

Larger colony sizes favour greater division of labour between queens and workers in ants

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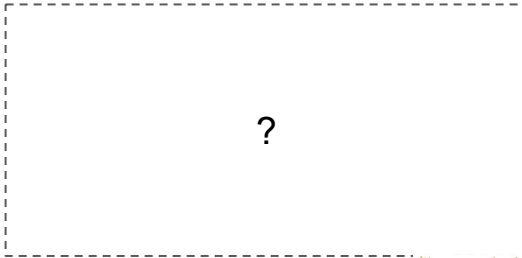
Dr. Stuart West's lab studies the evolution of social behaviours and social insects.



Dr. Juliet Turner



Professor Stuart West



Dr. Louis Bell-Roberts



James McCulloch

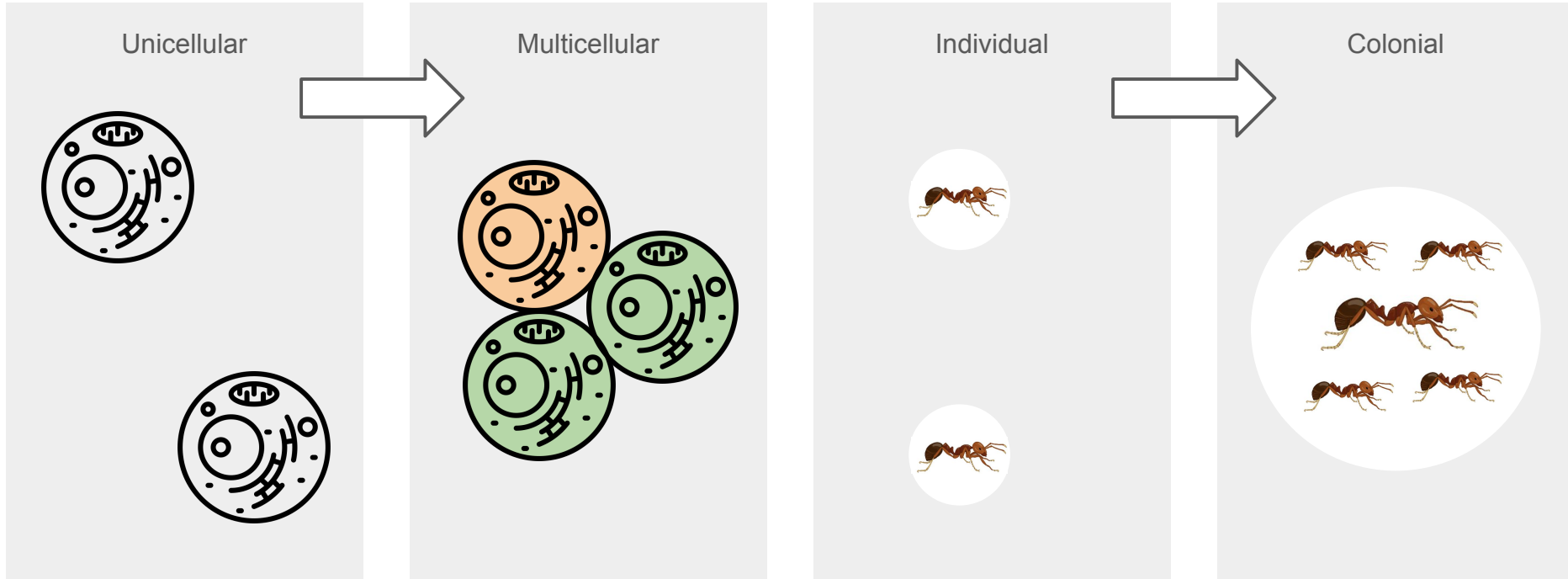


Dr. Matilda Brindle

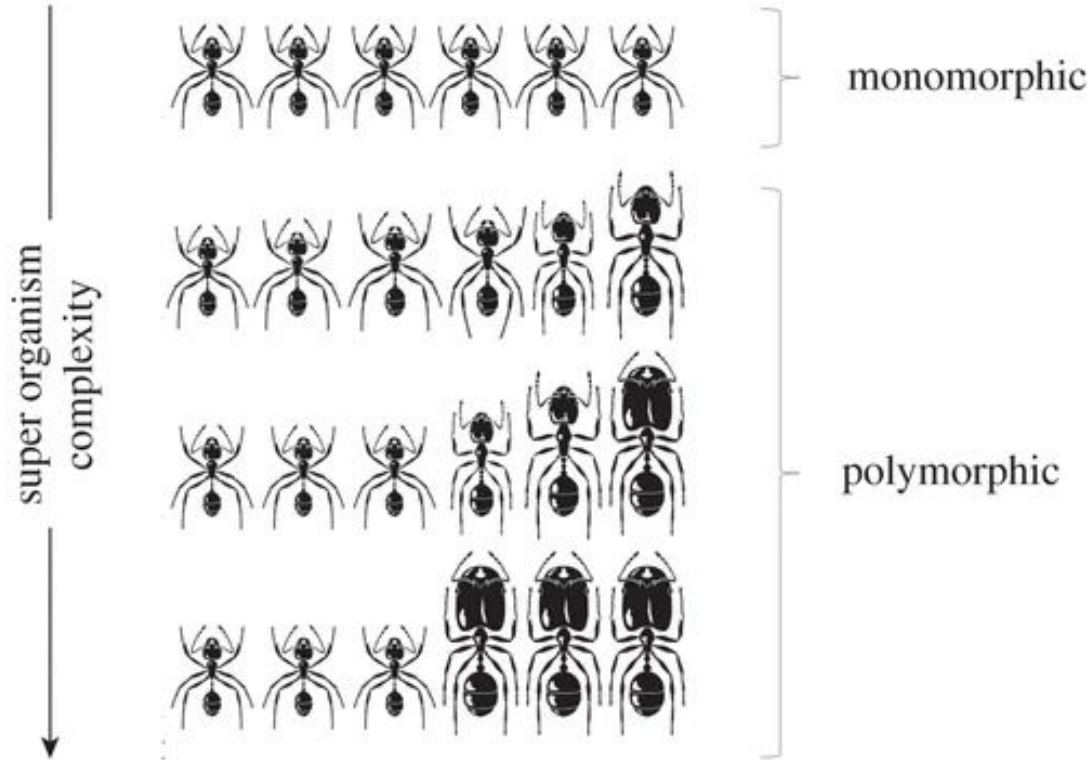


Dr. Rosa Bonifacii

Do major transitions in biological complexity follow the same rules at different scales?



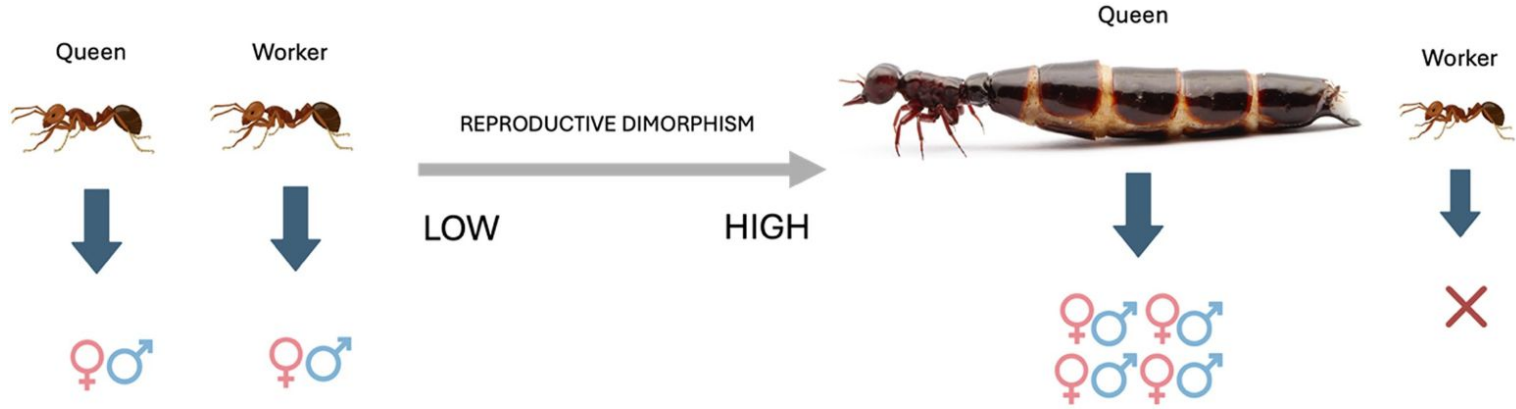
Ants are a living experiment for the division of labour



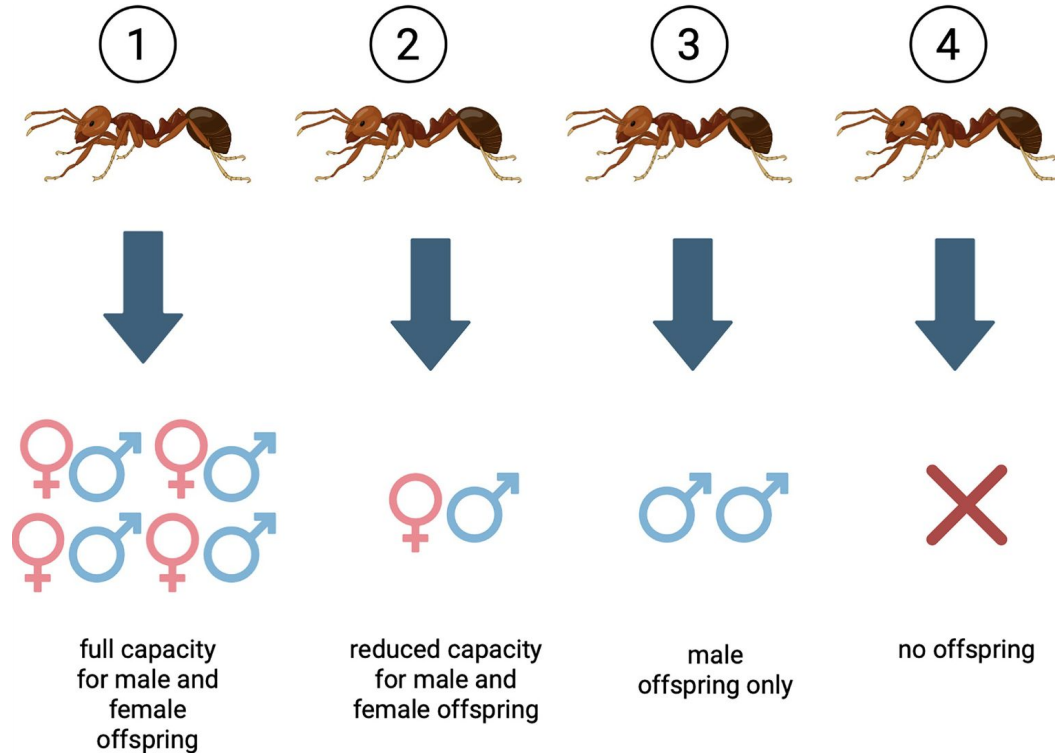
Reproductive labour tends to be divided in more complex organisms



The extent of reproductive division of labour varies across ants

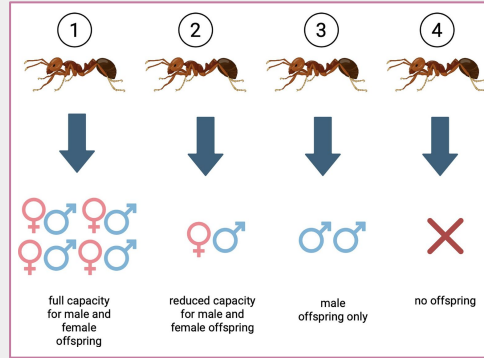


The extent of reproductive division of labour varies across ants

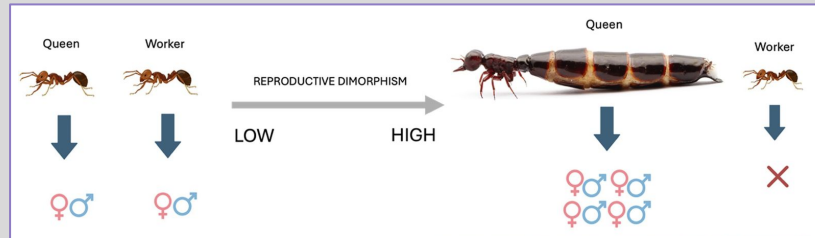


Two Metrics for the Division of Reproductive Labour:

1. Worker Reproductive Capacity

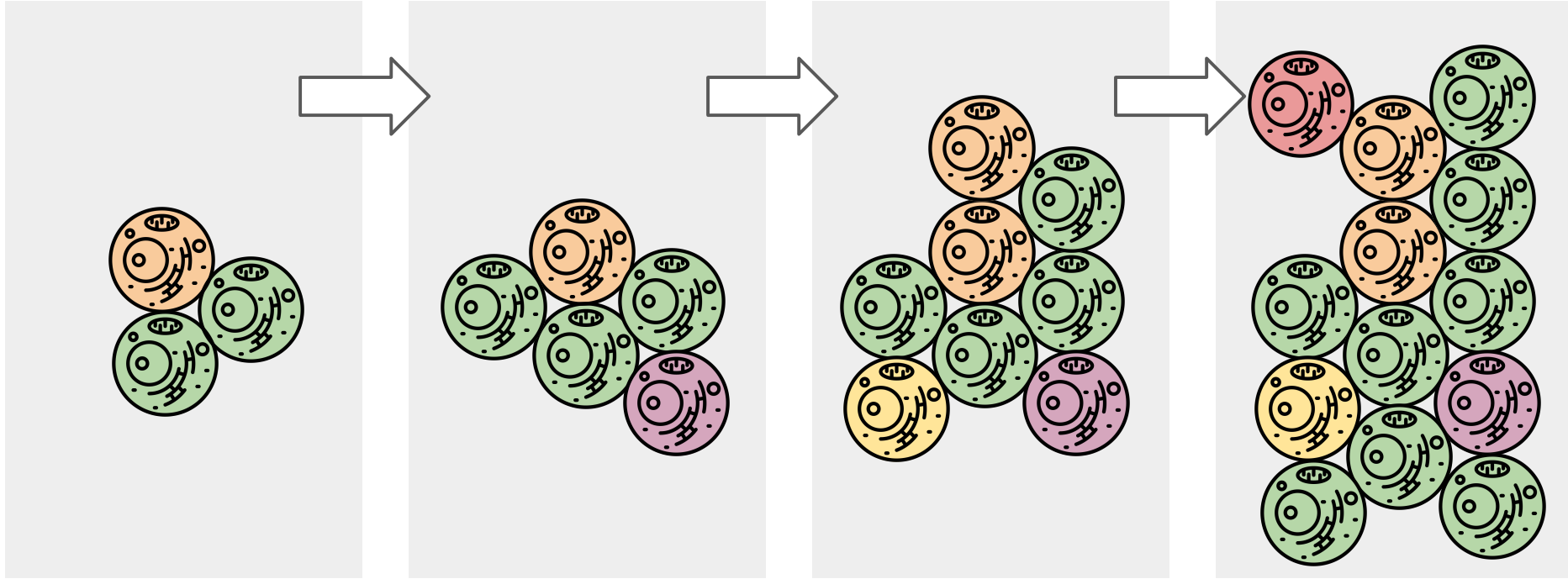


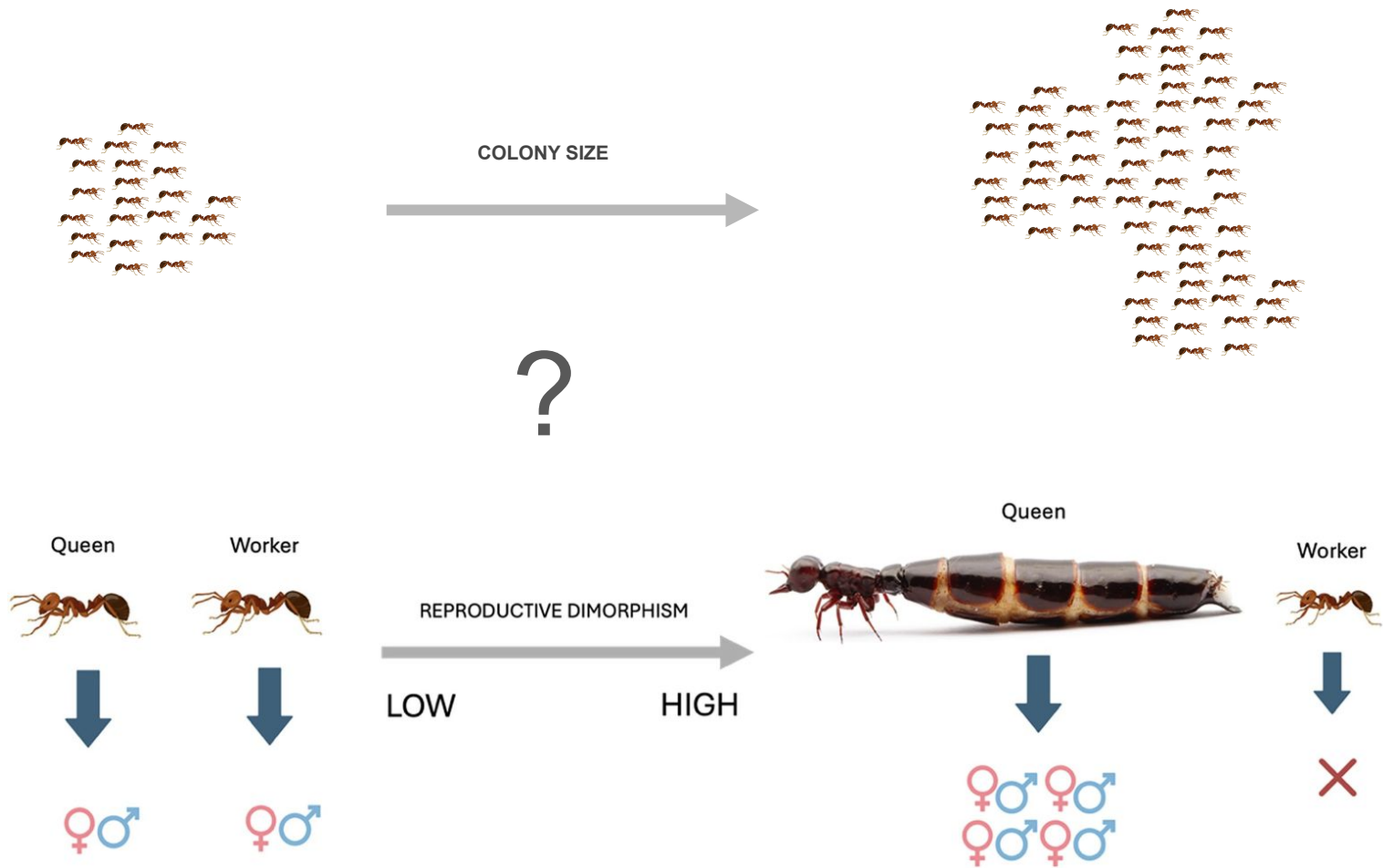
2. Worker - Queen Dimorphism



Why is reproductive labour divided?

The size-complexity hypothesis





Two Questions

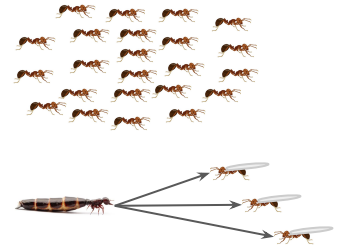
(1) How often has extreme reproductive division of labour evolved in ants?

(2) How is the evolution of reproductive division of labour caused by explanatory variables such as:

(a) colony size?

(b) the number of males that queens mate with (polyandry)?

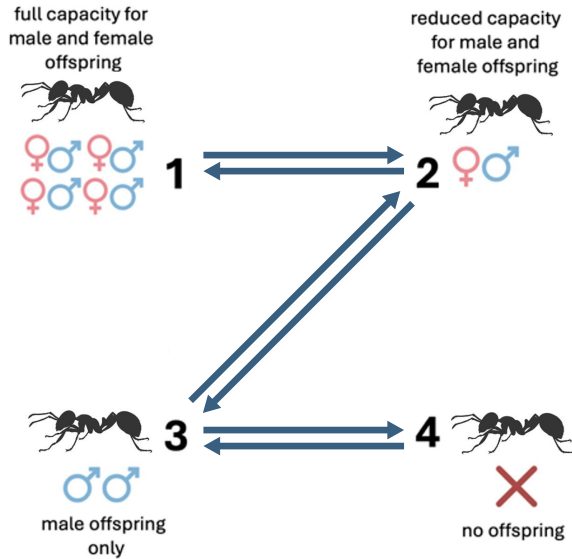
(c) the number of queens (polygyny)?



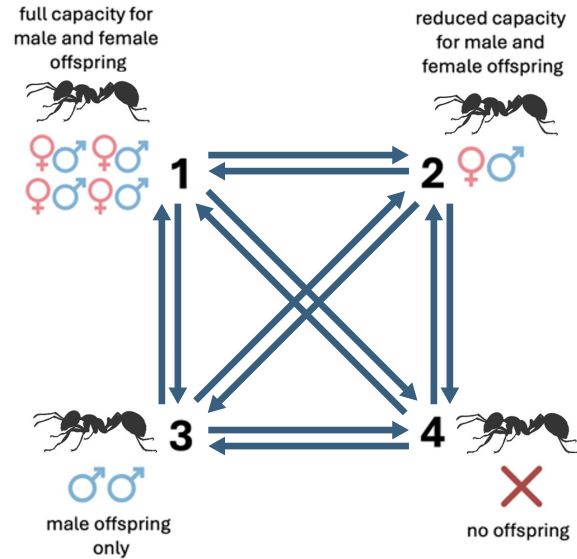
Methods & Results

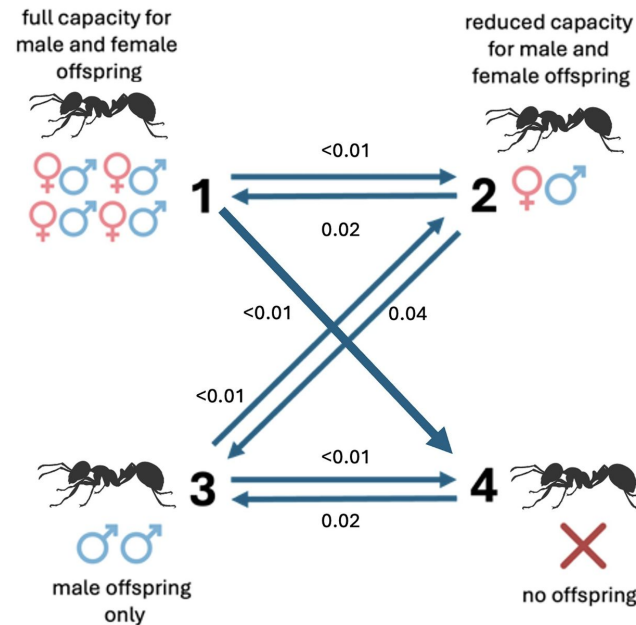
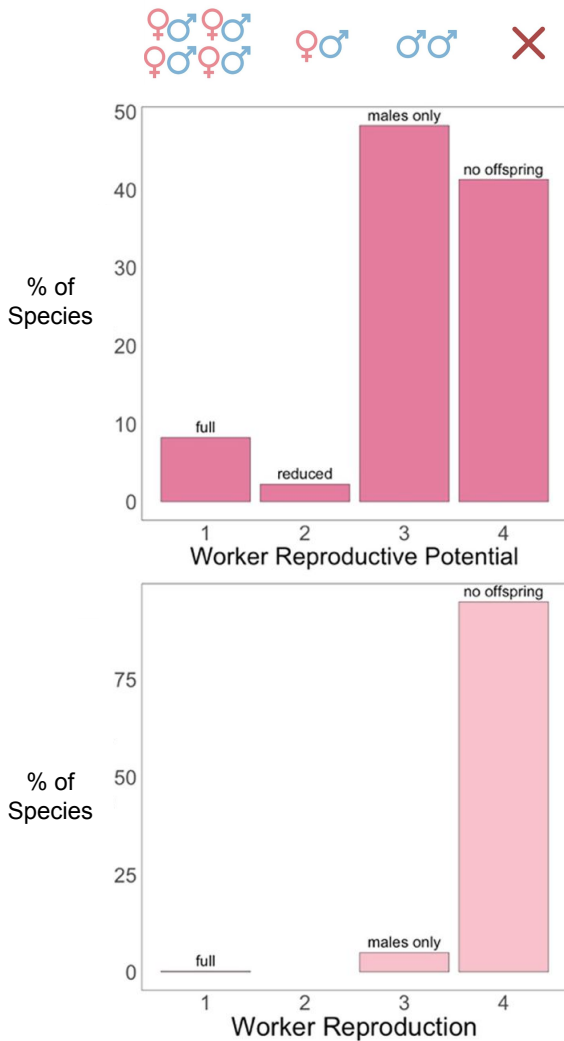
Does worker sterility evolve through a continuum?

H1: continuum of states



H2: non-ordinal states



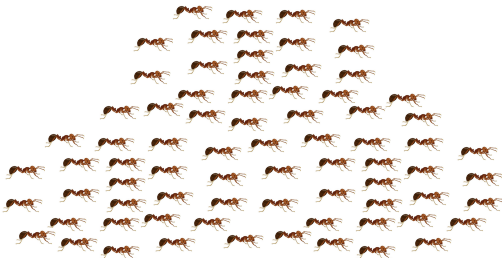


Worker sterility evolves along a continuum (mostly)

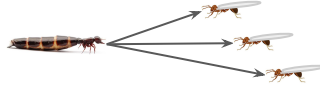
Though many species' workers *can* produce males, very few *do* produce males in natural colonies

Why does the division of reproductive labour evolve?

(a) colony size?



(b) the number of males that queens mate with (polyandry)?



(c) the number of queens (polygyny)?

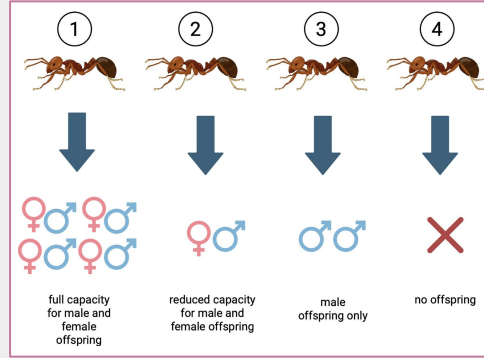


Three Approaches

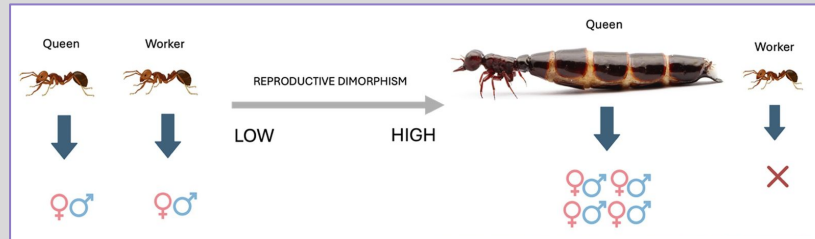
1. Phylogenetic Path Analysis
2. BayesTraits Test for Correlated Evolution
3. Ancestral State Reconstruction

Two Metrics for the Division of Reproductive Labour:

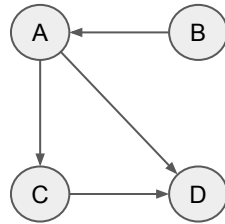
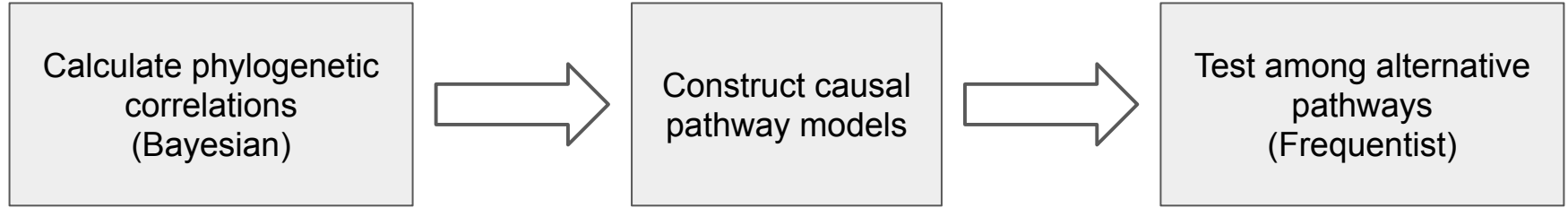
1. Why does Worker Sterility evolve?



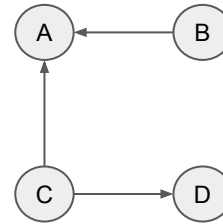
2. Why does Worker - Queen Dimorphism evolve?



Phylogenetic Path Analysis

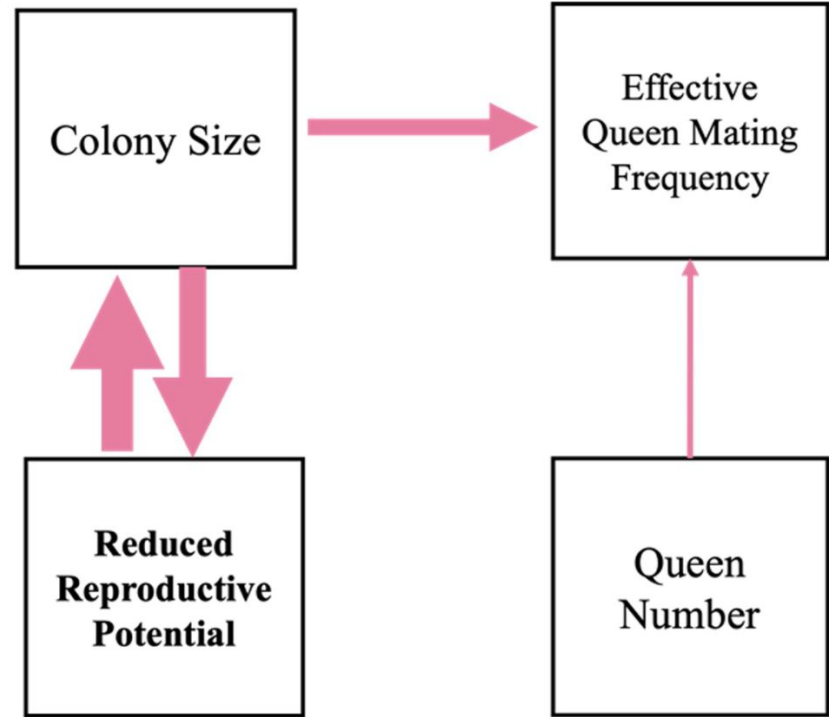


VS



Phylogenetic Path Analysis

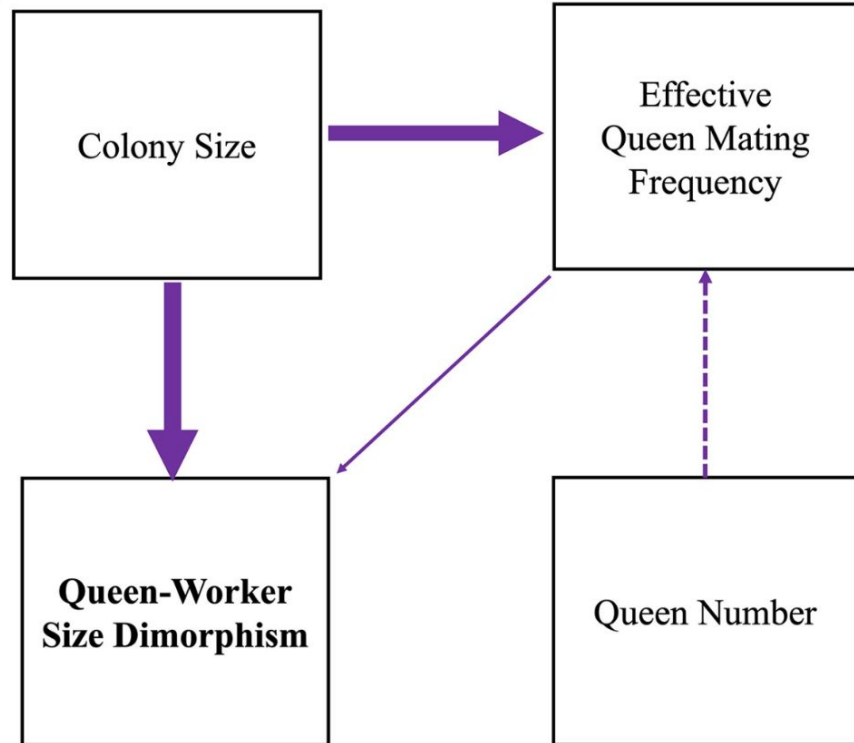
Why does Worker Sterility evolve?



Greater worker sterility may cause larger colony size. But, larger colony size could also cause greater worker sterility.

Phylogenetic Path Analysis

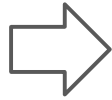
Why does Worker - Queen
Dimorphism evolve?



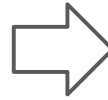
Larger colony sizes may directly *and* indirectly cause greater reproductive dimorphism.

BayesTraits Test for Correlated Evolution

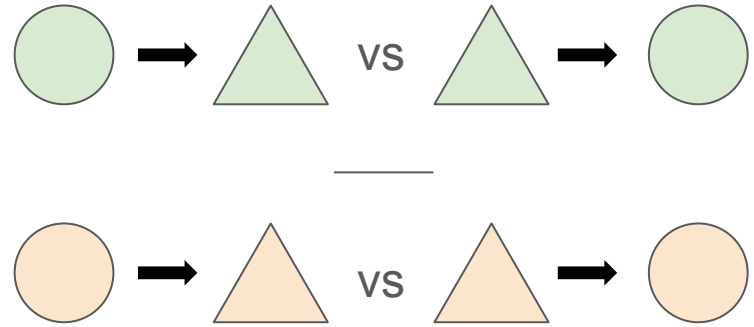
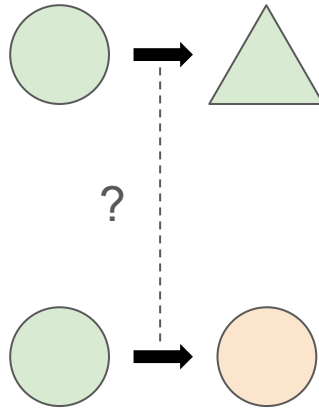
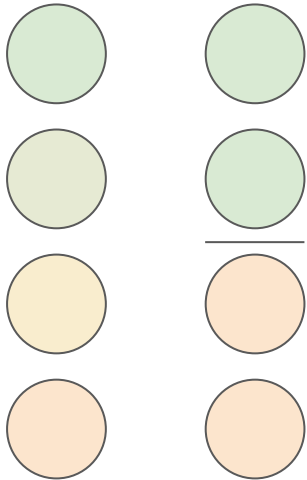
Make all traits binary



Compare models of dependent vs. independent evolution for pairs of traits

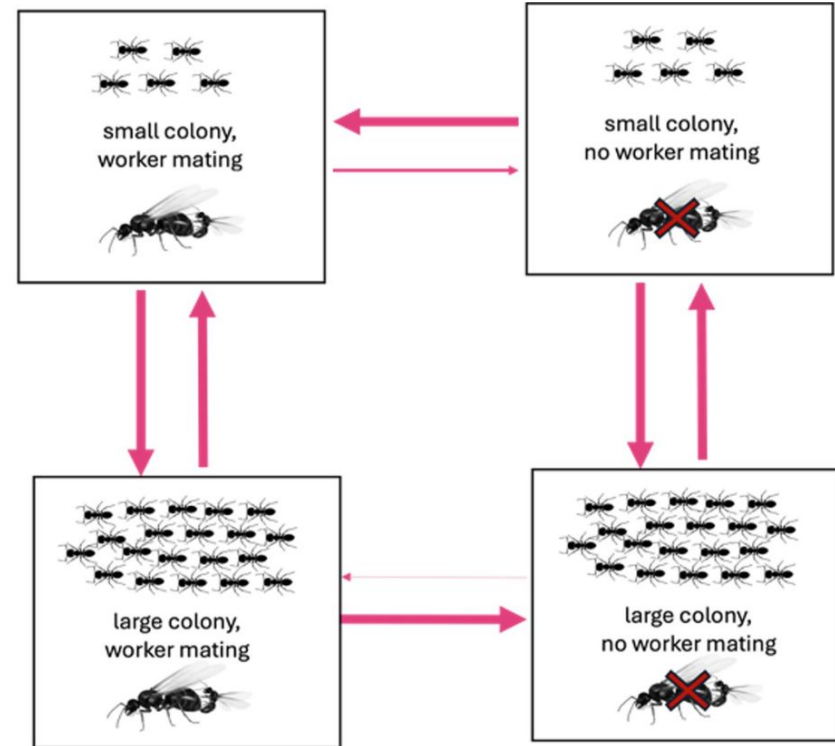


If dependent: compare frequency of $0 \rightarrow 1$ and $1 \rightarrow 0$ transitions in trait B when trait A is 0 vs 1.



BayesTraits Test for Correlated Evolution

Why does Worker Sterility evolve?

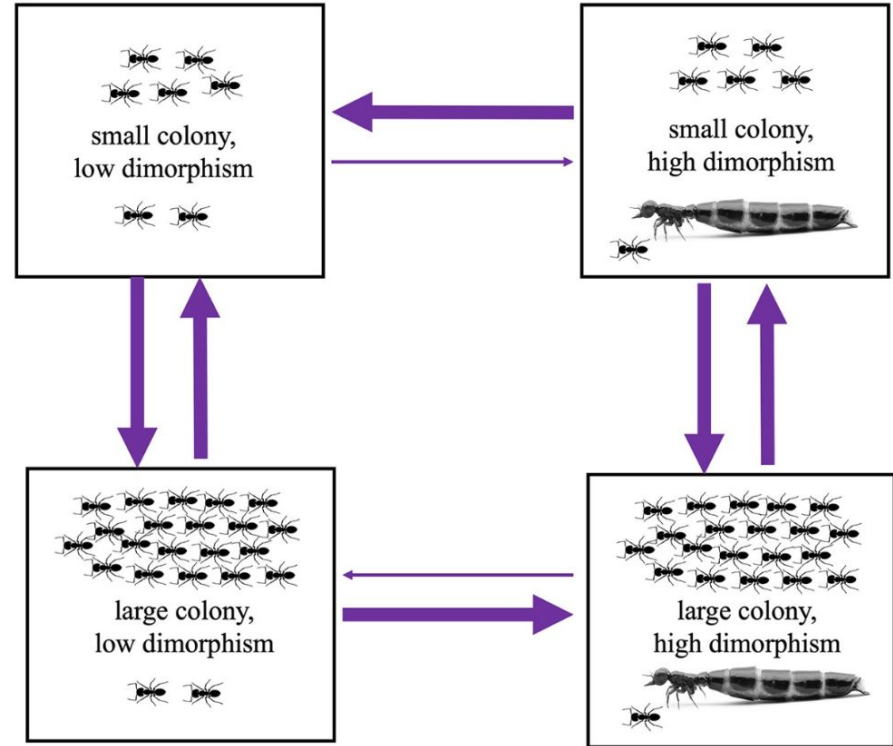


Worker mating is rarely gained in large colonies, and rarely lost in small colonies.

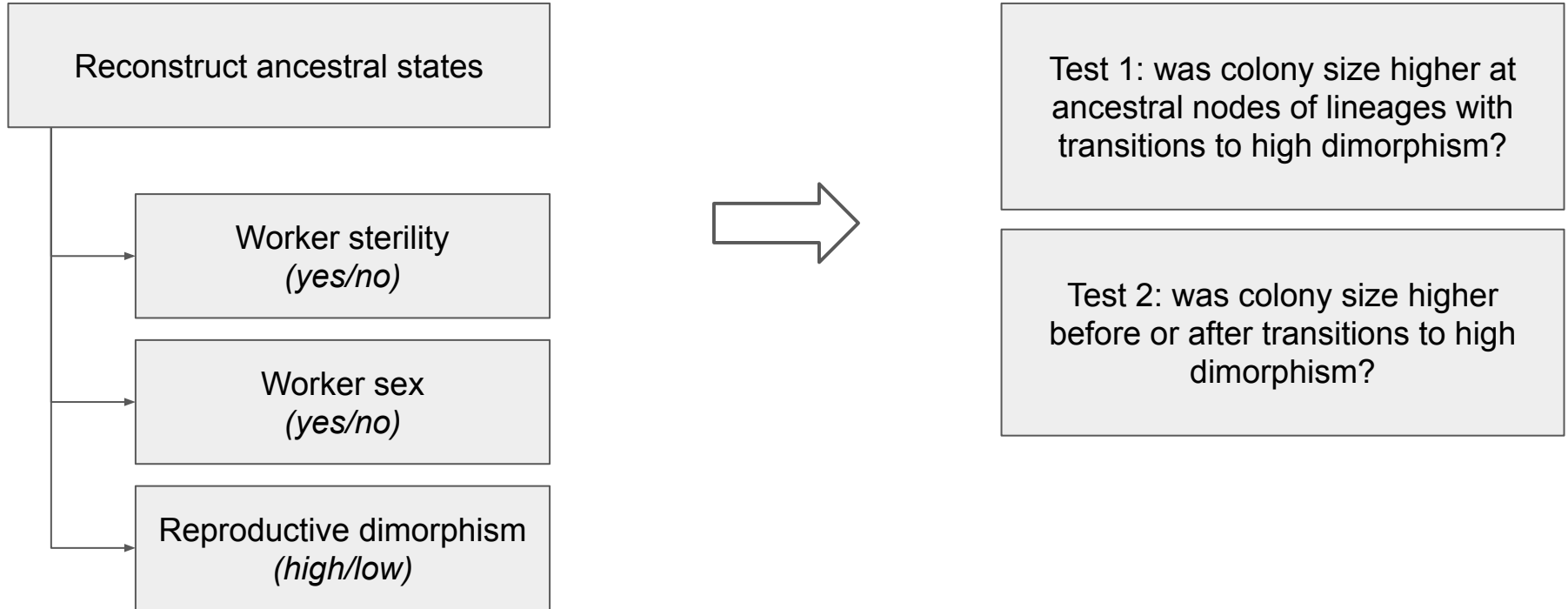
BayesTraits Test for Correlated Evolution

Why does Worker - Queen
Dimorphism evolve?

High dimorphism is rarely lost in large colonies, and rarely gained in small colonies.



Ancestral State Reconstruction

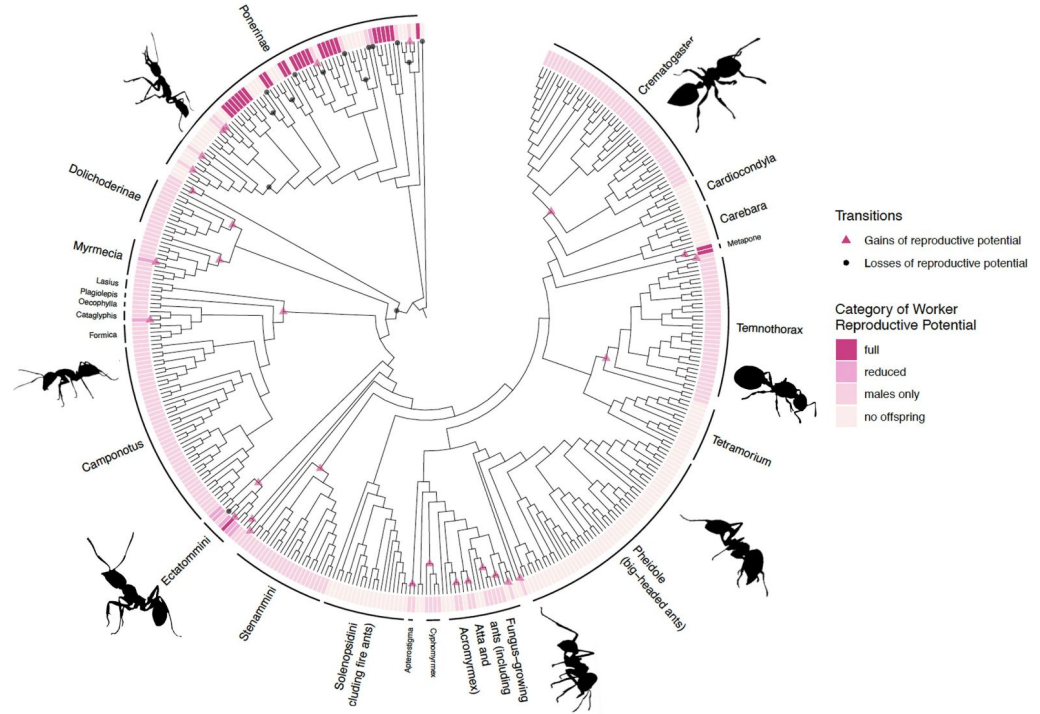


Ancestral State Reconstruction

Why does Worker Sterility evolve?

The ancestral ant worker was likely capable of reproduction, but did not reproduce under normal conditions.

The loss of reproductive potential was associated with larger colony size, but not significantly.

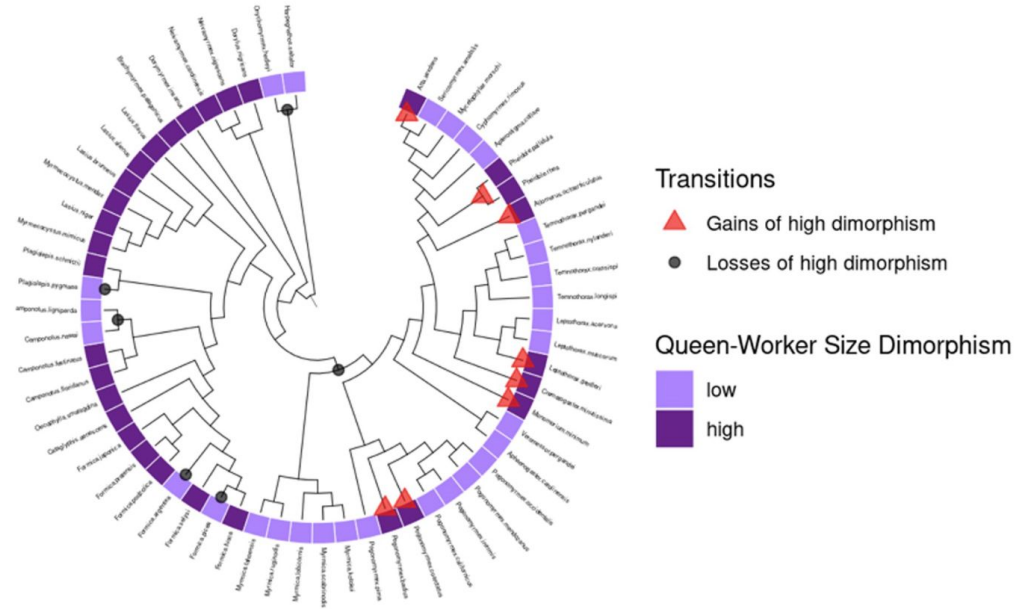


Ancestral State Reconstruction

Why does Worker - Queen Dimorphism evolve?

The ancestral ant species likely had high worker - queen dimorphism.

Gains of high dimorphism were associated with larger colony size, but not significantly.



Summary

- Reproductive labour was already divided in ancestral ants (high dimorphism & limited worker reproduction)
- Complexity is reversible - ants have frequently gained and lost reproductive division of labour
- Increasing reproductive division of labour is often associated with larger colony size, consistent with the size-complexity hypothesis

Main Strength

Uses multiple parallel lines of evidence to address causality

Main Caveats

Is this a justified use of path analysis to infer causality?

Some analyses required constricting continuous, discrete, or ordinal traits into artificial binary categories

Overall, is the evidence strong enough to conclude causality?

The
End

