Honeybee Democracy by Thomas D. Seeley (Princeton University Press 2010)

This book addresses an intriguing question. We know that once a swarm has decided then off they go making a bee-line to their new site. They know where to go and they all go. A decision for all on a unique site has been reached. How does an insect manage such a group decision? When foraging we know bees perform a waggle-dance when returning to the hive. That dance combines information on distance/direction/quality of forage but it doesn't especially matter if bees forage in different sites, indeed there may be advantages. However, if bees split and go to different nesting sites they are going to be in trouble. Furthermore it is not about finding any old site; they have to find the best possible site. The 'best possible' will involve a number of variables and would need to be found in a wide geographic area if 'best' is to mean anything. The greater the search area the better nesting site they will find.

To understand the difficulty we could suppose all the bees in the swarm go together to find a site. All the bees would have to cover the search area. That's a lot of bee distance (i.e. number of bees x distance travelled) for things to go wrong in. It would also have to include the queen making the journey, surely not a good strategy for successful reproduction of the hive? How anyway would they decide between sites? Could they somehow score a first site for its desirability? Then they are off again.. another site?...another site? ..and so on. How many sites? Would they remember the scores to compare? And where, anyway, was that third site they visited that had such a good score? This is a difficult problem for bee biology to solve… maybe they could just choose the first site that meets some minimal standards ... that would solve a lot of problems but all the bees would be travelling and they would be subject to the vagaries of the first site that fitted the criteria to the minimum standard. That would still be a lot of bee distance. Another possibility would be the queen doing the search but if that was the case she'd be risking the life of the future hive as she searched. For that strategy the hive would probably be better off producing many queen bees so covering the probability of deaths but then the hive couldn't accompany all the queen bees. That strategy would require each queen, if she survived, to set up her new hive from scratch. Indeed, that is what ants, wasps and bumble bees do. This is why bees are so extraordinary. The level of coordination required for the single queen swarm of the honey

bee is considerably more than for a nest that produces many queens. How can the queen swarm be worth it? More fascinating though is how it is even possible?

Our honey bees must have a way of making decisions that produces a consensus that all bees stick to; it must give the swarm a decent chance of survival, and in doing this it should economise on the energy and risks involved in bee distance including travel by the queen. Furthermore, there is no standard best site out there for bees, different sites have to be assessed, information has to be produced and then passed on to other bees. Then each site will somehow be rejected or, for one, selected. This could be put differently: bees have to make an intelligent decision. A bee however is not intelligent. They act according to instinctive patterns that can change given certain signals or triggers. If you give a bunch of bees queen cups they make queens. If you give them a supersedural cell they will take it as giving them a queen. It is because they act on instinct that beekeepers can not only manage them but also pass on to others the knowledge of how to do so. Yet somehow our little sisters make an intelligent decision!

In *Bee Democracy* Thomas Seeley sets out not just how bees do this but also shows how he works this out. He tells us the process of finding out by careful experiment by which he and his researchers could work out what the bees do. This is fascinating since we are not just told the results but also the kind of research that could be open to any beekeeper.

Of course he has some advantages. He can set up on Appledore Island, a relatively barren place, where it is feasible to conduct controlled experiments on the process by which bees choose their nest site. Accompanied by his research team they construct hive nesting boxes that can be varied for size and for entrance opening. They were selecting for two of the variables that they had worked out the bees took account of. Given the barrenness of the island they knew where each possible hive box was placed so they could link the waggle dances to the differently configured hive boxes. This work was simple because of the controlled conditions they could produce on Appledore Island but simple or not it required a painstaking work, sitting all day at a site for example, by people experienced in observing bees.

What we learn from their work is that the bees adapt their forage waggle dance to site notification. Some of the foraging bees, it seems the older ones, will switch to site hunting, once the swarm is set up. For experiments,, necessarily, researchers provoked swarms to enable experiment to progress. The site searching bees would then leave to investigate possibilities. Not all the bees go, only a few become site hunters. This already saves on bees journeys. Also the bees that hunt go off in different directions so the hive is covering a relatively large area. Each bees is endowed with the means of assessing sites according to different criteria. These include for example the size of the site, the possible entrance, its size and distance from ground. The degree of shelter the site offers, holes in the 'roof', is one criterion but it doesn't feature so strongly in scoring as the size since bees can fix up a site if necessary. Each bee can then generate a score for a site they have found. An important point here is that it only needs one bee to discover a potential site, so other bees are simultaneously searching and finding other sites. A larger area can be covered with less bees on behalf of the whole swarm. Eventually the searching bees return to 'report back'.

It's in the reporting back that the wonder of this process is seen. What the researchers discover is that the dance translates the score for the site into a number of dance circuits that includes a rate of dance circuits and duration of dance circuits. What this means is that the better a site so the more circuits danced by the returning bee and this also means that more bees will, by chance, come across this dance. The original dancer will in general not go out again although it appears some do go out once more. The searching is then taken up by the new bees coming across the dances. Each bee now will go to the site designated by the dance they found, a matter of chance not choices made. Sites with higher scores then translate into more vigorous dances that then translate into more bees searching for that particular site. This will initiate a cascade of bees, since each bee on finding the designated site will return and repeat the same dance (score) for new bees. They in turn will go out. During this process it soon appears that one site is winning the day with lesser sites (the lower scored being pushed out of the running). Some bees will still initiate searches so a late candidate site may gather more dancers and become the dominant danced site. In general what happens is that ultimately only one site is danced for and that, the one with the highest score, becomes the site that the swarm goes to.

What the bees have done they could only do acting together. This is more clear than in the case of foraging where the advantage of many foragers and the ability to indicate good sites is obviously an advantage, it gives the bees something like a portfolio. In the case of a new nesting site the decision making involves a mechanism that only works through the actions of many bees and cannot work otherwise. It is a probabilistic model for it only requires chance for a particular bee to come across a dance but as the scores of sites get bigger so the more prominent the dance they engender. Better site, bigger score, more vigorous dance, more chance of new bees coming across it, more bees search that site, more of that dance repeated across the swarm. As each new cohort of bees becomes searchers so a cascade effect starts in favour of the 'best' site. The result is an intelligent decision that the bees produce through their own conduct despite the fact that no one bee could even remotely be capable of achieving this. The probabilistic method of decision making necessarily requires a good number of bees involved.

It is quite fascinating to follow the research in to discovering this mechanism. Seeley allows us to see the process and gives us a good idea of how it works. I don't think this is spoiled by his tendency to translate what the bees do into human terms. Yes in a way it is a consensus but it is some way from being a human consensus. Yes it does have some feature of being a democracy with voting and converts to a viewpoint but again this isn't really much like human democracy. What is remarkable about bees is not that they make simply better decisions through the probabilistic method but rather that they make decisions of a different order of betterness. Their conduct produces a form of computer for finding the best site.

The point is illustrated by an experiment where Seeley manipulated two identically good sites. This interrupted the cascade effect that the mechanism relied on and rather produced a split decision that the 'computer' that generated this result could not resolve. There is no disclaimer here, bees were hurt in the making of the experiment; the swarm failed. The computer could not, so to speak, step outside its own process. This showed the limit of the process but yet also illustrates just how incredible the process is that, short of such a case, that was anyway manipulated, the bees could scout a wide area with a minimal number of bees, assess the available sites,

pass on the information to a process that could then produce a decision for the best site.

In the course of the book we not only discover the process but how it is discovered plus the evident respect and passion for bees that comes out, along with real knowledge of bees in all aspects. It also includes a number of very useful and interesting illustrations. Definitely worth a read? I think so. Worth a browse? Yes also.