Supplemental Methods

Field experiments were performed with colonies of the red harvester ant *Pogonomyrmex barbatus* at the site of a long term study near Rodeo, NM, USA, monitoring a population of about 300 colonies for which the ages of all colonies are known (Gordon and Kulig 1996; Ingram et al. 2013). Observations were made in August 2013 and August 2014.

Interactions of potential foragers with returning foragers take place inside the nest entrance chamber, a chamber about 5 cm long, and 2-3 cm below the surface. The entrance chamber connects to the nest entrance by a small tunnel, and further tunnels lead from this chamber to deeper nest areas. Films of the entrance chamber of four actively foraging colonies were made by removing the top layer of soil above the entrance chamber and placing a transparent piece of glass over it to maintain humidity (Pinter-Wollman et al. 2013; Davidson et al. 2016; Pless et al. 2015).

We manually tracked the interactions and locations of all ants in 1 to 3 minutes of each video using a Java program we developed. An interaction was considered to occur when the tracked ant's head came within one head width of another ant. The location of an ant was marked with a tracking point when it significantly moved positions or changed the course of its trajectory in a subsequent video frame; this allowed an approximate reconstruction of the ant's entire trajectory by linearly interpolating between tracking points. Ants that were in the entrance chamber when the focus period began were followed back in time to establish if they were returning foragers or had come from a tunnel.

Trajectories were classified based on starting and end location, whether the ant was seen carrying objects, and whether the ant left a tunnel to walk around the entrance chamber. The classification of ant trajectories used here is that same as (Davidson et al. 2016), and includes the trajectory categories showing in Table S1.

The density function ρ_D^{RF} for returning foragers includes ants with labels {f, g, or h} in Table S1, and the density function ρ_D^{PF} for potential foragers includes ants with labels {a, b, or d}. These labels are included in the linked data files.

To compare groups of returning foragers and potential foragers (Fig 7), we calculated averages using only individual ant trajectories that were completed during the focus period. For returning foragers, this included categories {f, g}, and for potential foragers categories {a, b}, both with the restriction of the ant completing its trajectory during the focus tracking period. The additional label of whether the ant completed its trajectory during the focus period is included in the linked data files. Similarly, the comparison of potential foragers ants (Figs 8-9) uses labels a or b, with the condition of the ant completing its trajectory during the focus period.

Label	Description	Notes
a	From tunnel, left to forage	
b	From tunnel, into tunnel	
c1	From tunnel, carrying (not a potential forager)	Emerged from a tunnel carrying an object, and thus were likely to have been engaged in in nest maintenance work.
c2	From tunnel, always in tunnel (not a potential forager)	Never left a tunnel area to walk around the entrance chamber
c3	From tunnel, down tunnel, shorter than fastest outgoing forager (not a potential forager)	Returned to the deeper nest but stayed in the entrance chamber for a time less than that of the fastest outgoing forager
d	From tunnel, lost	Lost during tracking
e	From tunnel, uncertain action (colony 1)	Colony 1 (field study colony #242) had a location in the upper right area of the video frame that was an area of active nest maintenance. Ants that emerged from a tunnel that were not seen to be carrying dirt, but ended their trajectory near this area were labeled as having an uncertain end action.
f	Returning forager, left to forage	
g	Returning forager, into tunnel	
h	Returning forager, lost, uncertain, or incomplete trajectory	This includes ants that were lost during tracking, not tracked until trajectory completion (for ants that appeared near the end of the focus tracking period), or ended their trajectory in the upper right area of the video frame for colony 1 (an area of active nest maintenance) but were otherwise not seen to be carrying dirt.
i	Not many tracking points	Had 3 or fewer trajectory location makers placed during tracking. These ants either appeared in the video frame for a very short time, often at the edge of the frame or never leaving a tunnel area, or were lost and could not be followed any further
j	Other (uncertain start action)	These do not fall into any of the other categories, and mainly include ants that could not be followed back in time to discern where they started from, or ants that entered the video frame but never entered the entrance chamber.
k	Nest maintenance	If an ant carried dirt or debris out of the nest, it was considered to be a nest maintenance worker. For colony 1, if an ant first appeared in the upper right area of the video frame, it was also considered to be a nest maintenance worker since the colony was engaged in maintenance work in this area.

Table S2. Labels and descriptions of categories of tracked ants.

Approximation for average relative speed between ants

Here we approximate the average speed between a focus ant i and the surrounding ants j. Let the velocity of the focus ant be $\vec{v_i}$, and the surrounding ants $\vec{v_j}$. The average relative speed is an average over the surrounding ants:

$$\langle s_{rel,i} \rangle = \left\langle \sqrt{(\vec{v_i} - \vec{v_j}) \cdot (\vec{v_i} - \vec{v_j})} \right\rangle_j$$

Assume that the velocities of the focus ant and the surround ants are uncorrelated. We then then neglect the term containing $\vec{v_i} \cdot \vec{v_j}$, and approximate the relative speed as

$$\langle s_{rel,i} \rangle \approx \sqrt{s_i^2 - \langle s_j \rangle_j^2}$$

where $\vec{v_i} \cdot \vec{v_i} = s_i^2$, and a mean field approximation is also used to move the averaging over j inside the square root. This expression is used to evaluate the expected collision rate for the random mixture model.

For an average over local density and relative speed, we wish to compute the quantity

$$\langle \rho_D s_{rel,i} \rangle = \left\langle \rho_D \sqrt{(\vec{v_i} - \vec{v_j}) \cdot (\vec{v_i} - \vec{v_j})} \right\rangle_j$$

Again assumed uncorrelated velocities and using a mean field approximation, we arrive at

$$\langle \rho_D(x_i(t), y_i(t), t) s_{rel,i}(t) \rangle \approx \sqrt{\left(s_i(t)\rho_D(x_i(t), y_i(t), t)\right)^2 - \left\langle \left(s_j(t)\rho_D(x_i(t), y_i(t), t)\right)^2 \right\rangle_j}$$

Here we note explicitly that the density function is evaluated at the current location of the focus ant i, and that the speed of each ant is a function of time. This expression is used to evaluate the expected collision rate for the local density model.

References

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