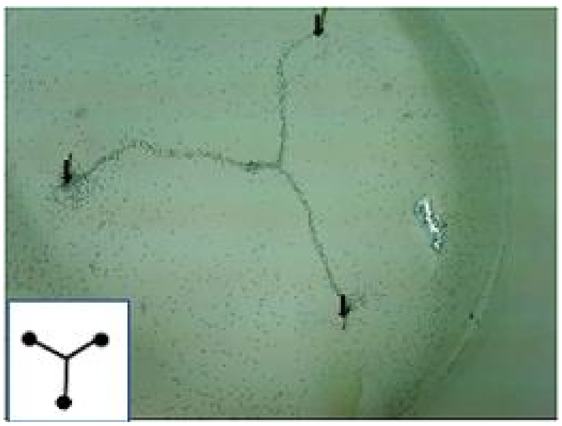
Leader-less ants make super efficient networks

February 11 2011



Argentine ants connect three nests in an empty arena via the shortest possible network. The ants have created a difficult Steiner network by adding an extra hub in the centre of the triangle, thus creating the network of absolute shortest trail length. The computer generated Steiner network for three nests is depicted in the square inset. Credit: Tanya Latty

(PhysOrg.com) -- Ants are able to connect multiple sites in the shortest possible way, and in doing so, create efficient transport networks, according to a University of Sydney study published in the Journal of the Royal Society Interface.

The research also revealed the process by which the ants solve network design problems without the help of a leader.

Dr. Tanya Latty, principal author from the School of Biological Sciences said the ants make as many trails as possible, then prune them back to the most efficient configuration.

"The findings sheds light on how other 'simple' natural systems without leaders or even brains - such as fungi, slime molds and mammalian vascular systems - are able to form efficient networks, and can help humans design artificial networks in situations lacking central control," she said.

"Engineers and urban planners face the task of designing efficient and cost effective networks. Building longer roads or tracks requires more resources and is therefore more costly, so a challenge for engineers is to design transportation networks that minimise resource use while still maintaining connectivity between sites such as cities or stations.

"Argentine ants face the same dilemma as transport engineers. This species of ant is a highly invasive pest in many countries because it can form super colonies that consist of thousands of nests connected by a network of pheromone trails. Because longer trails require more pheromone to build and maintain, the ants would benefit greatly from building efficient networks with the shortest possible trail length."

University of Sydney Associate Professor Madeleine Beekman, and co-author, who worked with the team of researchers from the University of Leipzig, Hiroshima University, Hokkaido Future University and University of Uppsala said the team posed the following question.

"Are ants able to solve this network efficiency problem given they have no leader, planner or anybody with global knowledge of the whole environment? And if so, how do they do it?" she said.

To see whether Argentine ants (Linepithima humile) could create internest networks that minimized trail length, the researchers gave ants the task of connecting three or four nests together. The nests were placed in an empty arena and the ants were allowed to connect them in any way possible. After two hours, the resulting ant networks were photographed and compared to computer-generated images of networks that used the shortest trail length.

For each treatment, there were only two 'efficient' solutions that resulted in the shortest networks: the Minimal Spanning Tree, which connected the nests in the shortest way without adding an extra hub; and the Steiner Network, which used added hubs to connect the nests in the absolute shortest trail length. The Minimal Spanning tree is the simplest solution, but the Steiner network, with its added hubs, represents the most difficult but ultimately the most efficient route.

After two hours, the ants had created networks that closely resembled both efficient solutions. They frequently created difficult Steiner Networks, adding a central hub in the three-nest treatment and two central hubs in the four-nest treatment.

Dr. Latty said: "It's interesting that the ants were able to create, on a blank slate, the mathematically shortest network between multiple points. This network design allows Argentine ants to distribute brood, workers and food between nests with extreme efficiency, and might help explain why they viciously out-compete other ant species outside their native home of South America.

"But just because the ants are as good as computers at solving network design problems, doesn't mean that they use complex processes. We videotaped the ants forming their networks to work out exactly how they create this efficient solution, and found that networks formed through trial and error. Initially, ants built inefficient networks that had many redundant trails and dead ends but over the next few hours, redundant trails gradually disappeared until the network reached its final, efficient configuration.

"So even though the ant colony seems to behave intelligently, the ants are simple individuals following even simpler rules. Understanding how simple organisms like ants build efficient networks can inform the design of human transportation networks."

Provided by University of Sydney