

Worker aggregation leads to collective chamber excavation in leaf-cutting ants

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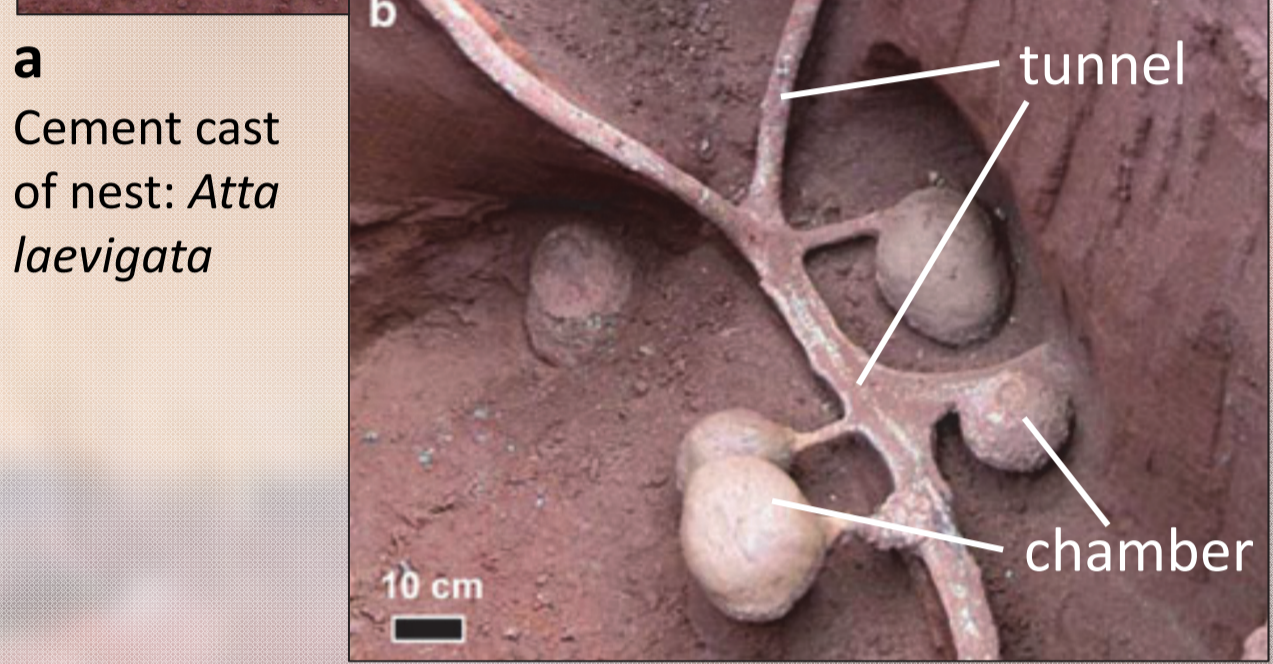


Introduction

The underground nests of the leaf-cutting ants (genus *Atta* and *Acromyrmex*) consist of a complex system of round, spherical chambers and oblong, narrow tunnels. The mechanisms leading to the excavation of these morphologically different structures are yet to be discovered. It is known, however, that the building of nests is a self-organized process where workers only have access to local information and excavate accordingly.

Aim of the study

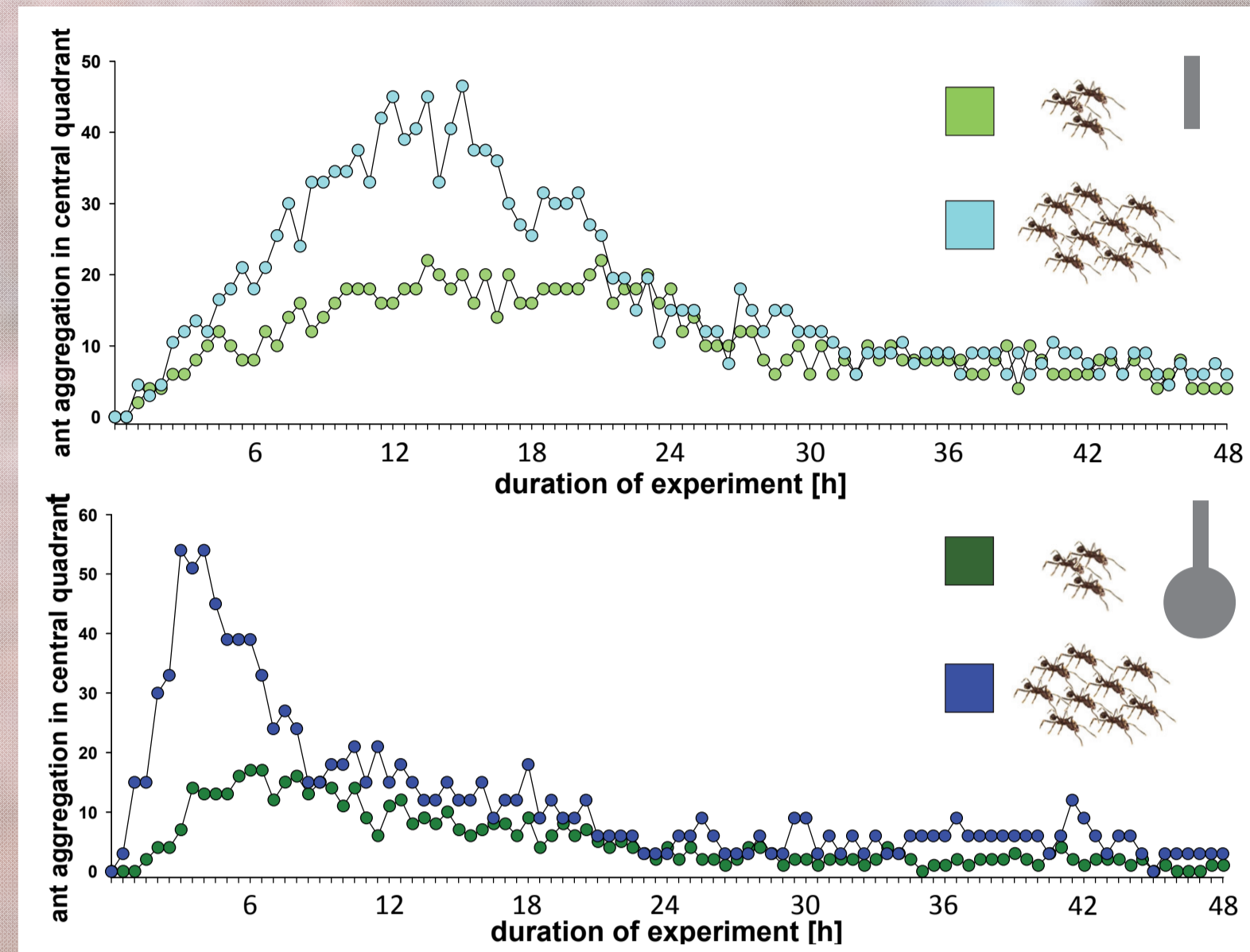
Our aim was to evaluate whether the excavation of either chambers or tunnels depends on local worker aggregation, i.e. the concentration of 'workforce' at one place within the nest.



a Cement cast of nest: *Atta laevigata*
b The different structures of an ant nest: chambers and tunnels

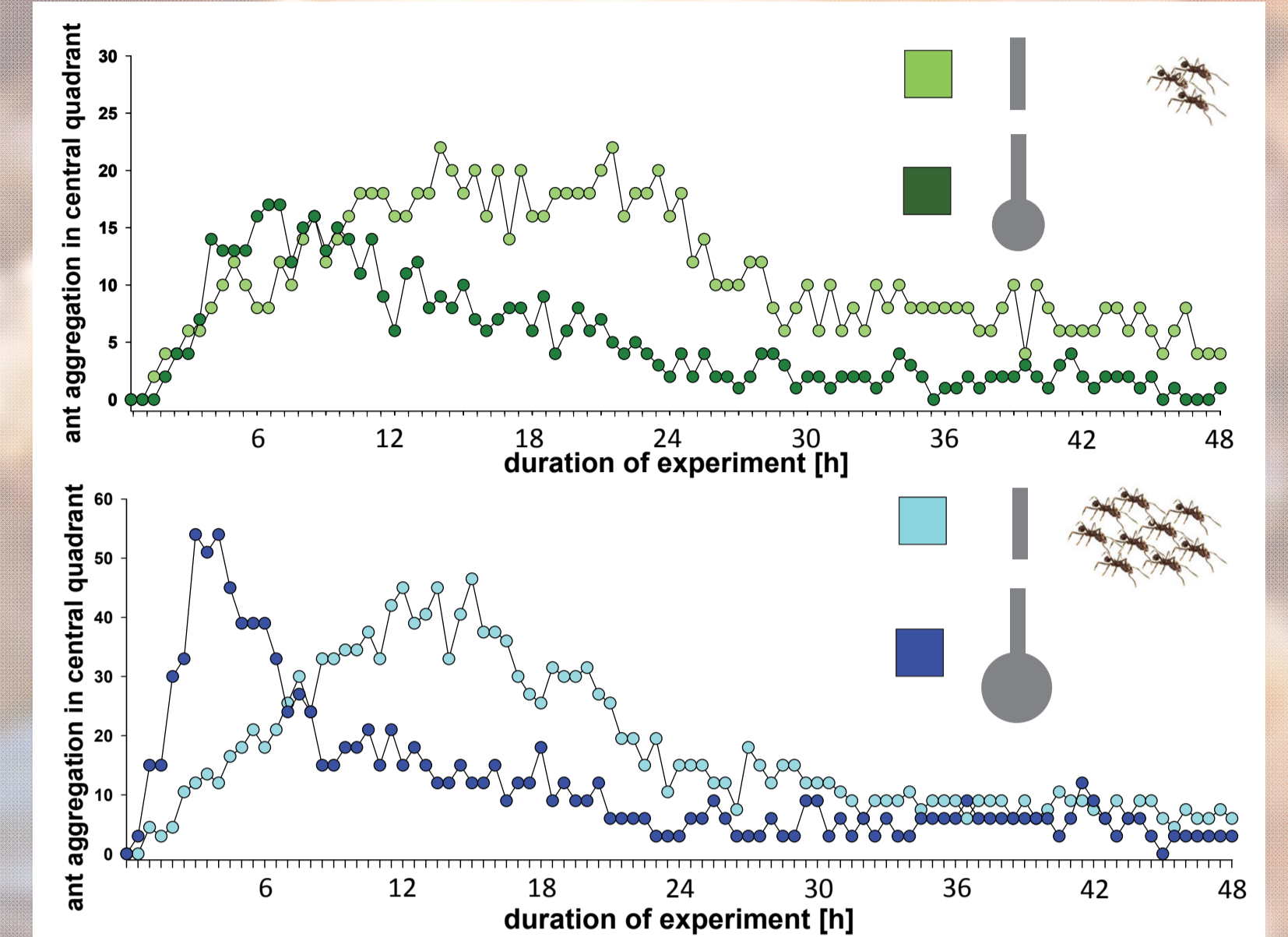
Results: Worker aggregation

Does worker aggregation depend on group size?



- Worker aggregation was higher in the large group, independent of available space.
- At any given time only a portion of the workers aggregated inside the arena.
- Worker aggregation in the central quadrant decreased with time and leveled out at comparable levels.

Does worker aggregation depend on available space?



- Worker aggregation was not increased, when ants had access to ample space, but the peak of worker aggregation was reached earlier.
- Worker aggregation increased slower in the reduced space setup (because the ants had to create the space themselves).
- Worker aggregation decreased rapidly in ample space

Methods

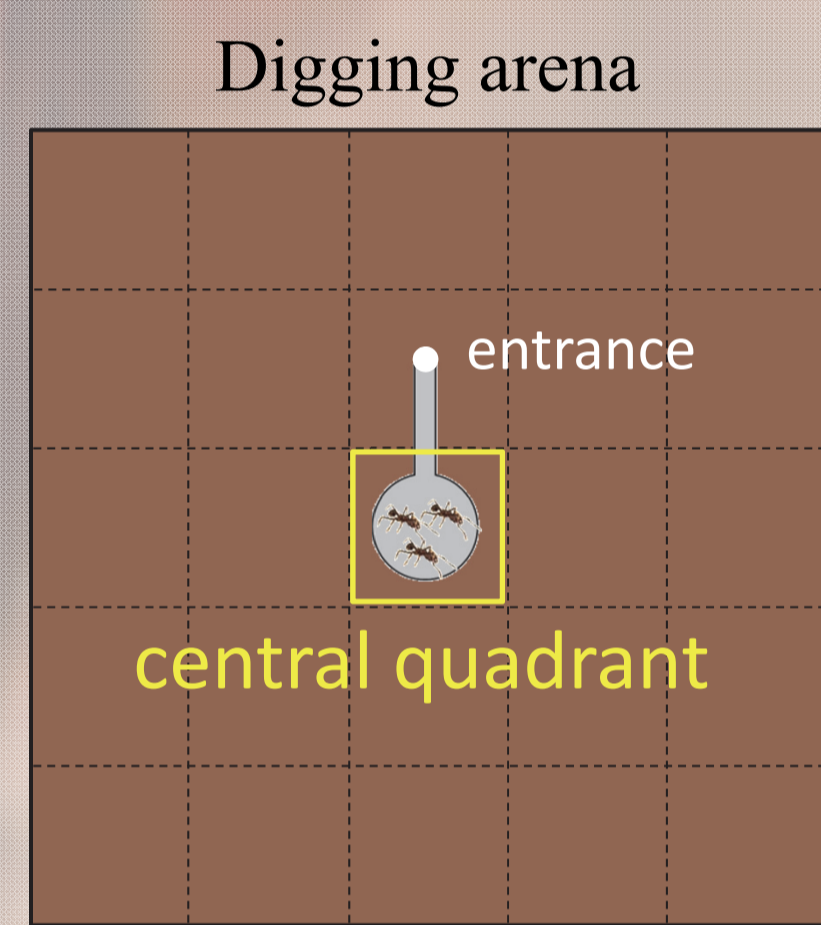
Excavation setup:

2-D digging arena (50x50 cm, 1 cm high), filled with moist clay

Arena virtually divided by grid (10x10 cm quadrants, drawn on covering glass plate for assessment of worker aggregation)

48 h excavation time

50 pieces of worker-attracting brood per setup (which were deposited in the central quadrant by the ants)



We manipulated worker aggregation in two ways:

1. Using different group sizes

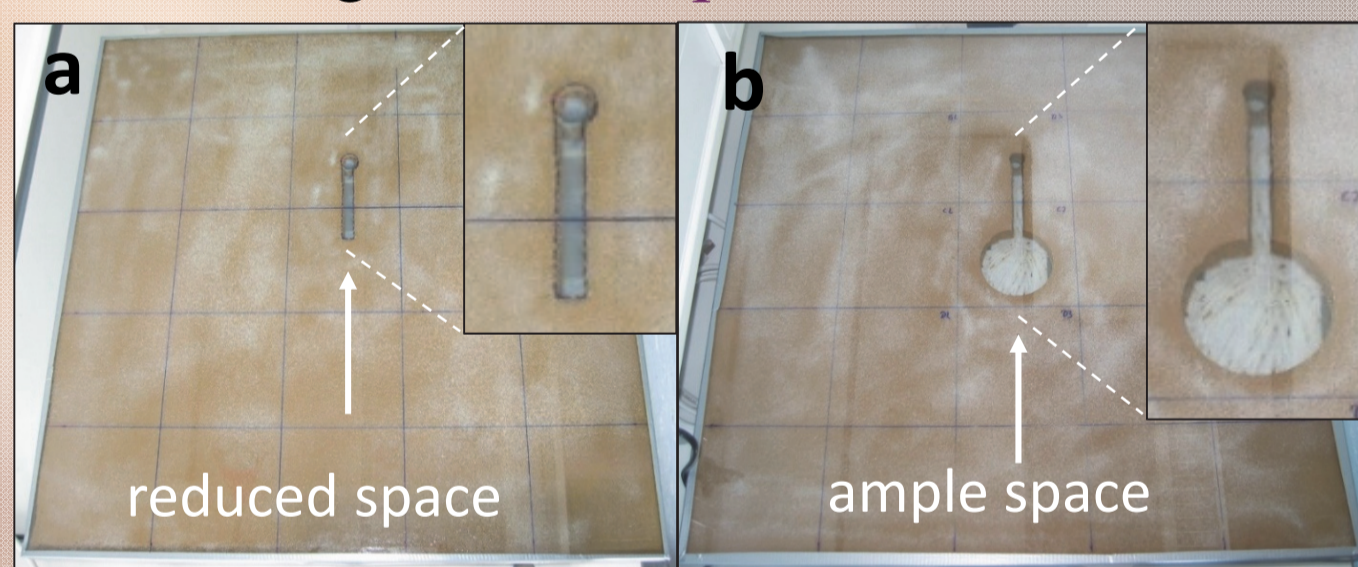
Small group

Large group



100
Acromyrmex lundi

2. Offering different space



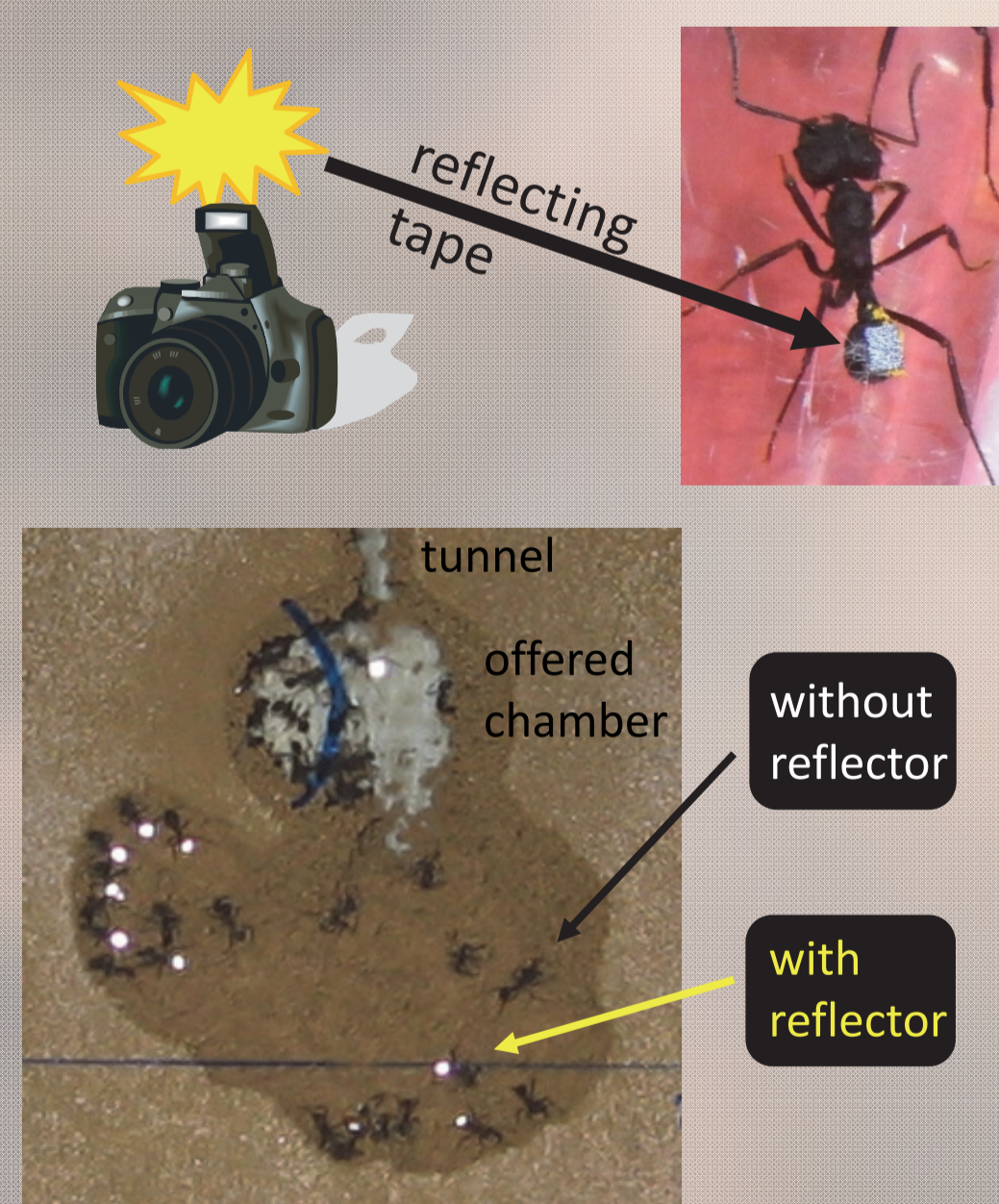
The self-excavated chamber volume emerging in the reduced space setup (a) was offered in the ample space setup (b)

Evaluation of worker aggregation

Interval photo of digging arena every 30 minutes during the experiment.

A portion of workers were marked with reflective tape (50% - 100 setup, 33.3% - 300 setup) to increase countability. Only marked ants were counted in each photo (and multiplied times 2 or 3 for evaluation).

Workers aggregated first in the central quadrant of the digging arena (yellow square). Therefore aggregation in this quadrant was evaluated.



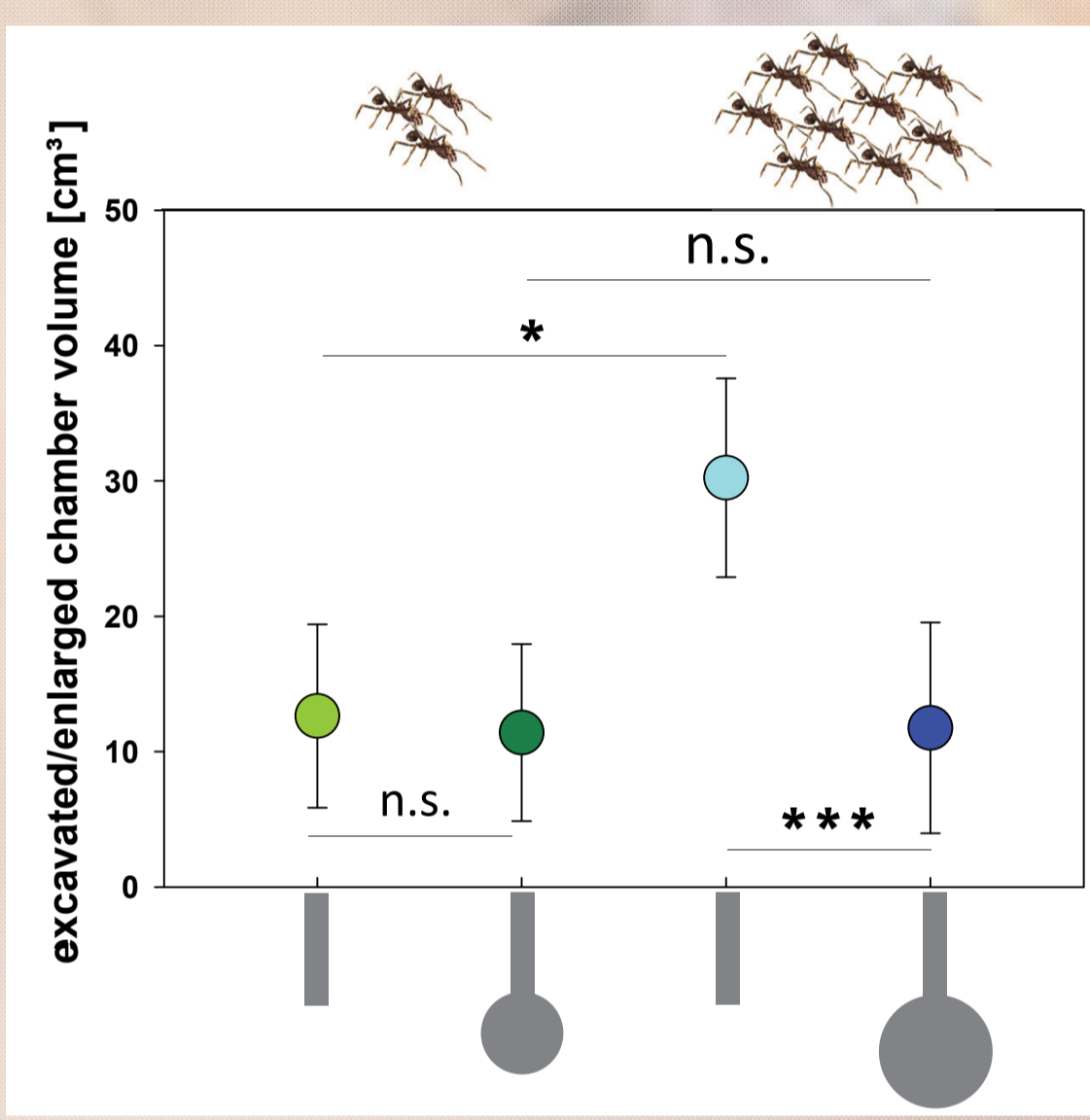
Four experimental series were performed

| Experimental series | Reduced space | Ample space |
|---------------------|---------------|-------------|
| Small group | | |
| Large group | | |

Evaluated parameters:

- Worker aggregation
- Size of excavated chamber/ chamber enlargement
- Size of excavated tunnel
- Time of tunnel emergence

Results: Emergence of chambers and tunnels



Chamber emergence

In reduced space chambers were excavated by both groups, but the large group excavated bigger chambers.

➡ Worker aggregation was higher in the large group.

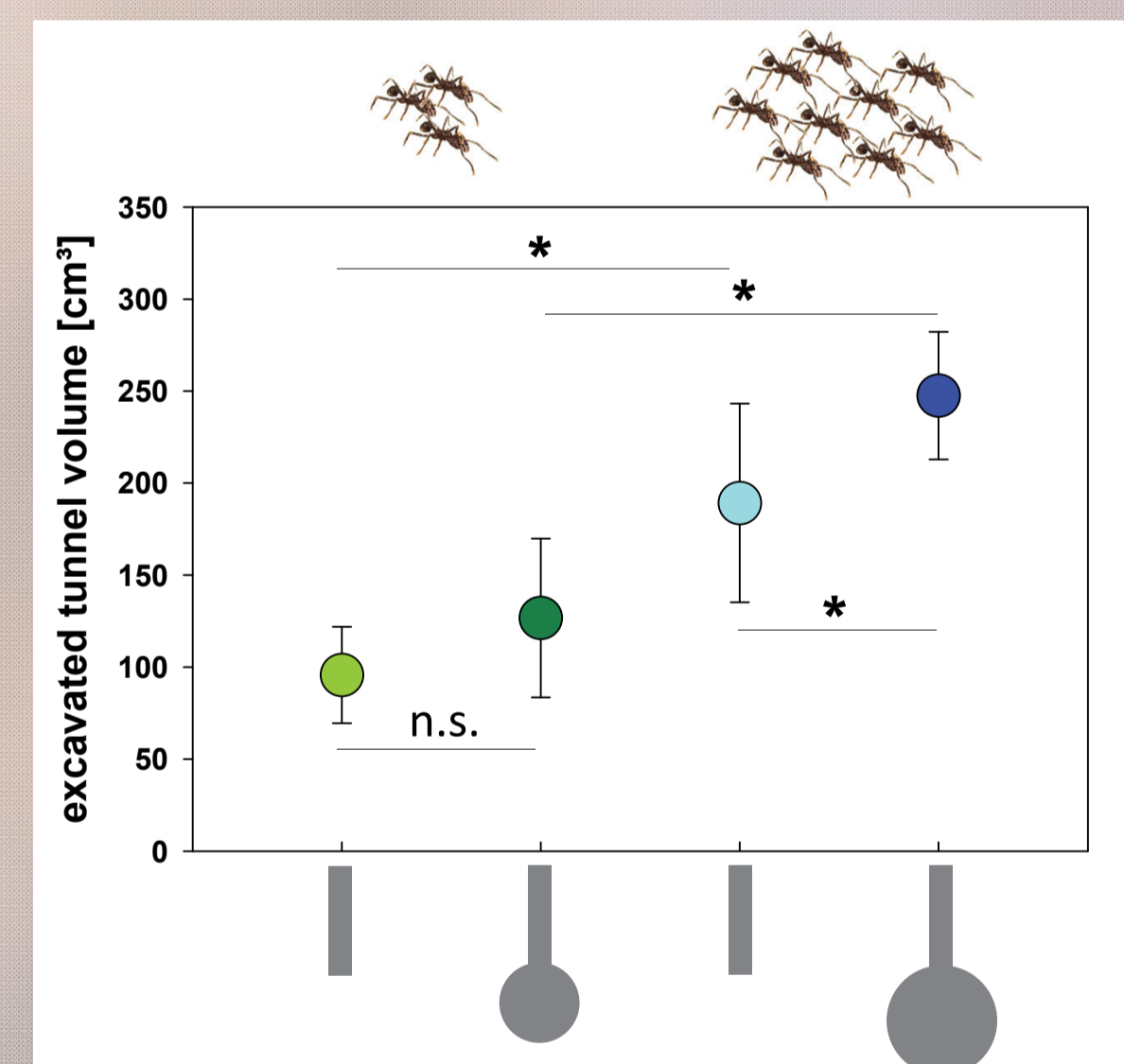
In ample space the small group enlarged the existing chamber by the same volume of their formerly self-excavated chamber, while the large group excavated less chamber volume and enhanced the offered chamber only marginally.

➡ Steeper and quicker decrease of worker aggregation in ample space.

Tunnel emergence

Both groups excavated tunnels (as well as chambers.), but large groups excavated more tunnels (as well as larger chambers).

➡ More 'workforce' can engage in digging activity



More tunnels were excavated when a chamber was already available.

➡ Marginal chamber enlargement and switch to tunnel excavation

➡ By offering ample space, worker aggregation was reduced (equal number of workers present in a larger volume)

Timing of tunnel emergence

The large group engaged earlier in tunnel excavation

➡ Aggregation in- and decreased quickly here, while in the small group aggregation decreased not as rapidly.

In ample space both groups engaged earlier in tunnel excavation.

➡ Low worker aggregation in central quadrant early in the digging process.

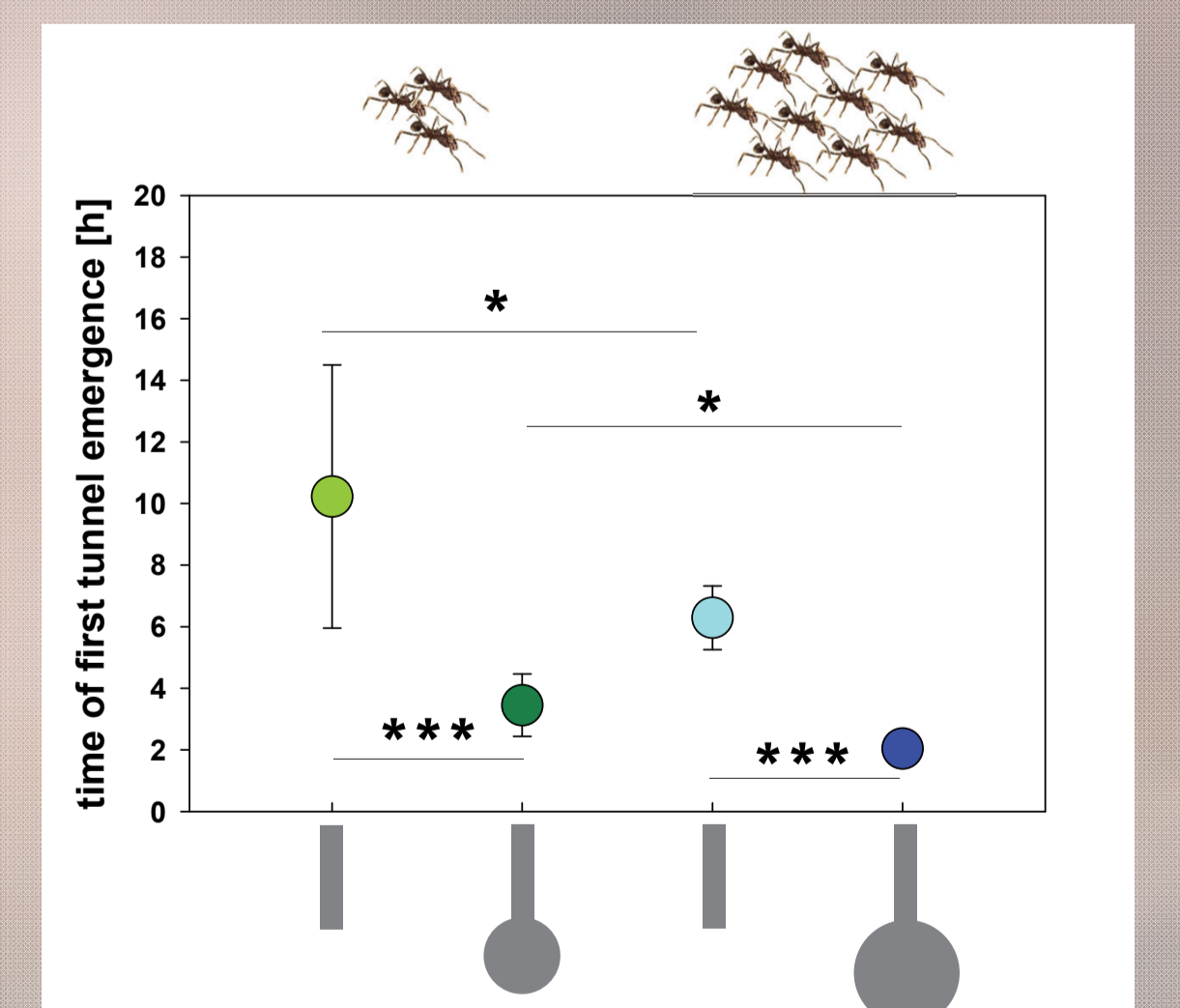


Photo credits:

Background photo ©Alex Wild
Ant photo ©James Waters

Conclusions

A high worker aggregation during nest excavation leads to chamber emergence.

Low worker aggregation, i.e., dispersed workers during excavation, leads to the excavation of tunnels

There is a timed sequence during nest excavation. First chamber excavation (high aggregation), then switch to tunnel excavation (low aggregation).