Using correlated random walks to analyze interaction between Brown Hyena pairs in Northern Botswana

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1. Introduction

The nature of interactions among individuals of a population is a fundamental aspect of a species' behavioural ecology. Information on the frequency and duration of these interactions is vital to understanding mating and territorial behaviour, resource use, as well as infectious disease epidemiology. However, the number of times an individual animal comes into contact with another is an extremely difficult parameter to estimate, with previous studies typically focusing on highly observable species living within protected areas. For relatively rare or secretive species, or those occupying less-accessible habitats, complete and accurate information regarding rates of intraspecific contact typically is lacking.

Spatial interaction between individuals is typically estimated by calculating home range overlap ('static interaction;' Doncaster 1990); however, this does not account for the possibility of temporal avoidance (Begg et al 2005; Schauber et al 2007). 'Dynamic interaction' (Doncaster 1990) between two individuals provides information on possible attraction and repulsion of animals that are in the same area at the same time. When dynamic interaction rates (number of encounters between individuals that overlap in space in time) can be calculated, they are often just compared in the context of some individual (age, sex) or environment (resource availability, season) characteristics, rather than against a more objective 'random' interaction, or null model, baseline.

Increased availability of modern equipment such as remote download GPS (global positioning systems) collars has facilitated the collection of high-resolution spatiotemporal information on animal movement, however the ability to collect the data has far surpassed the ability to analyze them (Bailey and Thompson 2006; Young and Shivik 2006). Basic GPS collar data includes geographic coordinates (x,y), the time at which the location was recorded, and elevation of the location. These spatiotemporal data are typically summarized using statistics such as mean neighbour distance (or mean distance apart for two specific individuals), mean daily distance travelled, and mean rate of travel. Dynamic interaction for an individual is defined as occurring when another individual is located within a defined distance, both spatio- (ex. 500 m.) and temporal (ex. 60 minutes). These interactions have been summarized similarly using, for example, mean time between interactions and the interaction rates compared as a function of differences in sex, season, resource availability, and clan membership. However, none of these interaction metrics facilitates an understanding of whether these encounters occur more or less frequently than they would occur if the individuals were moving randomly across their range, suggesting evidence of attraction and avoidance respectively.

A correlated random walk (CRW) is a theoretical model based on three parameters: number of steps, distribution of step lengths, and distribution of turn angles (Byers

2001). Modelling movement as a CRW provides a firm foundation from which to explore habitat use and behavioural ecology of animals and can be used to develop more complex models.

CRW models can be used as a ‘null model’ to reveal how behaviors and other factors can influence individual movements (Codling et al 2008). Significant differences between simulated (CRW) movement paths and an individual’s real movement path suggests either preference for or avoidance of a specific region (Bergman et al 2000), which can then be explored further. To my knowledge, no previous research has examined dynamic interaction between CRW paths simulated for two individuals. Further, while studies that use CRW to quantify space use have a relatively long history of use in invertebrate studies (Root and Kareiva 1984), they have only recently been applied to larger mammals (Codling et al 2008) and even less frequently to carnivores (Young and Shivik 2006).

Although the ecology of the brown hyena (Parahyaena brunnea) is reasonably well understood in protected environments, it has not been studied extensively outside of protected areas, where much of its range occurs and where it often coincides with human populations. The brown hyena was listed in the IUCN 2003 red list of threatened species as lower risk: near threatened, and the global population size is estimated to be between 5,070 – 8,020 individuals, with Botswana estimated to have the highest population of approximately 3,900 individuals (Mills & Hofer 1998). Brown hyenas live in small groups or clans of between 2- 12 individuals that share and defend a common territory, and use scent markings to maintain territorial boundaries. Little is known about how brown hyenas have evolved their foraging strategies to overcome environmental and human constraints and how they have adapted their spatial distribution in particular when competing for limited resources.

2. Significance

This research will serve two important purposes: the first examines the spatial pattern of interaction between brown hyena pairs, a relatively unstudied aspect of their ecology; the second purpose involves the development of a new way of examining these spatial interaction patterns based on GIS theory and technology for use with newly available high resolution spatiotemporal information.

The results of this research will contribute to a greater understanding of how brown hyena individuals interact, based on age, sex, clan membership, resource availability, and season, as well as provide a new way of analyzing these interactions that can be used to explore interaction between members of many other species as well.

3. Data and Methods

The data used in this projected were collected from GPS collars on fifteen hyena individuals (8 females, 7 males) from six different clans. The field data were collected in a 4800 km^2 area in the Makgadikgadi Pans region of northern Botswana between June 2004 to December 2007.

For each of the 15 individuals, the following is calculated for each of the three time periods (lean season, peak season, all):

- Kernel-based home range
- actual movement parameters (mean step length, mean turn angle)

These parameters will then be used to calculate for each individual and time period:

- 100 correlated random walks with the same origin as the real data and *n* steps, where *n* corresponds to the number of real observations and time of observation for that individual/period.

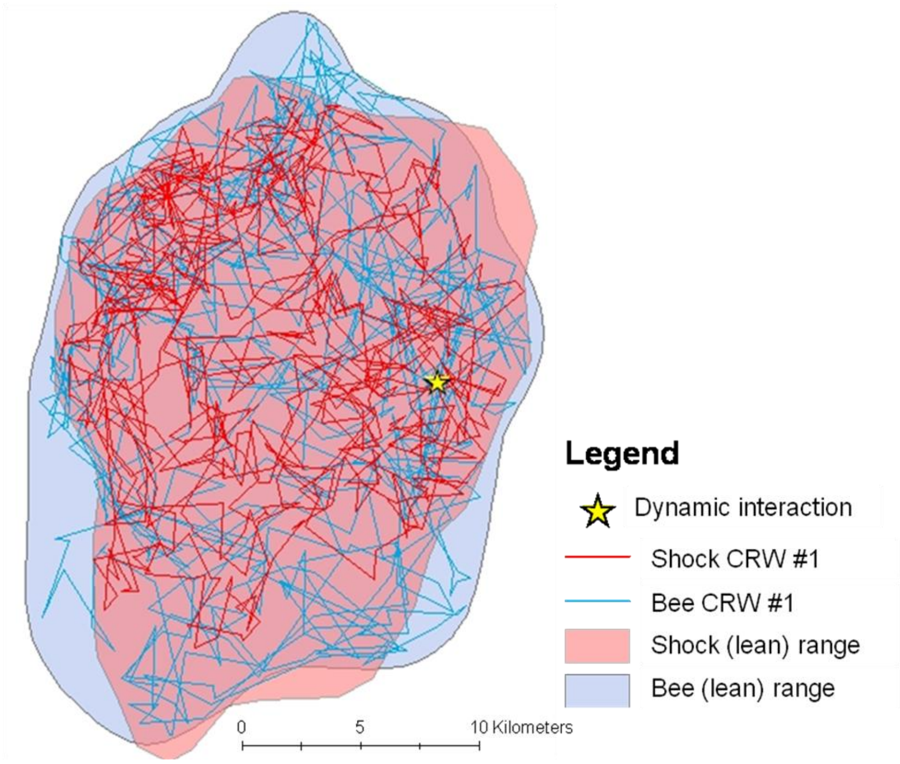

Figure 1: Example of the results of one set of simulations: There is one instance of dynamic interaction (spatiotemporal overlap where d<=500m and t<=60 min) between the correlated random walks for two female hyena individuals within the same clan ("Bee" and "Shock") during the lean period

The analysis will involve space-time queries of each pair of correlated random walks based on real dyads so that an interaction will be selected only if it meets both the space (d <= 500 m.) and time (t <= 1 hr) criteria. Statistics summarizing these simulated interactions (ex. proportion of dynamic interactions, mean distance apart) will then be compared to those from the actual interactions to determine the degree to which individuals might be avoiding or attracting each other, and whether there are differences associated with individual age, sex, clan membership, resource availability, or season.

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