Events calendar: Mathematics & Statistics

Wed, Jan 14, 2026

FREE

MATHEMATICS & STATISTICS

Master's Defense: Bee Determined: A Mathematical Analysis of Trapline Formation in Bees

9:00am - 10:30am PST (10:00am - 11:30am MST)

Mathematics & Statistics

Speaker: Ferdinand Gruenenwald
Location: Hybrid

Examining Committee

Supervisory Committee

- Dr. Mark Lewis, Department of Mathematics and Statistics, University of Victoria (Supervisor)
- Dr. Eric Foxall, Department of Computer Science, Mathematics, Physics and Statistics, University of British Columbia (Outside Member)

External Examiner

- Dr. Junling Ma, Department of Mathematics and Statistics, UVic

Chair of Oral Examination

- Dr. Amy Verdun, Department of Political Science, UVic

Abstract

Traplining is a behaviour where animals visit stationary, renewing food sources in a repetitive, non-random order, like a trapper visiting their traps. Reynolds, Lihoreau and Dubois et al. developed biologically plausible models for how traplining might emerge as a result of a simple iterative improvement foraging strategy of bumblebees [44, 31, 14]. While these models have been investigated extensively empirically through simulations, a theoretical understanding of their properties has not yet been determined, and these models have never been fit to data directly. We address both of these research gaps.

In Chapter 1 we provide a mathematically rigorous description of the model, framing it as a version of an edge-reinforced random walk. We show that the model outlined by Reynolds et al. can give rise to stable traplining behaviour where simulated bees visit the same set of flowers in the same order at all large times. In fact, under the additional assumption that simulated bees do not visit any flower twice within the same foraging excursion, also called a bout, we show that the process is guaranteed to converge to a stable trapline eventually. We argue further that the model bridges a gap between two seemingly competing hypotheses for how traplines form in bee foraging behaviour, the nearest neighbour-hypothesis and the order of encounter-hypothesis. The nearest neighbour hypothesis says that bees prefer to fly to the nearest neighbour, whereas the order of encounter hypothesis claims that bees simply retrace their steps. We argue that when bees imperfectly retrace their steps, only weakly reinforcing each step, the resulting trapline is more likely to be the nearest neighbour route and under strong reinforcement, the resulting trapline is more likely to resemble the order of encounters.

In Chapter 2, we fit these models to flower visitation sequence data. Using a simulation study, we verify that we are able to accurately retrieve model parameters and distinguish among several candidate models. We apply these methods to real flower visitation sequence data collected by [53]. We are able to show that bees tend to retrace their steps and seem to be able to remember entire bouts. We find that linear reinforcement better models bee learning than exponential reinforcement, indicating that bees might not converge to the stable traplines previously hypothesized.