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Explaining lazy workers in social insect colonies with evolutionary game theory

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In social insect colonies we often observe substantial levels of laziness, i.e., workers that do not engage or appear not to engage in any tasks. This is puzzling, because colonies with lazy individuals seem to be wasteful and may not be using their resources optimally. A common hypothesis is that lazy workers are a reserve workforce that can be quickly activated when rapid changes in the environment demand it.

We present an alternative explanation for laziness based on game theory. We assume that insects play a game in which they allocate their energy towards two competing tasks, foraging and temperature regulation. Both tasks need to be performed successfully for colony survival, thus the set-up reflects a coordination game.

The benefits of regulation are assumed to be concave and maximised at intermediate levels of task engagement. The benefits of foraging are assumed to be linear in effort. Benefits are shared by the whole colony, whereas costs are borne individually. Individuals learn to play this game by using social learning, and occasionally experimenting with new strategies. When experimentation is rare the population is monomorphous most of the time, and the learning trajectories of colonies can be modelled by using adaptive dynamics. Levels of laziness in the long run can be determined by studying the fixed points of the dynamics.

We find that the level of laziness crucially depends on the costs of performing the tasks. In particular, laziness can be stable under marginally increasing costs. Constant and marginally decreasing costs result in colonies without lazy individuals. Monte Carlo simulations show that our theoretical prediction is accurate under moderate levels of noise.

Our model is the first one to link specific ecological features to the puzzle of lazy workers. We discuss potential implications for empirical work and extensions of the model.

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