Substrate evaporation drives early collective construction in termites

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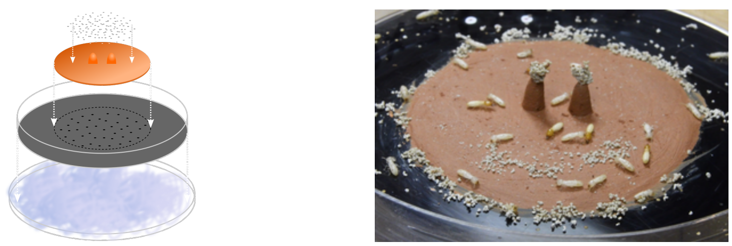

Figure 1. Sketch of the experimental setup (left), and snapshot of one experiment after 24h (right).

Termites are known to build complex and intricate nests from self-organised collective behaviour. Here we aim at finding minimal organizing principles of nest morphogenesis. In a previous study we have shown that using a phase-field approach and a single non-linear equation we can reproduce the nest growth process and retrieve the main geometrical features of real nests geometry [1]. Our model equation relies on the hypothesis that building activity is locally enhanced where the mean curvature of the nest walls is high. We present now laboratory experiments to verify this hypothesis. The experimental setup consists of a thin disk of wet, red clay placed at the center of a petri-dish and kept hydrated through a system of tiny holes that suck water from a reservoir filled with wet cotton underneath (Fig. 1, left). Two curvature cues in the form of small pillars are added at the center of the arena, which is covered with sparse grey pellets of clay obtained from previous experiments and successively sterilised. A fixed number of 50 termite workers is finally introduced in the arena. We observed that the sparse pellets are progressively collected and deposited in two specific regions which are (i) the top of the pillars and (ii) the edges of the clay arena (Fig. 1, right). The high deposition frequency in region (i) confirms the hypothesis of our growth model, because the pillar tips are the region where the mean curvature is the highest in our setup. Conversely, region (ii) is almost flat, which suggests that a different driving cue may be at play. Indeed, a common feature between regions (i) and (ii) is that the evaporation flux is the highest there [2]. Supported by previous evidences about termites sensing the humidity gradient [3], we propose that evaporation flux is the relevant cue that drives termite building activity. However, our model remains valid as disk edges are thin cusps of humid substrate, i.e. humidity gradient covaries with curvature.

References

1. G. Facchini *et al.*, A growth model driven by curvature reproduces geometric features of arboreal termite nests, *J. R. Soc. Interface*, **17(168)**, 20200093 (2020).
2. R. Deegan *et al.*, Capillary flow as the cause of ring stains from dried liquid drops, *Nature* **389**, 827–829 (1997)
3. R. Soar *et al.* Moisture gradients form a vapor cycle within the viscous boundary layer as an organizing principle to worker termites. *Insect. Soc.*, **66**, 193–209 (2019).