Collective problem solving in ants

Ant colonies embody all of the most important aspects of biological organization. In simple terms they are more than the sum of their parts and they are robust flexible systems that are capable of self repair. The fundamental advantage of ant colonies as experimental biological materials is that they can be quickly taken apart and rapidly and easily put together again. This is the reason why we study ant colonies rather than natural neural networks which exhibit similar capabilities but can be experimentally intractable.

Our recent studies have begun to demonstrate the algorithmic basis of the self organization of ant colonies. Our focus is on the simple rules of interaction among worker ants that generate complexity and sophistication at the level of the colony. We have developed mathematical models that show how the interaction of simple rules at the microscopic level (individual workers) can generate complexity at the macroscopic level (the colony). These mathematical models of self organisation, often in the form of non-linear differential equations have been experimentally verified. We have shown that the ability of ants to generate spatial structures in their societies is critical to their organisation. This work has been made possible by our development of dynamic, digital, image analysis systems. These systems are some of the most sophisticated of their kind used anywhere in the study of animal behaviour.

Our research into the collective intelligence of ant colonies has been supported not just by biological funding sources but those from both the academic and industrial computer science communities. Other aspects of our research runs over the entire spectrum of ant studies from pheromone chemistry, through the study of the influence of kin selection on life history evolution, to the structure and conservation of ecological communities particularly in tropical rain forest.

Activities / Findings

We have shown that tandem running, a one-to-one form of recruitment in ants, qualifies, according to a strict definition, as a type of teaching. We have also shown that such teaching can involve three different forms of evaluation and that the tandem followers (i.e. the pupils) can extrapolate from incomplete tandem runs (partial lessons) and can exhibit a very sophisticated search for their lost leader. This involves first a sub-diffusive search whilst the leader is likely to nearby and then a super-diffusive search when they are on their own.

We also investigating collective decision-making in ant colonies choosing new nest sites and are examining the role of individual and public information in this system and the extent to which comparisons between nest sites occur only at the colony-level and not by individual workers.

We have also pioneered the use of RFID tags in such studies and in analyses of the division of labour.

Teaching

- Sole Teacher on “Behaviour and Ecology of Social Insects” Level 3 course Biology.
- Contribute to Level 2 “Acquisition of Behaviour” Course.
• Level 2 co-ordinator and Field Course and Laboratory Workshop Co-ordinator.

Keywords
• Decision-making
• complex systems
• self-organisation
• mathematical biology

Processes and functions
• Distributed decision-making

Methodologies
• Video tracking
• computer vision
• RFID tagging

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Recent publications
• Baddeley, RJ, Franks, NR & Hunt, ER, 2018, 'The Bayesian Superorganism II: optimal foraging and the information theory of gambling'. bioRxiv.
• Richardson, TO, Giuggioli, L, Franks, NR & Sendova-Franks, AB, 2017, 'Measuring site fidelity and spatial segregation within animal societies'. Methods in Ecology and Evolution, vol 8., pp. 965-975

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