More Fun Than Fun: What Can We Learn from Insect Societies?

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Thomas D. Seeley learning from honey bees. Photo: Thomas Seeley.

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This article is part of the 'More Fun Than Fun' column by Prof Raghavendra Gadagkar. He will explore interesting research papers or books and, while placing them in context, make them accessible to a wide readership.

Many insects such as ants, bees, wasps and termites organise themselves into societies with division of labour, communication, conflict, cooperation and altruism. Insect societies resemble human societies in many ways and are arguably more efficient than ours in some ways. They sustainably harvest environmental resources, engineer their environments both inside and outside their nests, practice agriculture, fight disease with a combination of individual and social immunity, organise social hunting parties, navigate their environment using terrestrial and celestial cues and majorly influence the evolutionary trajectories of other organisms such as flowering plants.

They do all this with brains the size of a pinhead and without a leader, by harnessing the power of self-organisation and social intelligence. They have earned the name 'superorganism' and are among the most ecologically dominant species on the planet.

So, can we humans not learn anything from insect societies? Well, there are difficulties, not so much to do with them but with ourselves. But perhaps we can overcome these problems, especially if we can recognise and learn from our past mistakes.

The naturalistic fallacy

When we justify human behaviour and our social and moral norms based on what we see in nature, we are said to commit the *naturalistic fallacy*. This is considered a fallacy because it is believed that there is a neither logical nor a moral justification for the argument that what is seen in nature ought to be what we should ourselves be doing. There is also a practical problem in using nature as a guide. We find everything in nature, the good, the bad and the ugly. We can find suitable examples in nature to justify anything we want – monarchy, slavery, murder, matricide, fratricide, infanticide, siblicide or, if we so wish, democracy, socialism, egalitarianism, altruism, self-sacrifice… you name it.

Distinguished philosophers of the 18th and 19th centuries such as Immanuel Kant, David Hume and John Stuart Mill have cautioned against committing the naturalistic fallacy, while some contemporary philosophers have taken a position against appealing to nature altogether, and suggested that we stick to human nature alone. Having studied insects societies all my life, I am, of course, enamoured by them, and can't help thinking that it would be such a shame to ignore them altogether.

I hope that we can find a middle ground so that we can learn from insect societies without suffering the ill-effects of the naturalistic fallacy. My prescription is that we should always decide what we wish to do, on our own, unmindful of whether we find it in nature or not, whether animals do the same or not. Having made a decision, however, it is often useful to turn to nature to learn how to do it well. Let us begin with some relatively non-controversial examples.

Ant colony optimisation

Ants are smart enough to choose the shortest path from among those available to traverse between their nest and food source. With a landmark experiment in 1989, Jean-Louis Deneubourg from the Unit of Behavioural Ecology at the University of Brussels and his colleagues discovered how they do so. Not by the intelligence of individual ants, but simply by all ants following the pheromone trails of others and laying trails of their own, without any plan, goal, leader or knowledge of the lengths of different paths. Such self-organised, emergent behaviour is now known to be the secret behind the mind-bogglingly complex behaviour of tiny-brained members of insect societies.

Imitating the ants' simple behaviour, Marco Dorigo and his colleagues from the Artificial Intelligence Research Laboratory in the University of Brussels, invented many efficient algorithms for computer programmes that have now developed into the sub-field of computer science called ant colony optimisation (AOL). AOL, based on learning from insect societies, has since been applied to solve many real-life problems including, the travelling salesman problem, adaptive routing in communication networks, distributed algorithms for data clustering, dynamic resource sharing, graph colouring, machine scheduling, vehicle routing, sequence learning, and machine learning.

Aerial robotics

A natural honey bee nest is shown on the left. The tree housing the nest has been split open, to reveal the combs containing honey (above) and brood (below). The entrance hole, 5 cm wide and 8 cm tall, is on the left, about two-thirds of the way up the cavity and is enlarged on the right some of the bees inside. Photos: Thomas Seeley

Honey bee foragers return home and recruit their naïve sisters to help transport the nectar and pollen they have found. They do so through a dance language in which they communicate the distance and direction to the food source. But how do the foragers estimate the distance they have flown, in the first place?

Mandyam Srinivasan, then at the Australian National University in Canberra, and his colleagues showed using a deceptively simple experiment that honey bees estimate distance flown by measuring the extent of backward flow of the image of their environment in their visual field, on their eyes. They made bees fly through a narrow tunnel and measured the extent to which they overestimated the distance flown because of the increased optic flow caused by the nearness of the bee's surroundings in the tunnel as compared to the natural environment. Today such principles of navigation learned from the honey bees are being used to engineer, guide and navigate unmanned aerial vehicles.

Ant and termite agriculture

Insect societies such as those of ants and termites have been practising agriculture for over 50 million years. Leaf-cutter ants in the New World tropics, for example, harvest leaves and use them to grow specific fungi so that the tens of thousands and sometimes millions of colony members rely entirely on their agriculture produce for their nutrition. Like in our own agriculture, the ants face problems associated with loss of soil fertility and disease spread in their monoculture gardens. The ants have evolved many effective strategies to deal with these problems.

Ulrich Mueller from the University of Texas in Austin and his colleagues who have long studied ant agriculture discovered many fundamental similarities and differences between ant and human agriculture. They thus derived several lessons that we may learn from the ants. In particular, the most important lessons to be learned concern how the ants (through the process of natural selection) carefully choose and manage their microbial consortia beneficial for nutrient uptake and disease resistance. We have a long way to go, to match their efficiency in this matter.

Let us now move on from these relatively easy-to-accept examples to a potentially more controversial and contentious territory. Can we, and should we, learn from insect societies about how to conduct ourselves in social and political matters. This is a territory with potentially dangerous landmines. It is in such matters that the naturalistic fallacy can, and has been, most pernicious. As I work on conflict and cooperation in insect societies and often give public lectures entitled 'War and Peace', I am frequently asked whether we can learn from insect societies. I am always cautious and say that 'we should not blindly imitate insect societies' and go no further than to claim that 'insect societies hold a mirror to us and help us understand ourselves better'.

House-hunting honey bees

And yet, I am now convinced that there is at least one area in which we have an excellent opportunity to imitate insect societies without suffering the ill effects of the naturalistic fallacy. Honey bee colonies comprise a single fertile queen bee and tens of thousands of sterile worker bees. When a daughter colony is produced, the mother queen leaves her nest with a fraction of the workers to build a new nest, leaving the old nest, with the remaining workers, the brood, honey and pollen reserves for her daughter queen to make a start in life. The mother queen and her entourage of workers first settle in a cluster nearby and may remain there from a few hours to a few days. From this 'swarm' a few scout bees will fly out in search of suitable cavities to build a new nest.

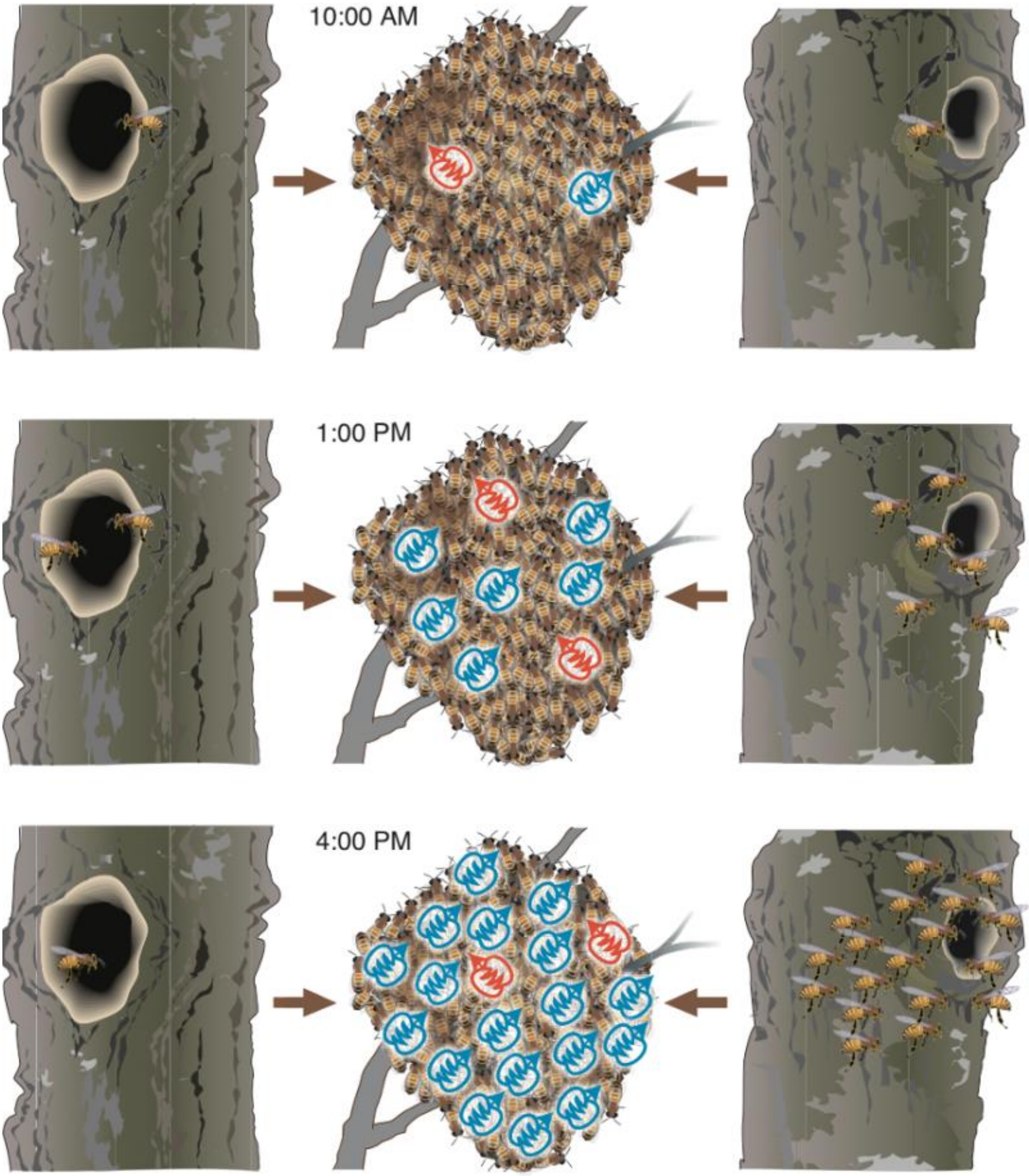
Worker bees labelled for individual identification. Photo: Thomas Seeley

Scout bees will periodically return to the swarm. Using the same dance language that foragers use to indicate food sources, they will advertise their find, indicating the distance and direction to the potential new nesting site. While the German Zoologist Karl von Frisch discovered the dance language of the bees, his illustrious student Martin Lindauer discovered that the bees use the same dance to relocate to a new nesting site.

When multiple foragers advertise different food sources, different groups of hive bees can go to different food sites and harvest the nectar or pollen. But when multiple scouts advertise different potential nesting sites, as they always do, there is a real problem, because all the bees have to eventually go to a single location, and hopefully, to the best site among those on offer. How they accomplish this no mean task, has been the subject of long-term passionate research by Thomas D. Seeley, of the Department of Neurobiology and Behaviour at Cornell University, Ithaca, New York. In the words of Seeley, “These homeless insects will do something truly amazing; they will hold a democratic debate to choose their new home.”

Collective decision making

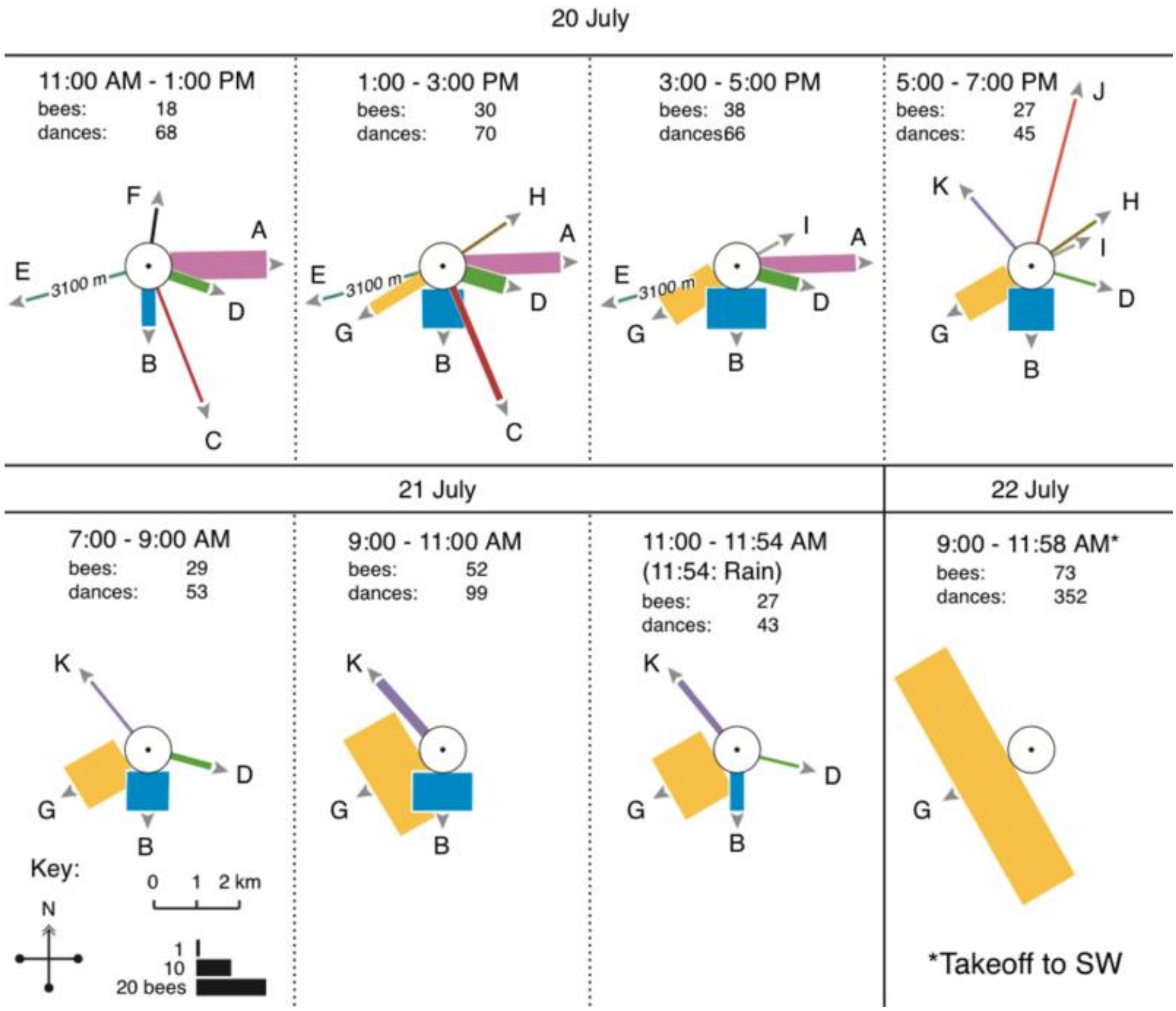
Although several scout bees will dance to advertise the site they have each found, the strength of their dances (i.e. the number of times they will perform their waggle circuits) is proportional to their assessment of the absolute quality of the sites they have found. A good site will elicit a strong dance and result in more dance followers who will visit that site and return to perform even more strong dances. A poor site will elicit a weak dance and result in fewer followers who will visit that site and return to perform weak dances. Hence, the number of bees that will dance in favour of the good and poor sites will increase and decrease exponentially.



A schematic showing how bees arrive at a consensus (see text for details). Image: Thomas Seeley

The debates can be quite intense and prolonged with the popularity of the various sites waxing and waning over several days. Still, the bees almost always converge successfully on a single site and almost always on the best available site. Once a consensus is reached, scouts who are most familiar with the winning site invite and lead the whole group to their new home by making piping sounds at the swarm and releasing pheromones at the destination.

Two habits of the bees impressed me most. One, their decision is based on attaining a quorum and not necessarily a consensus. This means that a single stubborn bee cannot hold the group to ransom, endlessly delaying the decision. Second, bees whose initial sites fall out of favour retire from the competition and let others decide whether to persist advertising for their site or not – "if you don't like my site, so be it". It is easy to see how the combination of these two strategies can greatly facilitate making quick and accurate decisions. It is equally easy to recall occasions when the absence of these strategies has prevented us humans from making decisions efficiently!



An example of how honey bees reached a consensus to go to site G after much debate, spread over two days, over eleven potential nesting sites (A through K) and especially prolonged competition between sites B and G. Image: Thomas Seeley

Town meetings

In his treatise boldly entitled *Honeybee Democracy*, Seeley has described in fascinating detail the sequence of events in the honey bees' democratic decision-making process and compared it to our own democratic decision-making. He uses traditional New England town meetings as a springboard for his comparison with human societies. Seeley tells us, "Once a year, on Town Meeting Day – traditionally the Tuesday following the first Monday in March – the citizens in a town come together in an open, face-to-face assembly and render binding collective decisions (laws) that govern the actions of everyone in their town." Seeley draws five compelling lessons by comparing town meetings with honey bee swarms, and I will quote him below:

1. Compose the decision-making group of individuals with shared interests and mutual respect.
2. Minimise the leader's influence on the group's thinking.
3. Seek diverse solutions to the problem.
4. Aggregate the group's knowledge through debate.
5. Use quorum responses for cohesion, accuracy and speed.

In the final chapter of his book, Seeley shows how these five principles are adopted by both his town and his bees and why they work so well.

A worker bee exposing her scent organ and tipping down the last segment of her abdomen to discharge pheromones to attract bees in the swarm and guide them to move in the direction of the new nest site. Photo: Thomas Seeley

Departmental faculty meetings

As if this were not charming enough, Seeley tells us how he himself adopted these "Five Habits of Effective Groups", as he calls them, in conducting faculty meetings in his department. In what is perhaps the most thought-provoking discussion in his book, Seeley tells us how the honey bees, Mr Larry Coffin, "the gentleman who has served for nearly four decades as the moderator of town meetings in Bradford, Vermont" and Seeley all use the same five principles to make efficient and conflict-free decisions.

Let's not throw out the baby with the bath water

There are over ten million biological species out there, each with potentially something to teach us. And natural selection has worked tirelessly for over 1.8 billion years to shape them and endow them with diverse and exquisite properties. The Harvard biologist Edward O. Wilson has coined the inspiring term 'Biophilia' to describe our "innate tendency to focus on life and lifelike processes". His profound little book with this one-word title is the source of much wisdom: "the million-year history of Jerusalem is at least as compelling as its past three thousand years … Humanity is exalted not because we are so far above other living creatures, but because knowing them well elevates the very concept of life."

Do we really want to be so against nature that we shut ourselves in a corner and ignore all other species as potential sources of knowledge and wisdom, just because we are afraid that someone will draw the wrong lessons and harm fellow human beings? We can't shut ourselves in a corner, even if we want to, because there is no corner outside nature – we are an integral part of nature. Besides, it would not behove the most intelligent species on the planet to be so terrified of what we might discover about our co-inhabitants. Let us have the self-confidence to raise our children to love fellow human beings and the rest of nature in equal measure, and have the sapience to distinguish right from wrong.

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