture rates across all villages (below)



	Village 1	Village 2	Village 3	Village 4	Village 5	Average
TR2	15.97%	5.24%	11.11%	26.60%	17.44%	15.27%
TR3	15.28%	9.36%	15.74%	26.60%	30.23%	19.44%
TR4	20.83%	12.36%	28.70%	30.85%	36.05%	25.76%

For population estimation, the data were analyzed twice separately; once without retaining village information and once with the village information, in order to compare the estimates provided by both.

4.1.1. Village information excluded:

The four possible models were p=c(.), p/=c(.), pi(p=c(.)), and pi(p/=c(.)), where pi is the probability of mixture for a heterogenous population, p is the probability of capture and c is the probability of recapture. Models that depended on sampling occasion (two occasions in January considered to be distinct from two occasions in February; for example, p=c(t)) were tested but failed to provide conclusive results. Of the four models that did not include time as a variable, model pi(p/=c(.)) also did not provide conclusive estimates as convergence was not reached and was therefore discarded. The results for the remaining models are reported in table 4.1.1-1.

Model number	Parameters	AICc	Delta AICc	AICc Weights	Model Likelihood	Num. Par	Deviance	-2log(L)
1	{pi(p/=c(.)}	3016.89	0	1	1	5	6627.54	3006.87
2	{p=c(.)}	3051.21	34.3202	0	0	1	6669.88	3049.21
3	{p/=c(.)}	3053.17	36.2762	0	0	2	6669.84	3049.17

Table 4.1.1-1: Model reporting for dog population estimation, village information excluded

Models two and three provided almost identical estimates for all parameters. As they were nearly indistinguishable from each other (indicating that a model where p/=c is not distinct from one where p=c) and had low AIC weights, they were discarded. Model one, where p/=c, therefore seems somewhat improbable, despite having the best AIC and highest likelihood. The parameter estimates provided by this model are as presented in table 4.1.1-2.

Parameter	Estimate	Standard Error	Lower CI	Upper CI
1:pi	0.66323	0.17738	0.2934284	0.90328
2:p	0.27994	0.06444	0.1720223	0.42113
3:p	0.33367	0.1046	0.16607	0.55735
4:c	0.46992	0.07125	0.3360148	0.6083
5:c	0.02446	0.09418	1.10E-05	0.98286
N-hat	807.60763	49.145	732.257	929.3988

Table 4.1.1-2: Estimates for dog population estimation, village information excluded

The pi value of 0.66 can be reasonably interpreted in terms of the spatial distribution of dogs in a village. Dogs near the center of the village, closer to roads and human habitation, occupy a smaller area and were more likely to be sighted during sampling than dogs towards the fringe, usually near farms. However, the p and c values seem somewhat unreliable, the second c value in particular (given the very high CI spread). Additionally, the N-hat estimates provided by models 2 and 3 were 796 and 804 respectively, which are very close to the estimate of model 1; therefore, while model 1 has the highest likelihood of being true, the parameters included do not explain observed patterns of capture and recapture.

4.1.2. Village information included:

Retaining ‘village’ as a covariate provided an estimate of N-hat for each village. Time was again trialed as a covariate, but all models with p(t) or c(t) had low likelihoods, indicating that the time difference of a month between surveys was not enough to significantly affect abundance estimation. The full list of models that were successfully run is presented in table 4.1.2-1.

Model no.	Model	AICc	Delta AICc	AICc Weights	Model Likelihood	Num. Par	Deviance	-2log(L)
1	{pi(.)p(.)/=c(vill)}	2995.78	0	0.38628	1	13	4890.54	2969.627
2	{pi(vill)p=c(.)}	2996.64	0.8628	0.25093	0.6496	7	4903.51	2982.594
3	{pi(vill)p(.)/=c(vill)}	2996.91	1.1363	0.21886	0.5666	16	4885.6	2964.689
4	{pi(vill)p/=c(.)}	2997.75	1.9769	0.14376	0.3722	9	4900.59	2979.68
5	{(p=c)(vill)}	3012.43	16.6535	0.00009	0.0002	5	4923.32	3002.406
6	{p(vill)/=c(vill)}	3013.16	17.3807	0.00006	0.0002	10	4913.98	2993.067
7	{pi(.)p/=c(.)}	3016.89	21.117	0.00001	0	5	4927.78	3006.87
9	{p(.)/=c(vill)}	3026.75	30.9719	0	0	6	4935.63	3014.715
10	{p(vill)/=c(.)}	3039.55	43.7755	0	0	6	4948.43	3027.518
11	{p=c(.)}	3051.21	55.4372	0	0	1	4970.13	3049.213
12	{(p=c((t)}	3052.74	56.9602	0	0	2	4969.65	3048.733
13	{p/=c(.)}	3053.17	57.3932	0	0	2	4970.08	3049.166
14	{(p/=-c)(t)}	3053.2	57.419	0	0	4	4966.09	3045.18

Table 4.1.2-1: Model reporting for dog population estimation, village information included

Models 5-16 were discarded due to low AIC weights, which include all models where pi was not included as a parameter. Of the models remaining, model 3 was also discarded due to unrealistic parameter estimates (pi = 1 and c ranging from 0.8 to 0.19 x 10^{-12}). Model one provided notably precise and realistic N-hat estimates; however, the c values once again ranged very widely (0.74 to 0.13 x 10^{-13}) and a model where the pi and p are constant across villages while only the c changes is not ecologically realistic and does not reflect field observations. Therefore, only model 2 and model 4, both of which were within >2 AIC of model 1, were retained for model averaging. Both models included pi as a parameter that depended on village as a covariate, which reflects the density of the dog population in each village - in villages with larger dog populations, recapture rates are lower since each dog is less likely to be resighted and distinct groups within the population with different sightabilities are therefore less likely to exist. The model-averaged parameters for the two models that were finally retained are presented in table 4.1.2-3. The total number of dogs sighted and uniquely identified in each village is also included for comparison.

Model number	Model	AICc	Delta AICc	AICc Weights	Model Likelihood	Num. Par	Deviance	-2log(L)
1	{pi(vill)p=c(.)}	2996.64	0	0.63562	1	7	4903.51	2982.59
2	{pi(vill)p/=c(.)}	2997.75	1.1141	0.36414	0.5729	9	4900.59	2979.68

Table 4.1.2-2: Selected models for averaging, village information included

Parameter	Estimate	Standard Error	Lower CI	Upper CI	Count of sighted individuals
1:pi	0.35164	0.11965	0.1624	0.60272	NA
2:pi	0.11256	0.07144	0.03027	0.34006	NA
3:pi	0.27587	0.12063	0.10447	0.5544	NA
4:pi	0.49778	0.14538	0.24073	0.756	NA
5:pi	0.51383	0.15526	0.23815	0.78134	NA
6:p	0.4642518	0.06767	0.33704	0.59629	NA
7:p	0.1423474	0.06591	0.05447	0.32348	NA
8:c	0.5028057	0.04973	0.40645	0.59896	NA
9:c	0.1031887	0.04513	0.04237	0.23032	NA
N-hat 1	193.645	38.973	117.258	270.032	143
N-hat 2	428.695	130.607	172.704	684.685	267
N-hat 3	194.29	48.3845	99.4559	289.123	108
N-hat 4	140.621	24.0614	93.4603	187.781	94
N-hat 5	127.256	21.4563	85.2019	169.311	86

Table 4.1.2-3: Estimates for dog population estimation, village information included

The model averaged pi estimates again reflect the probability of resighting dogs based on the size of the population in each village. The first p estimate is high when compared to the total recapture rates presented in table 4.1-4, when the maximum value was 36%; however, when considered as the capture probability for a high density group of dogs living in the center of the village, it seems reasonable. Similarly, a low capture probability towards the village boundary is reasonable and reflects the reality of sampling. The recapture probabilities also support this explanation. The p values being so similar to the c values indicates that sighting probability does not tend to differ between sampling rounds. The N-hat estimates are reasonable for all villages except village two, which is larger than would be expected given the size of the village. The sum of the N-hat estimates is 1084, 35% higher than the estimate when the village was not included as a covariate. With so many animals living so densely, the local context seems to play an important role in the accuracy of population estimates. A population of 1084 dogs in a combined sampled area of 3.42 sq km across villages gives a naive density estimate of 317 dogs per square kilometer, a household to dog ratio of 2.85, and a human to dog ratio of 8.08 (see table 3.1-1 for human population estimates). Dogs outside the sampled area with low sightability, such as on farms and roaming in boundary areas, have been enumerated using camera trap data (see section 'Dog-wildlife interface').

Closed capture models were also run separately for village two (Masinagudi) as it had a much larger population with lower recapture rates (see figure 4.1-4), and the estimate given by the above model was rather high with low precision. Additional data were collected for Masinagudi due to the low initial recapture rate. The models that were run were as follows (table 4.1.2-4):

Model No	Model	AICc	Delta AICc	AICc Weights	Model Likelihood	Num. Par	Deviance	-2log(L)
1	{pi(.)(p=c(.))}	1669.8376	0	0.49073	1	3	2520.847	1663.82
2	{pi(.)(p/=c(.))}	1671.3454	1.5078	0.2309	0.4705	5	2518.332	1661.31
3	{pi(.)(p=c(td))}	1672.5482	2.7106	0.12655	0.2579	5	2519.535	1662.51
4	{pi(.)(p/=c(td))}	1673.0501	3.2125	0.09846	0.2006	9	2511.961	1654.94
5	{pi(.{p=c(t)}	1674.3617	4.5241	0.0511	0.1041	7	2517.316	1660.29
6	{pi(.{p/=c(t)}	1680.6055	10.7679	0.00225	0.0046	13	2511.401	1654.38
7	{p=c(.)}	1705.8911	36.0535	0	0	1	2560.913	1703.89
8	{p/=c(td)}	1706.6972	36.8596	0	0	4	2555.696	1698.67
9	{p=c(td)}	1706.7206	36.883	0	0	2	2559.737	1702.71
10	{p/=c(.)}	1707.0292	37.1916	0	0	2	2560.046	1703.02
11	{p=c(t)}	1709.6519	39.8143	0	0	3	2560.661	1703.64
12	{p/=c(t)}	1713.1623	43.3247	0	0	6	2558.134	1701.11

Table 4.1.2-4: Model reporting for dog population estimation for Masinagudi village

Here, ‘td’ stands for time of day; that is, using morning versus evening sampling as a variable. It was included here as only Masinagudi had three morning and three evening samples to compare. However, it did not seem to be useful, as the best ranked model with ‘td’ (model 3) estimated nearly identical values for p(morning) and p(evening) as well as c(morning) and c(evening). All models with ‘td’ were therefore discarded. Models with ‘t’ as a variable gave both results that were inconsistent with reality (such as c values twice as high as p values in the same sampling occasion (model 12), or p values dropping from 0.34 to 0.05 across occasions (model 5)) as well as results that showed no difference in p across occasions (model 11). Time was also discarded as a variable due to this. Of the models remaining, only models 1 and 2 were considered due to their high AIC values. Model 2 estimated the p for group 1 (presumably the more visible group towards the village center) to be 0.28 while the c was estimated to be 0.44, which is too high to reflect reality when compared to p. The confidence intervals for all parameter estimates were also all quite large. The estimates for the only remaining model, model 1, are presented in table 4.1.2-5:

Parameter	**Estimate**	**Standard Error**	**Lower CI**	**Upper CI**
1:pi	0.1080621	0.0293757	0.0625	0.1804458
2:p	0.4276002	0.071545	0.2963846	0.5698591
3:p	0.0676168	0.0289348	0.0286526	0.1513137
N-hat	650.91111	169.87968	434.60106	1146.3963

Table 4.1.2-5: Estimates for dog population estimation, Masinagudi village

A low pi value is expected, as this is the largest and most dense population and recapture rates were low, leading to little distinct spatial heterogeneity in capture. The p values are therefore of little significance; however, the N-hat is too high for the population (651 animals in the village would imply a density of 266 animals per sq km, which is simply not present) and the confidence intervals are also quite large. Considering village data separately in this way does not seem to provide accurate or precise estimates, and pooling the data from multiple distinct locations within a study area while retaining village information as covariate as has been done above seems to be the best method of analysis.

4.2. POPULATION PROJECTION

To examine population growth in 100 years at various levels of sterilization using Program Vortex (Lacy & Pollak, 2021), simulations were initially run with no sterilization (50% females successfully breeding once per year), half the current level of sterilization (33% females breeding) with and without supplementation, and the current level of sterilization (15% females breeding) with and without supplementation. Two additional models were run with 25% breeding and 20% breeding to facilitate comparison between all models. The simulation results are presented in figure 4.2-1 and the population levels every ten years for each simulation are presented in table 4.2-1.

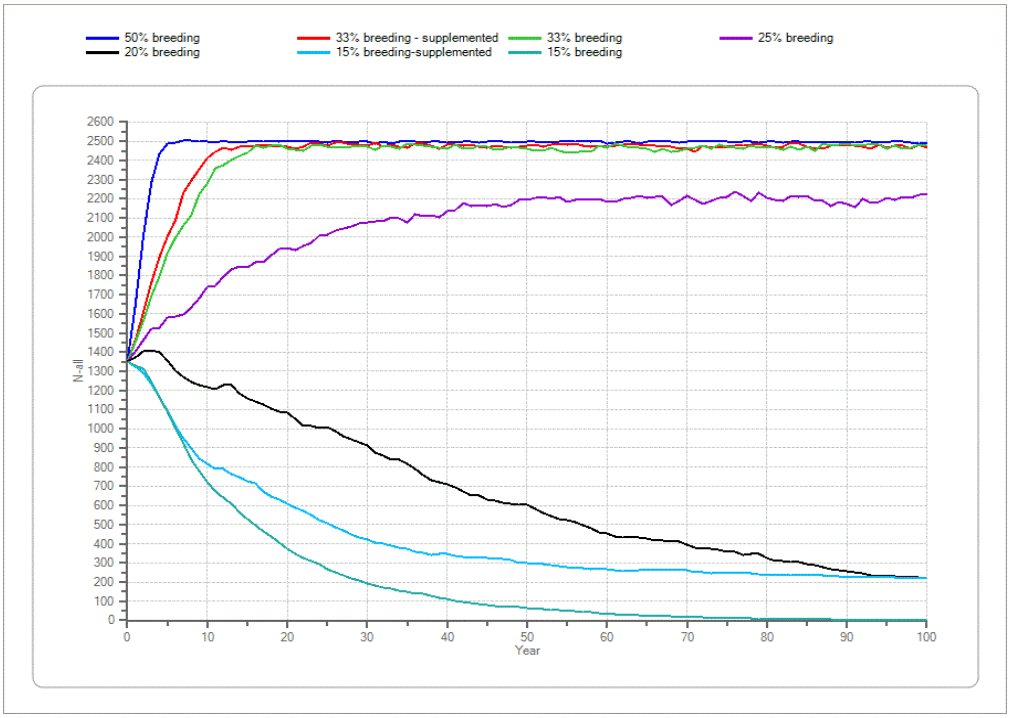


Fig 4.2-1: Dog population projection (100 years)

Populations	**Y1**	**Y10**	**Y20**	**Y30**	**Y40**	**Y50**	**Y60**	**Y70**	**Y80**	**Y90**	**Y100**
50% breeding	1645.9	2496.18	2502.5	2497.06	2493.04	2498.2	2490.3	2497.3	2500.66	2495.64	2495.66
33% breeding-Supplemented	1462.26	2413.98	2472.66	2479.16	2482.82	2478.1	2473.52	2462.8	2478.66	2475.28	2466.34
33% breeding	1452.42	2281.26	2462.6	2470.62	2461.64	2463.36	2464.86	2458.72	2465.62	2485.88	2479.7
25% breeding	1403.82	1742.26	1944.34	2079.12	2136.38	2193.68	2181.5	2215.5	2205.08	2172.94	2227.16
20% breeding	1370.66	1215.78	1083.9	910.56	707.54	604.02	452.22	395.4	326.1	254.58	219.28
15% breeding-Supplemented	1323.68	818.28	611.26	423.04	346.56	300.3	264.54	262.24	237.56	224.58	219.62
15% breeding	1328.92	719.16	375.14	189.7	109.66	64.02	33.76	17.12	6.78	2.24	1.06

Table 4.2-1: Dog population estimates (10 year intervals)

In the first three simulations, the population reaches carrying capacity (2500 animals) within 20 years. 33% breeding - half of an unsterilized female population of 70% - is clearly not enough to halt or even slow the growth of the population past 10 years. A sterilized percentage of 50% and a breeding population of 25% slows population growth more significantly, but the final population size is still 2227. 20% breeding and 15% supplemented breeding populations both converge at nearly 220 after 100 years, while the 15% breeding population falls to nearly 700 in ten years and below around 100 by year 40. These results indicate that to see a significant drop in the dog population in the short term (within the next 20-30 years), sterilization of female dogs needs to be consistently maintained at 70% across all villages.

4.3. HUMAN ATTITUDES TOWARDS DOGS:

Of the 112 respondents across villages, 69 were women and 43 were men, and their ages range from 20 to 80 figure 4.3-1. 78 respondents kept dogs (70% of the total number of respondents), while 34 did not. Of these, 35 people (44% of those who reported keeping dogs) had one dog, 22 people (28%) had two dogs, 14 people (17%) had three dogs, and 7 people (9%) had four or more dogs. People kept both male and female dogs, as 31 people reported keeping only females, 21 respondents reported keeping only males, and 24 people had both males and females.

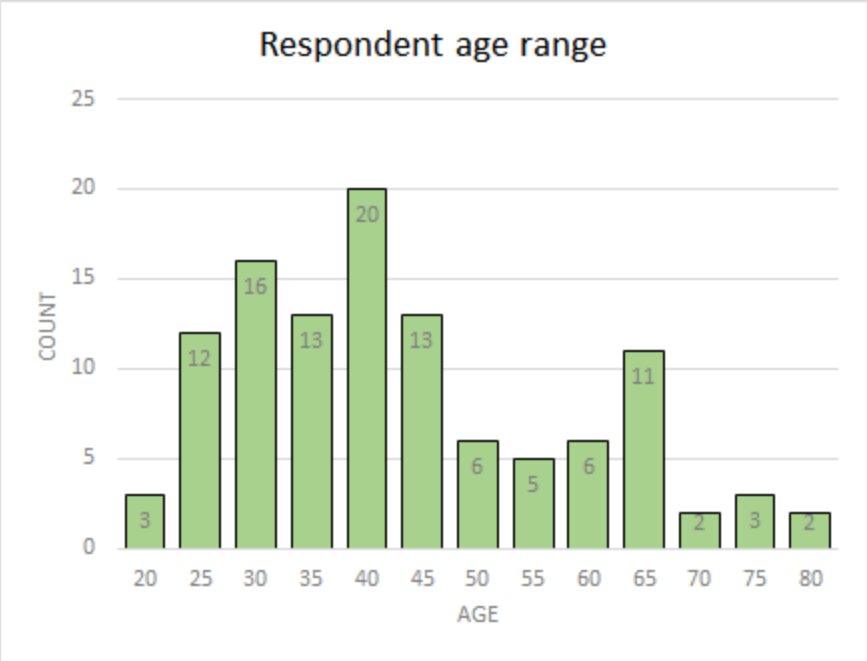


Figure 4.3-1: Questionnaire survey respondent age range

Most dog owners were unaware of veterinary care and 31 of the 78 dog owners had never given their dogs such care; however, the majority (55 out of 78) still had vaccinated and sterilized dogs, due mostly to the efforts of the two animal welfare NGOs in the area, which were also a first recourse for pet owners when their dogs were ill. Perhaps due in part to this, 94 respondents said they believed sterilization was positive and necessary for dogs, while 10 were unsure and only 3 responded negatively for reasons including harm to their dogs' health, death of their dogs', and reduction in the dogs' vigor. Most people did not confine their dogs and left them to roam free, as dogs are largely kept for security purposes and to alert people to the presence of wild animals. This protective alerting was also a motivation for people to take dogs with them to the forest while herding cattle, goats or sheep; however, interestingly, one respondent stated that bringing a dog along to the forest was a detriment rather than an advantage, as a dog barking at the presence of wild animals (particularly elephants) would only draw it closer, after which the dog would run and the human would be left behind to face greater danger.

Sterilization and vaccination		**Dogs confined or free roaming**	
Response	Count	Response	Count
No dogs owned	34	No dogs owned	34
No	4	Not always	6
Partial S, all V	6	Yes	16
Only V	12	No	55
S and V	55		

Table 4.3-1: Responses - sterilizing dogs and confining dogs

Motivation for dog keeping		**Dog presence in forest**	
Response	Count	**Response**	**Number**
		No	31
No dogs owned	34	Yes, but not recently/in the locality/not often/not far	18
Pet	22	Yes, with owner	4
Security	36	Yes, with livestock	45
Pet and security	15	Yes, alone as well as with owner/livestock	7
		Yes, alone	1
		Unsure	4

Table 4.3-2: Responses - motivation for dog keeping and knowledge of dog presence in the forest

Dog affecting wildlife		**Wildlife affecting dogs**	
Response	Count	Response	Count
No	43	No	34
Hunt infrequently/not recently/not nearby	10	Chased by wild pigs	1
Bark only	4	Lifting by leopards elsewhere/earlier	12
Chase and bark	30	Yes, lifting by leopards	63
Yes, hunt	17	Unsure	2
Unsure	8		

Table 4.3-3: Responses - knowledge of dogs affecting wildlife and wildlife affecting dogs

Lastly, respondents were asked whether they were aware of any ways that dogs affected wildlife or vice versa. Bias is likely to have played a role in the responses to the first question, as people are aware that dogs are considered to be a problem for wildlife by the Forest Department due to instances of hunting. The responses for both questions are presented in table 4.3-3.

While 38% of the respondents stated that dogs did not affect wildlife at all, 15% stated that they did hunt wildlife (referring to chital) and 30% mentioned chasing and/or barking at wildlife without causing any direct harm, including deer, monkeys, elephants, leopards and wild pigs. Respondents answered the question about harm to dogs from wildlife mostly in terms of leopard lifting, and several dog owners mentioned having lost multiple dogs to leopards in the past. However, it is worth noting that since dogs are usually left free to roam and are not kept track of by their owners, people may naturally assume that leopards are the cause if a dog abruptly goes missing (whether or not this is in fact true). Only one person mentioned injury to dogs by another wild species (wild pigs, due to their tusks).

4.4. DOG-WILDLIFE INTERFACE:

528 independent captures of dogs were obtained throughout the sampling period in village areas, which consisted of 969 trap nights across all cameras. Dogs were captured at 31 out of 37 sites (83.8% naive occupancy). Of these captures, 48.5% (256 out of 528) were independent of human or livestock occurrences. 155 roaming dogs were identified from these independent captures. Assuming that these dogs are a similar proportion of a fringe population of farm/roaming dogs as the 698 identified dog population is of the total abundance estimate, the roaming population would be 241, making the total, unified population number 1325. None of the roaming dogs had

been previously identified during population surveys, which may indicate that dogs that use fringe areas do not use population-dense village areas. This may also be due to sampling bias, either location-related - as village core areas were consistently sampled rather than fringe areas to account for the most number of dogs - or time-related, as many of these dogs were captured in the early morning (6:30 AM onwards) and at night.

Camera trap photos of dogs were also visually inspected for direct interactions between dogs and wildlife, of which 9 occurrences were found, 2 at one camera station in Bokkapuram and 7 in Vazhaithottam (6 of which were again at one camera station). Dogs were photographed chasing chital, or chital were photographed running away a minute or two before dogs moved in the same direction. All these encounters took place in shaded areas with tall bamboo brakes, where chital congregated in large numbers throughout the day to rest and feed. One notable capture, also in Vazhaithottam, shows a dog encountering a sambar doe and running away as the doe appears to proceed towards it, indicating that adult sambar might be at reduced risk of predation by dogs due to their size. Additionally, one photograph of an owned dog (indicated by rope tied around the neck) carrying what seems to be part of a scavenged chital kill was captured. Sample photos are attached in the Appendix. It should be noted that these are only instances of direct interaction (in terms of action or reaction by dogs/wildlife) and do not include non-independent captures of dogs and wildlife; instances of wildlife using an area less than half an hour before or after dogs have not been included. One example of this is chital grazing in front of a camera four minutes before a dog arrived, with neither the chital showing any signs of fleeing nor the dog showing any signs of pursuit in the photographs.

In total, twenty one wild mammal species were captured at village boundaries: blackbuck (*Antilope cervicapra*), chital (*Axis axis*), Indian spotted chevrotain (*Moschiola indica*), sambar (*Rusa unicolor*), Asian palm civet (*Paradoxurus hermaphroditus*), small Indian civet (*Viverricula indica*), Indian hare (*Lepus nigricollis*), jungle cat (*Felis chaus*), rusty spotted cat (*Prionailurus rubiginosus*), dhole (*Cuon alpinus*), Indian leopard (*Panthera pardus fusca*), tiger (*Panthera tigris tigris*), elephant (*Elephas maximus*), gaur (*Bos gaurus*), peafowl (*Pavo cristatus*), Indian crested porcupine (*Hystrix indica*), black-footed gray langur (*Semnopithecus hypoleucos*), bonnet macaque (*Macaca radiata*), stripe-necked mongoose (*Urva vitticola*), and wild pig (*Sus scrofa*). Species with fewer than 10 captures (tiger, Indian spotted chevrotain, rusty spotted cat, stripe-necked mongoose, gaur, blackbuck, and both civet species) were excluded from further analysis, as were the two primate species (bonnet macaque and black-footed grey langur) which, being arboreal, are not as regularly exposed to threats that dogs may pose as terrestrial species. Domestic species that were captured included cattle, buffalo, and goats and sheep (considered as a single category as they were herded together). Buffaloes were excluded from further analysis as they were usually left to roam free rather not accompanied by humans nor dogs, and had far fewer captures (58 compared to 792 cattle captures).

4.4.1. Village spatio-temporal overlap:

When temporal overlap was quantified between dogs and the species that were retained, the following results were obtained, arranged in descending order of Dhat values (table 4.4.1-1). Similarly, the results for spatial overlap as obtained from naive occupancy, are presented in table 4.4.1-2 in descending order:

Species	Dhat4/Dhat1	CI1	CI2	Number of occurrences
Human	0.86032	0.81696	0.90061	982
Cattle	0.75352	0.70803	0.79745	792
Goat	0.61391	0.56587	0.66352	378
Chital	0.59232	0.55573	0.62972	1355
Peafowl	0.55358	0.49682	0.61023	136
Dhole	0.51014	0.41486	0.60176	43
Wild pig	0.41751	0.34922	0.48489	137
Elephant	0.23404	0.15501	0.31764	77
Hare	0.23172	0.16247	0.30589	101
Sambar	0.2214	0.15664	0.28811	108
Leopard	0.1664	0.07159	0.2754	23
Sloth bear	0.15409	0.04873	0.29528	14
Jungle cat	0.12986	0.02884	0.25243	12
Porcupine	0.08192	0.03499	0.13331	75

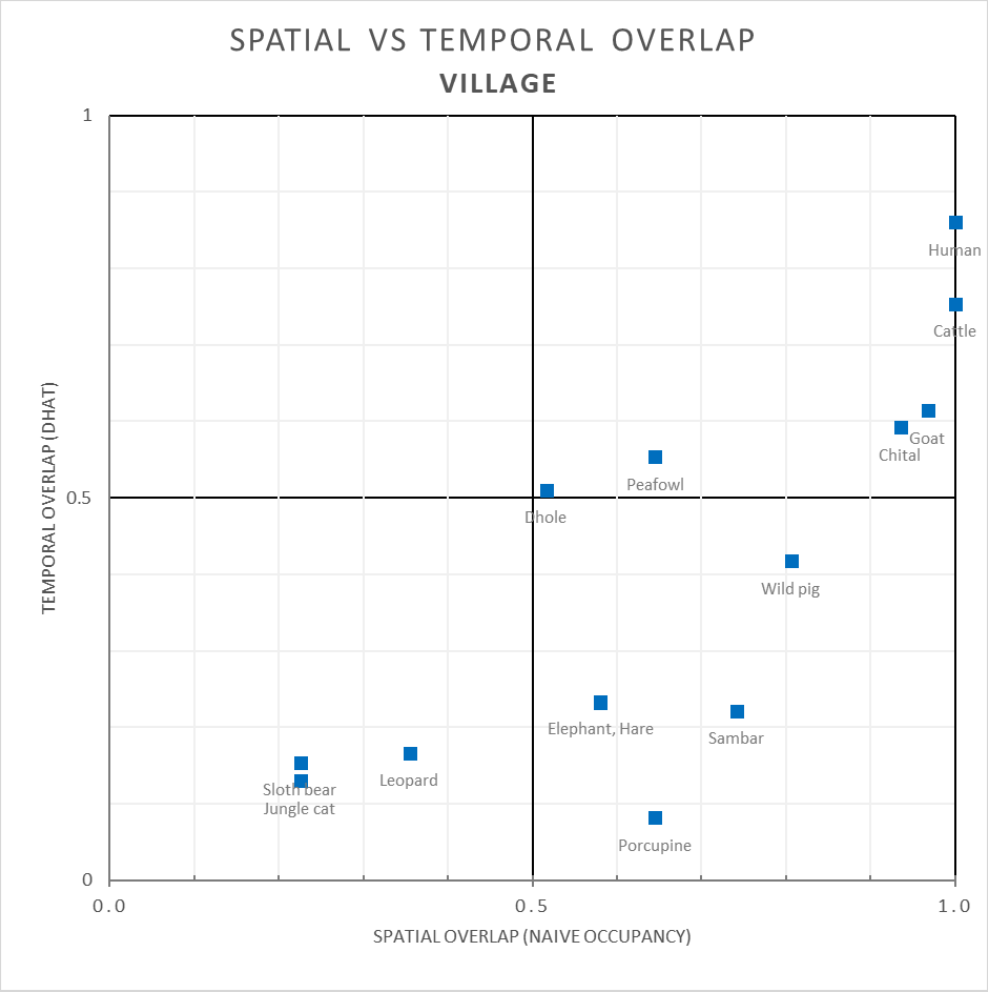
Table 4.4.1-1: Dog temporal overlap with wildlife and livestock at village boundaries (Highlighted cells indicated occurrences under 50, due which Dhat1 was calculated instead of Dhat4)

Species	Naive occupancy overlap
Human	1.00
Cattle	1.00
Chital	0.94
Goat	0.97
Sambar	0.74
Wild pig	0.81
Elephant, Hare	0.58
Peafowl	0.65

Porcupine	0.65
Hare	0.58
Dhole	0.52
Leopard	0.35
Sloth bear	0.23
Jungle cat	0.23

Table 4.4.1-2: Dog spatial overlap with wildlife and livestock at village boundaries

Figure 4.4.1-1: Spatial versus temporal overlap at village boundaries (below)



The spatial scores were plotted versus temporal scores for each species to determine which species have the highest probability of encounter with dogs (figure 4.4.1-1). The upper right quadrant indicates species with both spatial and temporal overlap above 0.5, which are the most likely to encounter dogs. Species in the lower right quadrant have high spatial overlap but low temporal overlap, indicating that direct contact is unlikely but signs such as scat or marking by dogs may affect the distribution and/or movement of prey species. Species with low temporal and spatial overlap are present in the lower left quadrant, while species with high temporal overlap and low spatial overlap would be in the upper left quadrant. This quadrant being empty, as well as most wild species having under 0.5 temporal overlap, indicates that these species adopt a nocturnal or crepuscular activity pattern at village boundaries (see temporal overlap graphs in Appendix), as dogs were mostly diurnal.

The species with the maximum spatio-temporal overlap with dogs in village areas are humans, goats and cattle, which is to be expected given that dogs habitually accompany all three. Chital has the highest overlap of all wild species, which is also reasonable due to their high abundance, similar to peafowl. Dholes seem to have moderate overlap with dogs, using approximately half of the same camera trapped sites and being active at least part of the day, generally the mornings and late afternoons. The other two predator species, leopards and jungle cats, have quite low composite overlap scores, as does sloth bear. Apart from chital, all other prey species (sambar, wild pig, and Indian hare) all have higher spatial overlap but low temporal overlap in the lower right quadrant of the graph. Porcupine has the lowest temporal overlap of all species.

4.4.2. Forest spatio-temporal overlap:

Dogs were detected 120 times at 17 out of 109 forest sites during a three month sampling period (Dec 2020-Feb 2021). Of these, 5 sites were <500m from settlements; the average of the distance of the remaining 12 sites was 3040m. These sites are mapped in figure 4.4.2-1. The data for temporal overlap and spatial overlap, arranged in descending order, are presented in tables 4.4.2-1 and 4.4.2-2:

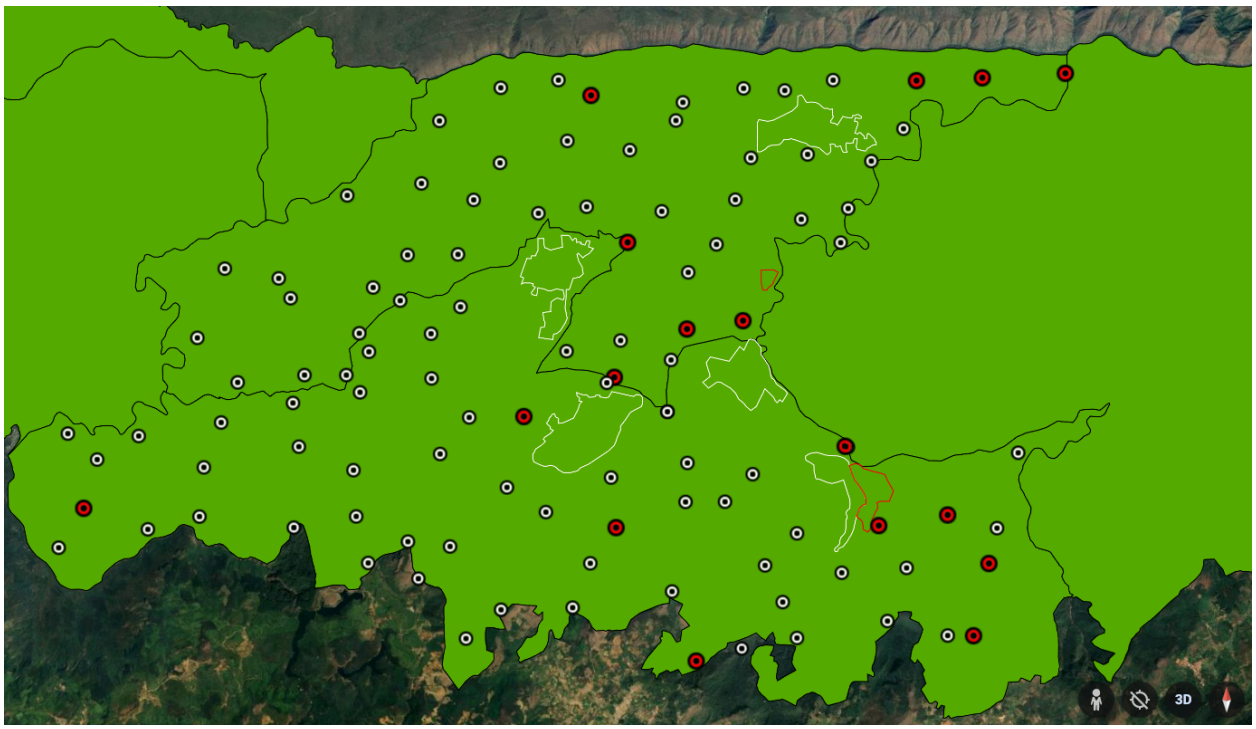


Figure 4.4.2-1: All forest camera trapping sites in Masinagudi and Singara ranges. Sites with dog captures are in red.

Species	Dhat4	CI1	CI2	Occurrences
Human	0.85298	0.78354	0.91308	8311
Cattle	0.85778	0.80091	0.90581	12566
Goat	0.65313	0.58135	0.72511	538
Chital	0.51503	0.4473	0.58057	50415
Peafowl	0.53012	0.45487	0.60178	513
Dhole	0.45474	0.38052	0.52784	371
Wild pig	0.5128	0.44338	0.57931	4456
Elephant	0.55209	0.4911	0.61009	4751
Hare	0.08217	0.04025	0.12609	1392
Sambar	0.51106	0.43606	0.58183	6798
Leopard	0.429	0.34574	0.51502	240
Sloth bear	0.57374	0.49329	0.65071	382
Jungle cat	0.11062	0.05878	0.16927	184
Porcupine	0.04771	0.01045	0.08977	1190

Table 4.4.2-1: Dog temporal overlap with wildlife and livestock at forest sites

Species	**Overlap occupancy**
Human	1.00
Cattle	0.94
Chital	0.88
Goat	0.35
Sambar	1.00
Wild pig	0.82
Elephant	0.76
Peafowl	0.65
Porcupine	0.94
Hare	0.82
Dhole	0.41
Leopard	0.35
Sloth bear	0.59
Jungle cat	0.47

Table 4.4.2-2: Dog spatial overlap with wildlife and livestock at forest sites

Spatial overlap and temporal overlap were plotted for forest data as well (figure 4.4.2-2), showing a marked shift in the position of most species along the Y axis. Dogs remained diurnal (though there is a peak at noon - see plots in Appendix), while sloth bear, sambar, elephant and wild pig were all in the upper right quadrant. Cattle and human remained more or less in the same location, but goat moved to the left upper quadrant, indicating much less spatial overlap. This is likely because people do not tend to take small-bodied livestock far into the forest due to predation risk. Porcupine and hare both have increased spatial but decreased temporal overlap. Jungle cat has also shifted towards higher spatial overlap, while leopard has shifted towards a much higher temporal overlap. Dhole has decreased slightly in both measures of overlap. Composite spatio-temporal overlap scores are presented in figure 4.4.2-3, for both village and forest data:

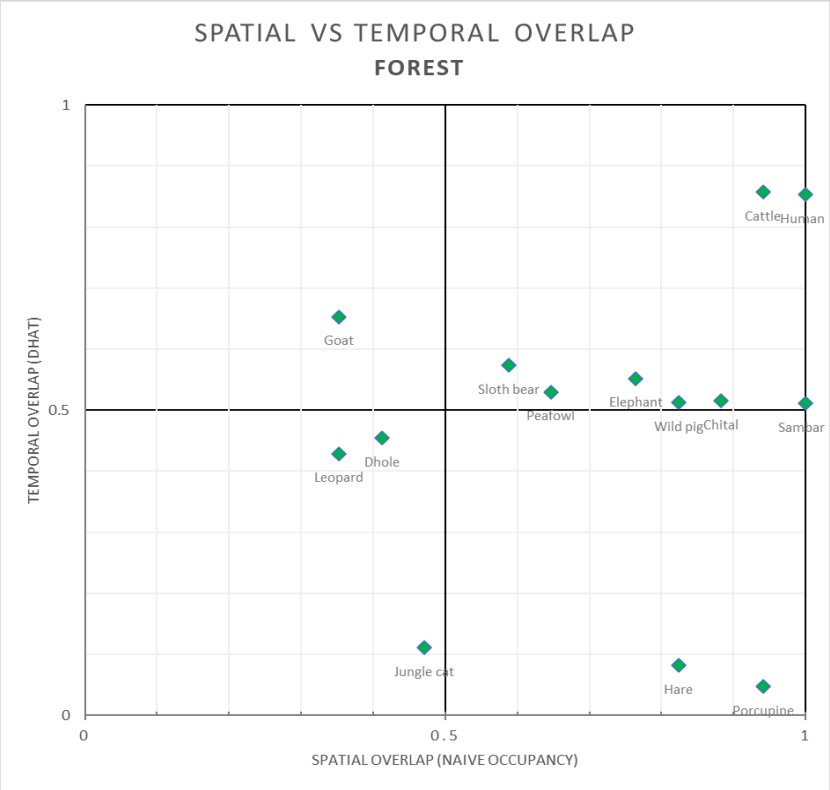
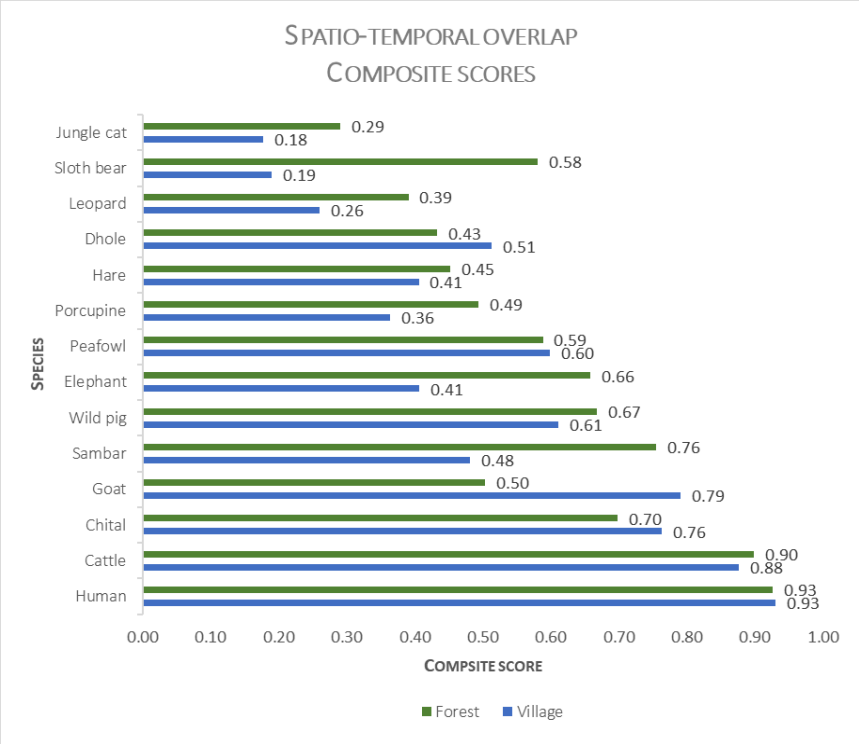


Figure 4.4.2-2: Spatial versus temporal overlap at forest sites

Figure 4.4.2-3: Composite spatio-temporal overlap scores (below)



The composite scores allow a side-by-side comparison of overlap with dogs in village areas and forest, and quantify the shifts in position displayed in figures 4.4.1-1 and 4.4.2-2. Sloth bear and sambar show the most dramatic increases in overlap from village to forest, while porcupine, wild pig, jungle cat and leopard show moderate increases. Goat, dhole and chital are the only species which show an increase from forest to village, with the increase for goat being the largest by far while those of dhole and chital are fairly small.

4.4.3. Royle/Nichols occupancy:

Occupancy was estimated within the Royle/Nichols framework for dogs and dholes using two models, a null model as well as one with distance from settlement as a covariate. This covariate was calculated including two small settlements that were within the two relevant ranges of MTR but not included for dog sampling, questionnaire surveys or camera trapping due to logistical constraints (outlined in red in figure 4.4.2-1). The AIC values for all four models are reported below (table 4.4.3-1). These values indicate that for dholes, distance from settlement is not a good predictor of occupancy, which is to be expected as there are many factors involved such as prey availability, co-predator presence, and habitat variables. However, distance from settlement functions as a good predictor of dog occupancy in the forest. When the values from this model were plotted, an exponentially decreasing curve that reached 0.25 at 2000 meters and 0.1 at around 3500 meters was obtained. These values can be assumed to provide a rough estimate of the distance from settlements at which dogs may be found in the forest (that is, unlikely to be further than 3 kilometers).

Model name (Dog)	Log likelihood	AICc	Delta AIC	Model name (Dhole)	Log likelihood	AICc	Delta AIC
Distance	-233.343	472.9	0.0	Null	-546.105	1096.3	0.00
Null	-239.962	484.0	11.12	Distance	-1424.534	2855.3	1758.97

Table 4.4.3-1: Model reporting for Royle/Nichols occupancy at forest sites(dog and dhole)

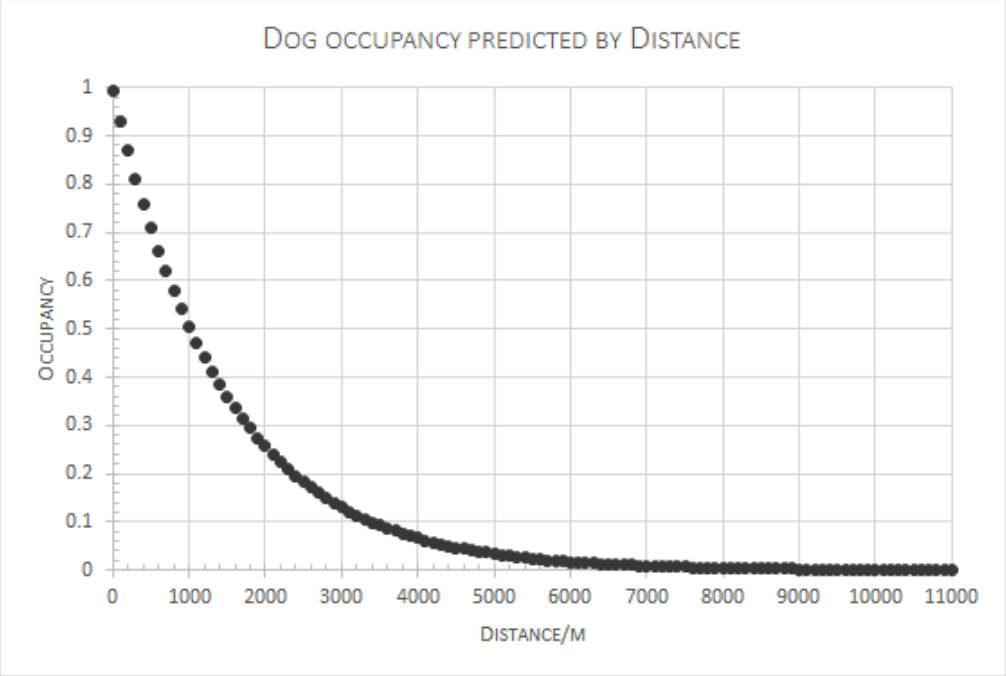


Figure 4.4.3-1: Predicted occupancy of dogs at forest sites versus distance from settlement (in metres)

The occupancy estimates provided by the null models were 0.2 (0.13-0.32) and 0.58 (0.40-0.83) for dogs and dholes, respectively. These estimates multiplied provide the likelihood of

occupancy of both dholes and dogs at any given forest site, which is 0.116. The probable spatial overlap between dogs and dholes, therefore, seems to be quite low as of February 2021.

5. DISCUSSION

5.1. Dog demography and population

Regarding the dog population estimation part of this study, the majority of dog population and demography studies have been done in urban areas (Belo et al., 2015) and/or through household questionnaire surveys (eg. Butler & Bingham, 2000), and the population estimates are therefore not directly comparable. The single similar study that was identified is by Belsare & Gompper, 2013, where a similar photographic capture-recapture study was carried out in six villages in Nannaj in rural Maharashtra, bordering the Great Indian Bustard Wildlife Sanctuary. While the method of analysis was different (using program CAPTURE), they estimated a total population size of 801, a median dog population density of 719 dogs per sq km, and a median human to dog ratio of 34. When compared to the results from this study, the Mudumalai population is several hundred dogs more in number, yet the density and human to dog ratio are much lower, indicating that the human population in Nannaj was higher and the village areas were much smaller (with the caveat that the human population sizes are 13 years out of date, though the current population does not seem to differ too drastically). The dog population of Nannaj also had a lower proportion of adults (between 67% to 86%) than the Mudumalai population (87% - 94%), a natural consequence of sterilization programmes in Mudumalai. Body and skin condition scores indicate a fairly healthy population. As vaccination drives are regularly carried out, the disease risk to wild mammals in Mudumalai is low. Population growth simulations point to the importance of continuing ABC as a long-term population control measure and maintaining a 70% sterilization level of female dogs at minimum.

5.2. Dog-wildlife overlap

Since no general assessment of spatio-temporal overlap of dogs with wildlife has been done in India, it is uncertain whether the estimates obtained from this study conclusively support immediate management intervention in Mudumalai or not. Previous studies in other parts of the world primarily use occupancy modeling and temporal overlap as two distinct components, and include studies in Taiwan (Yen et al., 2019), Thailand (Marshall et al., 2023), China (Weng et al., 2022), and Brazil (Carvalho et al., 2019). Three of these studies found spatial and temporal segregation between dogs and wildlife, arguing that avoidance of dogs by wildlife indicated that dogs have a negative impact on wildlife, while Carvalho et al. (2019) report that dogs themselves may be altering their activity patterns to better overlap with wild prey and avoid ocelots. In this context, the difference in temporal activity patterns of wildlife between forest and village areas indicates that such segregation is taking place only at the village interface, and not in the forest. The higher forest composite overlap scores compared to village overlap composite overlap scores are likely due to the lack of this temporal overlap as well as the low number of sites with dog occupancy (17 out of 109), which ensures that reasonably widely distributed species, such as sambar (present at 102 sites) or porcupine (present at 90 sites), will inevitably overlap with dogs at most if not all locations. This is also likely to be the explanation for relatively higher spatial overlap than temporal overlap near villages - wildlife richness and abundance are too high to allow for spatial segregation at village perimeters, which are only 3 to 5 km. Wildlife may choose to remain in proximity to villages for several reasons, including food and shelter; here, water is likely to be the primary reason, as all villages are situated near waterbodies and this study was conducted in the dry season when water was scarce. Therefore, as segregation is not taking place in the forest, the impacts of dogs on wildlife are likely to be minimal, while in

villages, temporal segregation indicates that management should be considered. Composite overlap scores indicate that chital and wild pigs are at highest risk of predation, while dholes show a moderate overlap and may be harassed or chased by dogs.

It should be noted that patterns of avoidance are also likely to be village specific, depending on the local context. Masinagudi, a built-up village with little open space and high open food availability for dogs within the settlement, had fewer captures of both dogs and wildlife at the boundary than Vazhaithottam, a village with a longer perimeter with the forest and much higher occurrences of wildlife, as well as several dogs that displayed cathemeral activity patterns. Such villages are at higher risk of dog-wildlife interaction; while temporal segregation may take place, the occurrence of so many species so close to settlements ensures that encounters will inevitably occur sooner or later. However, the vast majority of this dog population is unlikely to be actively involved in negatively impacting wildlife, as there is a clear distinction between village dogs with tightly defined territories that stick to densely settled areas and/or roads, and roaming dogs which tend to occupy larger areas such as farms and fringe areas where the wildlife interface begins. While dog welfare initiatives such as ABC programmes and vaccination drives should certainly benefit the entire population, management strategies meant to minimize harm to wildlife may thus reasonably focus mainly on these boundary dogs. Additionally, dogs seem to have very precise territories; no dogs photographed in fringe areas were found at multiple stations within the same village, even though the distance between stations was between 1000-500m - certainly not a difficult distance for dogs to travel. Management programmes may therefore only need to identify specific dog packs from specific areas to reduce active harm to wildlife.

5.3. Human attitudes towards dog management:

Management programmes will require owner cooperation to be successful, as dogs are likely to remain a permanent part of the landscape. The large proportion of questionnaire survey respondents who mentioned security as their reason for keeping dogs is supportive of the fact that dogs fulfill the role of an autonomous, inexpensive, and loyal alarm system in a region where elephants and leopards are part of ordinary life. They are therefore invaluable to many people, particularly those with farmland or livestock to protect. In this context, it is reassuring that people's attitudes towards dog management were broadly positive; while dogs are necessary and valued, they could also simultaneously be a nuisance by barking, chasing vehicles, and occasionally people. Several respondents who strongly supported dog sterilization practices complained that their village was already 'full of dogs'. This is despite the fact that several respondents were also unsure about what the operation entailed, or had negative perceptions about the effects of sterilization (including death, disease and loss of vigor). Ideally, an education campaign should be implemented in all villages within MTR to clarify the process and the numerous benefits of having sterilized dogs, which would support continued ABC programme implementation in the long run. This is perhaps the only way to restrict the population to a level where dogs are no longer of any concern as a threat to wildlife in a region where they are so indispensable.

6. CAVEATS AND WAY FORWARD

The major methodological caveat for this study is the data used for spatio-temporal overlap estimation. Since the forest and village data were collected at different times, for different periods, and using different study designs, they are not directly comparable but rather provide indicative estimates that should be used as benchmarks. Both sets of data were also collected during the dry season. Patterns of wildlife behavior are likely to be different during the monsoon, when resources are plentiful, and the dog-wildlife interface may decrease as wildlife move towards the forest. If such a phenomenon does not occur, researching the factors that cause wildlife to remain close to villages would be valuable. A multi-season study is required to confirm this. Additionally, spatio-temporal overlap is in itself a fairly coarse measure of predation risk, and only represents a potential for encounter. Encounter itself may depend on many factors including habitat variables, prey body size and patterns of movement, while predation depends on predator hunger levels as well as the probability of a successful chase, capture, and kill during the hunting sequence (Suraci et al., 2022). This is particularly relevant to the domestic dog, whose ecology is poorly understood; knowing that 155 individual dogs are present at the village wildlife interface provides no information as to how many of those dogs interact with wildlife or habitually do so. Fine-scale monitoring of specific individuals is therefore required. A project to accomplish such monitoring will be carried out using GPS collars in the coming months, for which independent funding has already been secured. Lastly, the focus of this study was specifically mammal wildlife. Dogs may have negative effects on wildlife from other taxa, and studies investigating impacts on amphibian, reptile and bird species would be very valuable.

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APPENDIX

1. Questionnaire survey

    1. Do you currently have dogs at home? How many? What are their ages and sex?

    2. Where did you get them from? Why do you keep them?

    3. What do you feed them?

    4. Are they vaccinated/sterilized? If not, why?

    5. What do you do when they get sick?

    6. Do they stay within the house or are they allowed to roam?

    8. Have you seen/heard of dogs going into the forest?

    9. Have you seen/heard of them chasing/killing wildlife?

    10. Have you seen/heard of wildlife chasing/killing them?

    11. Is sterilization good or bad? Why?

2. WVS sterilization data (recorded during booster vaccination programmes in Mudumalai 2023 and 2024)

	Owned	Stray	Total
Entire	42.13%	32.23	40.53%
Sterilized	57.87%	67.77%	59.47%

3. Dog-wildlife interaction camera trap images (including one domestic cat)

Dog pack traveling through bamboo brake

Dog chasing chital stag

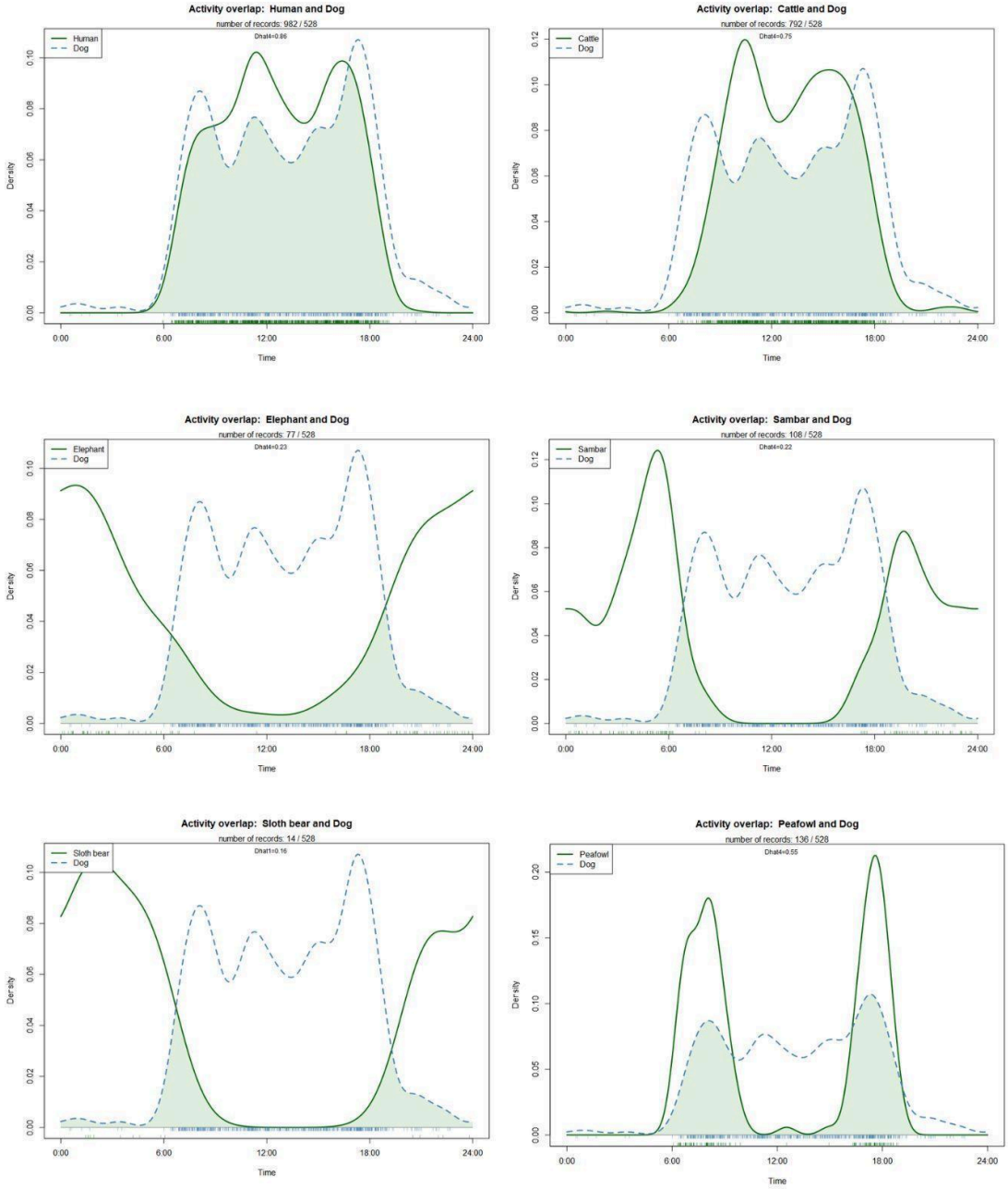
Dog encountering sambar doe

Chippiparai with scavenged kill

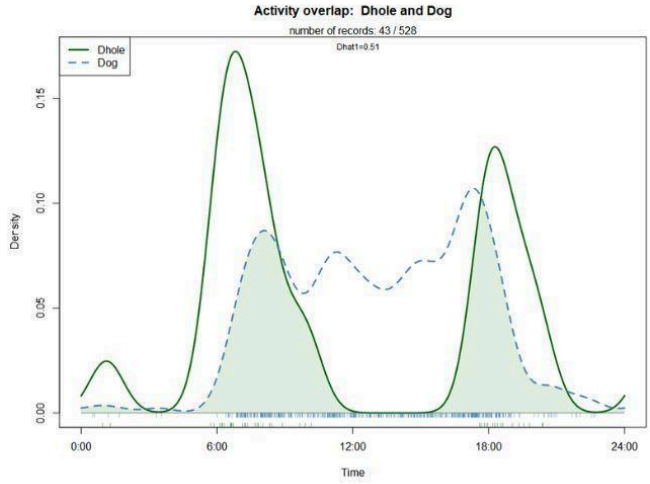
Domestic cat with hare kill

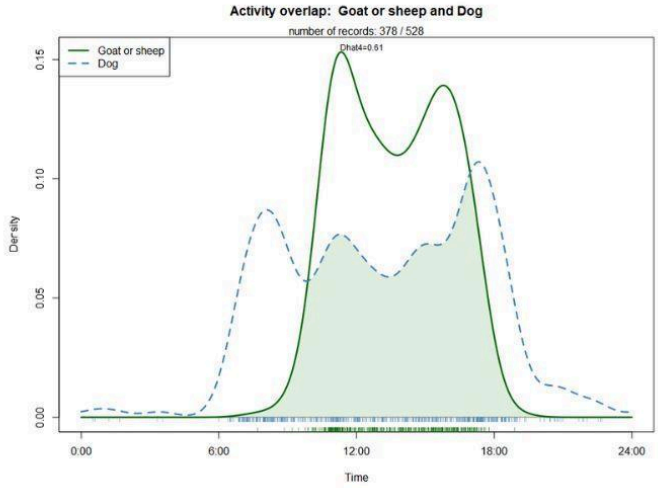
4. Temporal overlap graphs

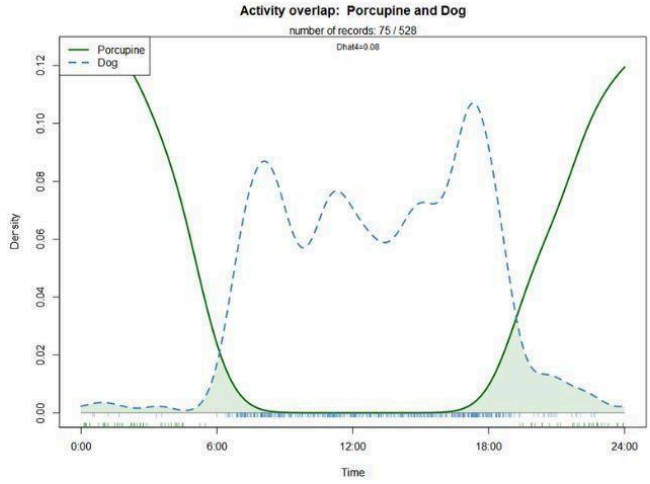
Dog-wildlife temporal overlap: Village

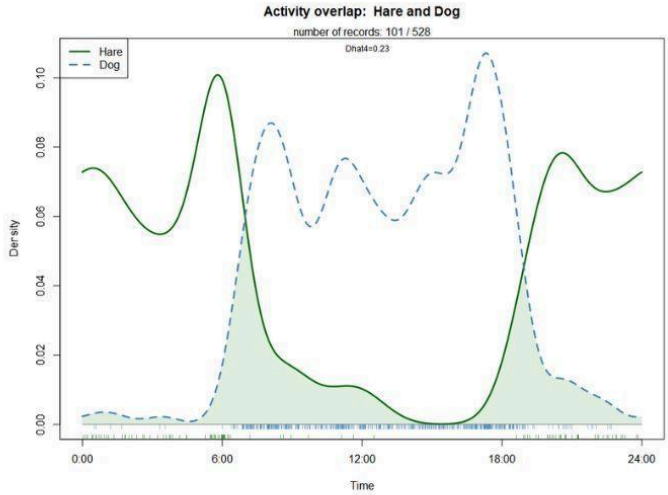


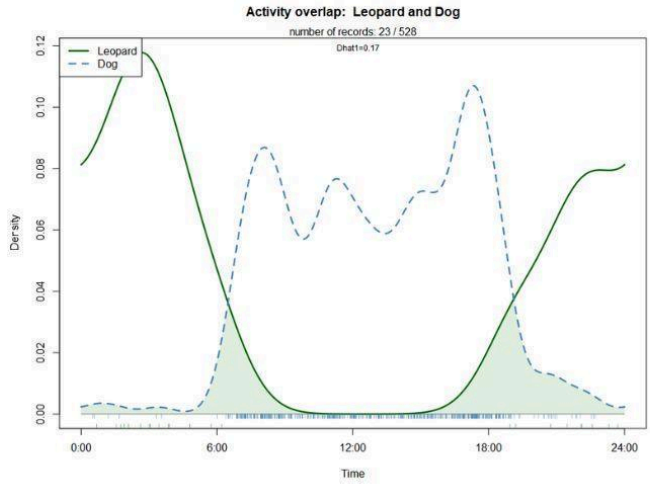
Dog-wildlife temporal overlap: Village

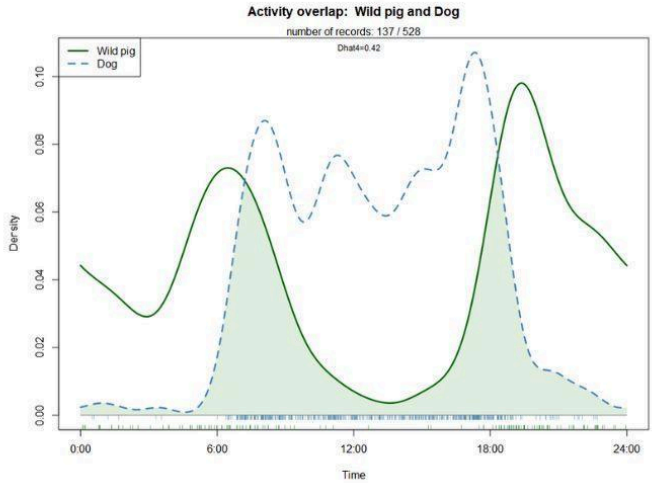




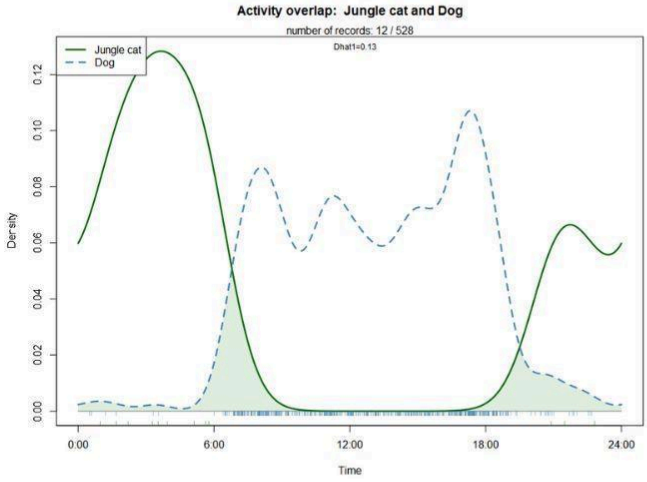


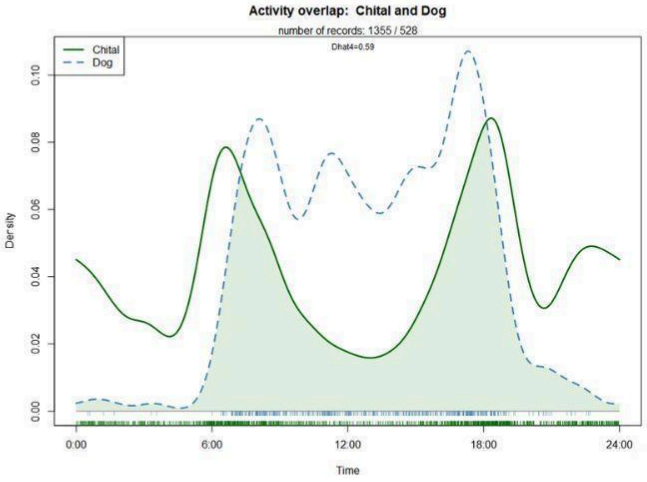




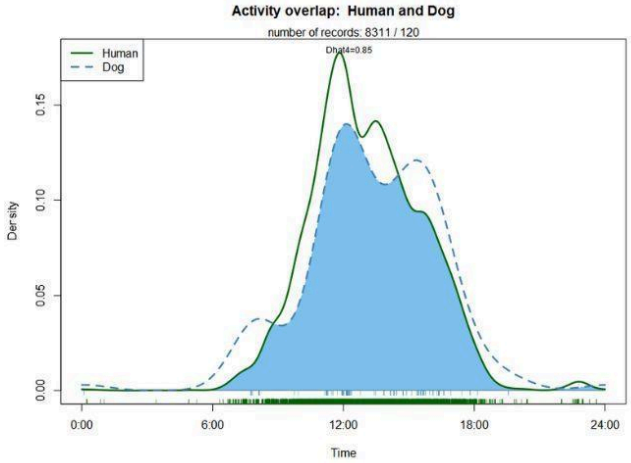


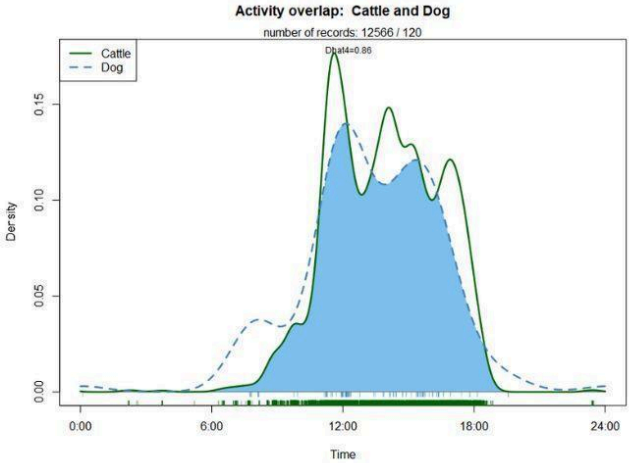
Dog-wildlife temporal overlap: Village

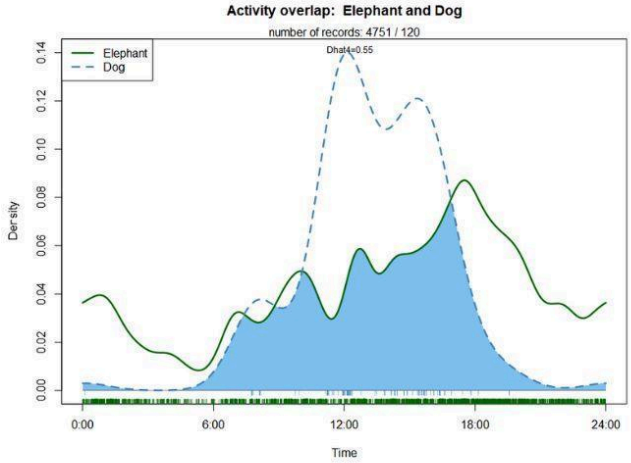


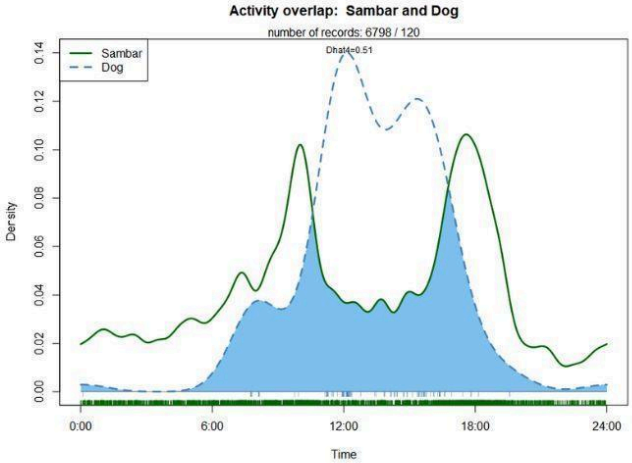


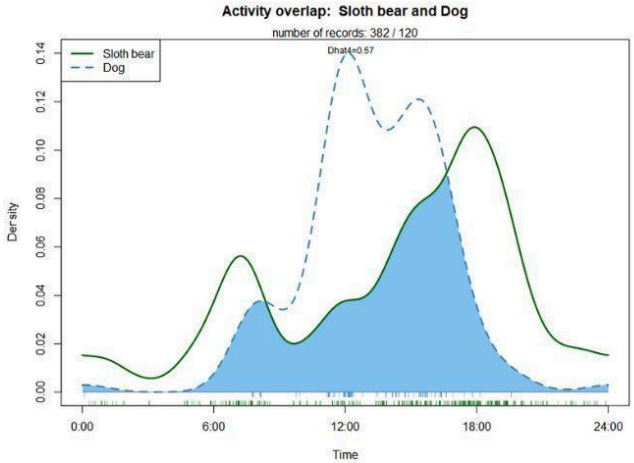
Dog-wildlife temporal overlap: Forest

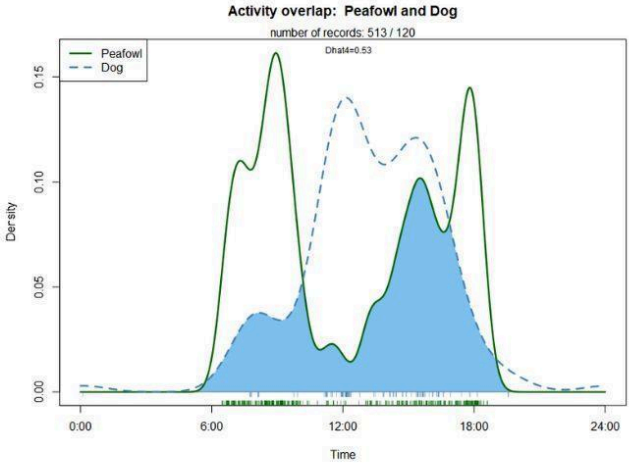




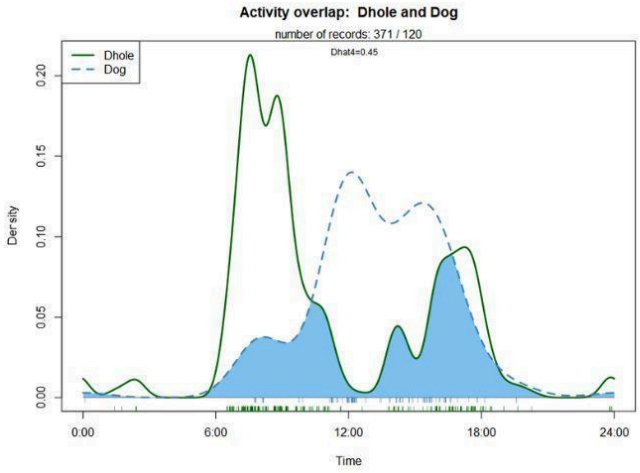


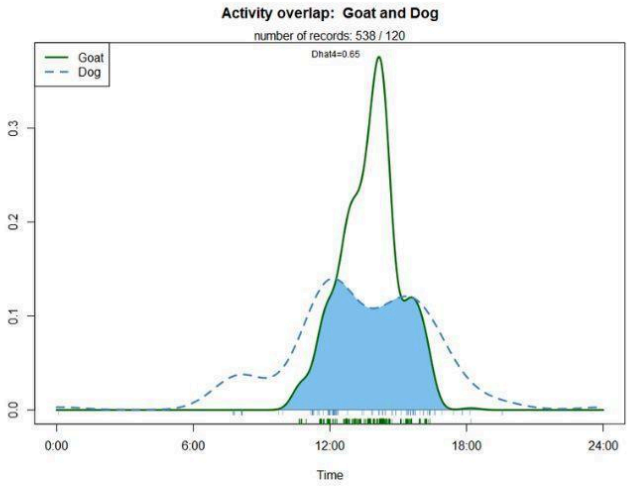


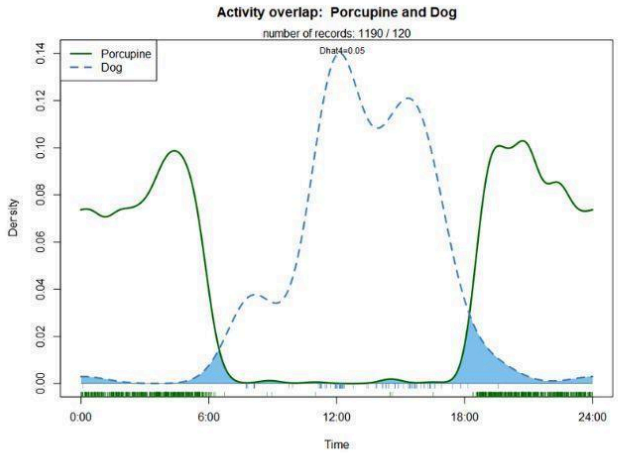


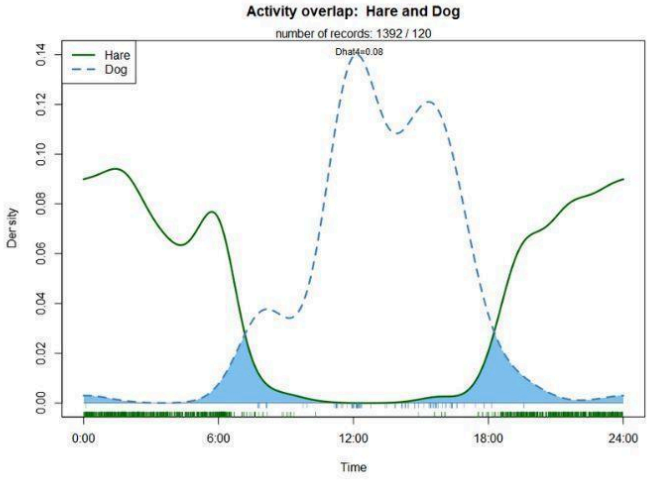


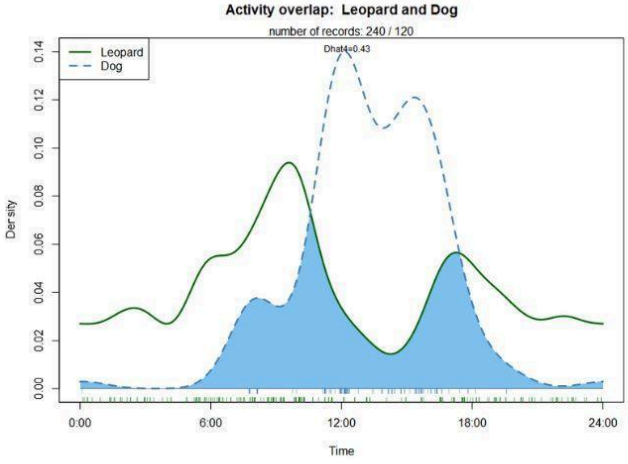
Dog-wildlife temporal overlap: Forest

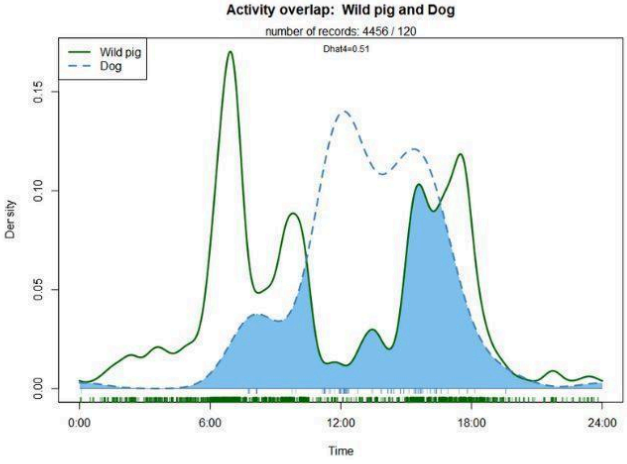












Dog-wildlife temporal overlap: Forest