

# EXPLORING THE ROLE OF ALTRUISM WITH DYNAMIC BEEHIVE MODELS

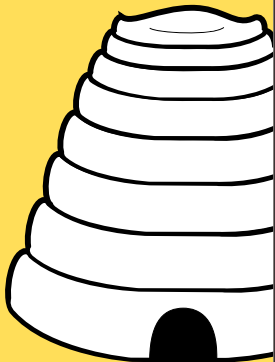
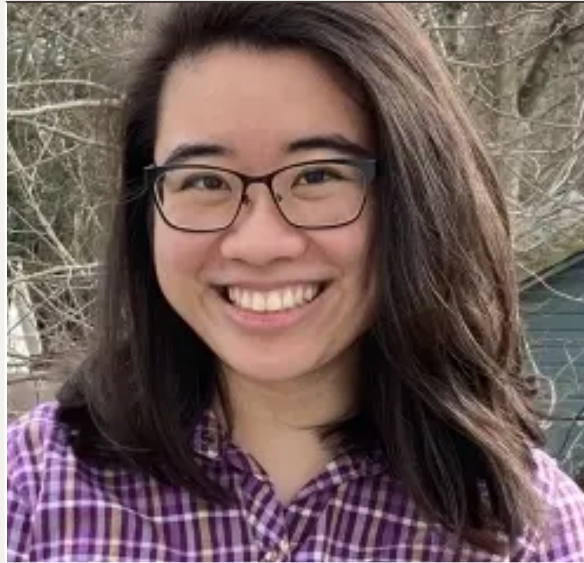
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In this work, we study the relationship between altruism and arrhenotoky in an evolutionary game theory (EGT) framework, using a dynamic model of beehive populations with three castes: workers, drones, and the queen. Arrhenotoky is a form of asexual reproduction characterized by the haplodiploid sex-determination system and exhibited by insects such as the Hymenoptera, including bees. In this context, altruism refers to actions taken by an organism that reduce its own fitness to increase the fitness of others. Eusociality, an extreme form of sociality characterized by overlapping generations, division of labor, and cooperative care of offspring, is also observed in the Hymenoptera. We employ an ordinary differential equation (ODE) model to simulate beehive populations over a range of parameters, controlling for altruism in workers and the queen. Our results show that altruistic behaviors are essential for beehive success, with optimal worker altruism corresponding to the division of labor observed in eusocial species. Furthermore, we find that modest altruism from the queen is also vital for hive survival, underscoring the delicate balance that sustains these complex social systems. Overall, our findings shed light on the co-evolution of altruism, arrhenotoky, and eusociality in the natural world.



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Olivia Chu is a Neukom Institute Postdoctoral Fellow and Lecturer in the Department of Mathematics at Dartmouth College. Her research focuses on the dynamics of behavior, in both human and animal populations, and in particular, the effects that different forms of heterogeneity have on these dynamics. She explores questions relating to: cooperation within and between groups; personality and its role in social integration; the dynamics of power; the rule of law; puzzling altruistic behavior in animal communities; plant community dynamics; and polarization in an increasingly divided world. She uses a combination of mathematical modeling, computational simulations, and data collection to answer these questions, and aims to gain insight into how we might be able to make our world (or at least our own social networks) more cooperative, kind, and fair. Olivia also serves as a mentor for a wide range of undergraduate research projects across math, biology, computer science, and quantitative social science. Prior to coming to Dartmouth, she received a B.A. in Mathematics from NYU and a Ph.D. in Quantitative and Computational Biology from Princeton. She is very excited to join the Department of Mathematics at Bryn Mawr College in Fall 2024!