Contact rates from utilisation distributions

Do different roaming patterns yield different contact rates?

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BACKGROUND

The Northern Peninsular Area (NPA), Queensland, Australia (Fig. 1), is at risk of a rabies disease incursion due to its proximity to rabies-infected islands of Indonesia. The NPA also has a large population of free-roaming domestic dogs (Fig. 2). A previous study has shown that NPA dogs' roaming patterns, can be categorised as 'stay-at-home', 'roamer' and 'explorer' types dependent on their utilisation distributions[1] (UDs). We hypothesise that these roaming patterns could result in heterogeneous contact rates that influence the speed or pattern of disease spread. These contact rates can be incorporated into disease spread models to better understand disease outbreaks within the population and subsequent development of mitigation strategies.

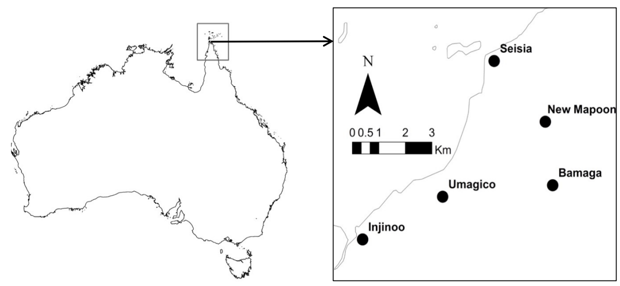

Fig. 1: Study location; Northern Peninsula Area, Queensland, Australia.

Fig . 2: Group of roaming dogs in the NPA. Pic: MP. Ward

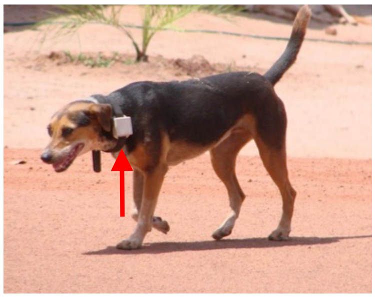

Fig. 3: NPA dog with GPS collar. Pic: MP. Ward

METHODS

Datasets from a previous dog GPS study in the NPA were used in which roaming categories were assigned to 21 dogs based on changes to their UD over monitoring periods > 60 days[1]. Examples of roaming category types are shown below - 'stay-at-home', 'roamer' and 'explorer' (Fig. 4a-c).

→ All possible pairs of dogs were chosen within and between each roaming category. For each pair, individual dog's UDs were placed at incremental distances of 10m apart (10-600m) and in a random direction (0-360º) to simulate variation in the position of dogs' homes within the NPA communities.

→ At each incremental distance, the Probability Home Range index[2] was calculated, which is the probability of finding Dog A in Dog B's 95% home range (HR) and vice versa. This index takes into account the area of overlap and the non-uniform distribution of time within the HR.

→ The contact probability in a 24 hour period was estimated by multiplying the two values provided by the PHR index ($PHR_{A,B}$ and $PHR_{B,A}$).

→ All pairs of dogs in 6 kernel combinations were simulated at a distance between 10-600 every 10m. The median and 95% range probabilities were calculated for each 10m increment and a logistic curve was fitted to estimate the probability of contact at every 1m.

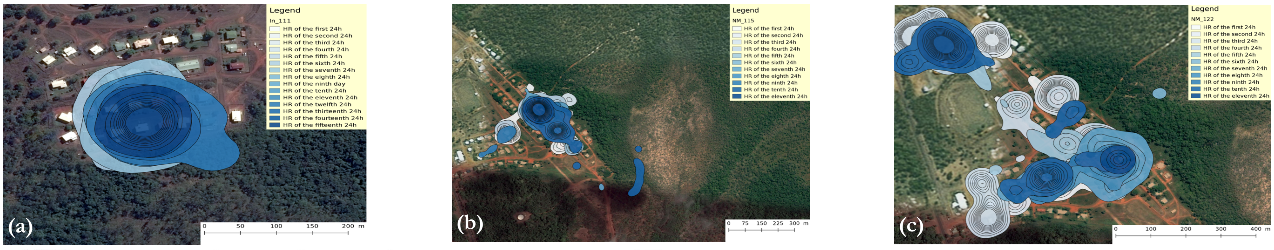

Fig. 4: Examples of (a) stay-at-home, (b) roamer and (c) explorer dog UDs[1]

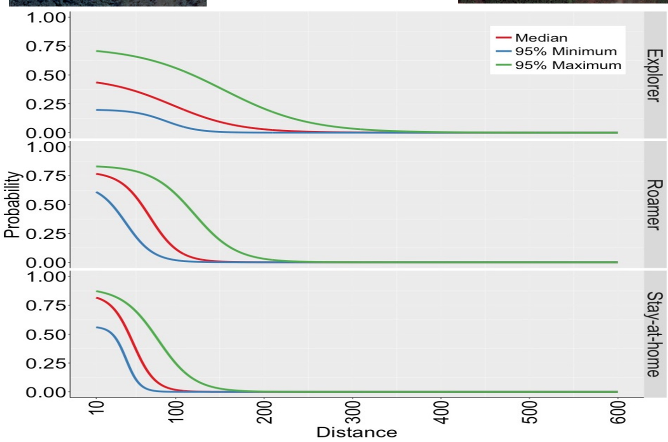

Fig. 5: Explorer and Explorer, Roamer and Roamer and Stay-at-home and Stay-at-home dog pair kernel as examples

Kernel	Median contact Pr. at 10m (95% range)	Median contact Pr. at 200m (95% range)	Distance for median to reach Pr. = 0.100	Distance for median to reach Pr. = 0.00
Stay-at-home – Stay-at-home	0.817 (0.560 - 0.873)	0.000 (0.000 - 0.003)	77m	140m
Roamer – Roamer	0.766 (0.609 - 0.830)	0.0003 (0.000 - 0.030)	102m	260m
Explorer – Explorer	0.436 (0.197 - 0.708)	0.029 (0.0005 - 0.208)	242m	420m

Table 1: Contact probabilities and distance values of three of the six kernels as examples. Pr. = Probability

RESULTS & DISCUSSION

The different roaming patterns found in the NPA dog population produced different contact kernels. The explorer kernel showed the most variation, especially at short distances (Fig. 5, Table 1). This is because explorer dogs do not stay in the same area on consecutive days as much as stay-at-home dogs or roamer dogs, who remain relatively in the same place. However, the median and the 95% range minimum and maximum contact probability reached zero at longer distances compared to the stay-at-home and roamer kernels. This is because the explorer UD areas are larger and allow for contact at longer distances. Although the roaming patterns of the stay-at-home and roamer dogs are different, their contact kernels are very similar and are not likely to cause any difference in disease spread. However, further analysis is required. Although the explorer dogs have lower probability of contact at shorter distance, they are likely to contact more dogs overall compared to the other categories. Explorers could therefore have a higher influence on the spread of rabies compared to stay-at-home and roamer dogs. These kernels will be incorporated into a rabies-spread model to take into account the heterogeneity of the roaming patterns within the population to simulate a potential outbreak in the NPA and provide potential mitigation strategies. Although these kernels have been estimated for a rabies model, they can be incorporated into any infectious disease model in which disease is transmitted by direct contact.

References: [1] Hudson EG, Brookes VJ, Dürr S, Ward MP. Domestic dog roaming patterns in remote northern Australian indigenous communities and implications for disease modelling. *Preventive Veterinary Medicine* 2017;146:52-60.

[2] Fieberg J, Kochanny CO. Quantifying home-range overlap: The importance of the utilization distribution. *Journal of Wildlife Management* 2005;69:1346-1359.