Optimizing the search for resources by sharing information. The case of Mongolian gazelles.

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Many living organisms, including bacteria, insects, and mammals, communicate for a variety of reasons including facilitation of social cohesion, defense against predators, maintenance of territories, and to pool information on resource locations when no single individual is sufficiently knowledgeable[1]. However, research on foraging efficiency has focused largely on independent individuals[2], or on comparing foraging behavior across species[3]. Very few models have examined the potential effect that long-distance communication can have on movement behaviors and population distributions, and many open questions remain, particularly on the interrelation between communication in a population and optimal search efficiency in a biological context. How can communication facilitate group formation and identification of areas of high quality resources? Does a communication range exist that optimizes foraging efficiency? To what degree does search efficiency depend on the communication mechanism? Finally, how does communication affect individual space use in a heterogeneous environment?

In this work[4,5] we address these questions with a general model of random search with two main ingredients: resource gradients and long-range communication. In a first part, we propose a model of Brownian searchers which are able to perceive the quality of the environment at its location, and with a long-range pairwise interaction that provides information on the habitat in far away regions of the space. First, we study the efficiency of the search depending on the range of the communication from a temporal and a spatial point of view. To this aim, we measure the population mean searching time (Figure) and the spatial distribution of individuals in the long time limit (Figure) respectively. Using Monte Carlo simulations and density equations our results point out that the search is optimal at intermediate scales of communication, showing that both an excess and a lack of information may worsen it.

In the second part we show an application of the model to the particular case of acoustic communication among Mongolian gazelles, for which data are available, searching for good habitat areas. We couple an individual based representation of our model with remotely-sensed data on resource quality in the Eastern Steppe of Mongolia and show that at intermediate lengths of communication gazelles optimize the search. Finally, the optimal communication range and frequency obtained with our model are in good agreement with experimental results, suggesting that gazelles might have optimized their vocal tract and the frequency of their voices to communicate in the Mongolian Steppe.

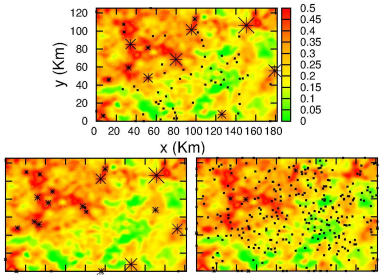

FIG. 1. Group formation in a population of 500 gazelles foraging in the Mongolian Steppe for communication at low (top), intermediate (bottom left) and high frequencies (bottom right).

Finally we compare the theoretical results obtained in the first part with the ones obtained considering Lévy flights instead of Brownian motion[6].

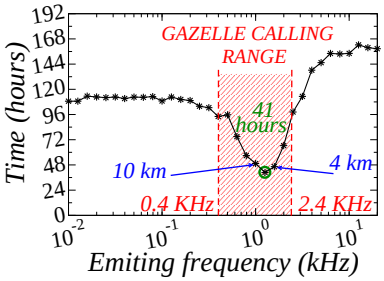

FIG. 2. The searching time is minimized at intermediate frequencies, at a value that agrees with the measurements done in Mongolian gazelles.

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