

## The Amazing World of the Honey Bees

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Honey bees have always fascinated mankind. We have clear references to them in ancient Indian and Chinese scriptures and Aristotle has much to say about them. Our fascination for the honey bee has been described by William Morton Wheeler, one of the greatest students of social insects of this century, in the following words:

"Its sustained flight, its powerful sting, its intimacy with flowers and avoidance of all unwholesome things, the attachment of the workers to the queen – regarded throughout antiquity as a king – its singular swarming habits and its astonishing industry in collecting and storing honey and skill in making wax, two unique substances of great value to man, but of mysterious origin, made it a divine being, a prime favourite of the Gods, that had somehow survived from the golden age or had voluntarily escaped from the garden of Eden with poor, fallen man for the purpose of sweetening his bitter lot".

Bees, which evolved from other insect ancestors about 70 million years ago, exist today in about 20,000 different kinds or species, as these kinds are called. Most have not the least resemblance to the honey bee and lead

a solitary life. Many are social to varying degrees but none have reached that pinnacle of social evolution achieved by the honey bees. Of the honey bees themselves there are four species namely, *Apis mellifera* which occurs as a native in Europe, Western Asia and Africa, but has been distributed by man throughout the world, *Apis cerana*, formerly called *Apis indica*, which occurs in Asia including China, and Japan, *Apis dorsata*, the familiar large rock bee and *Apis florea*, the tiny bee which nests routinely in our gardens, the latter two species being restricted to southern Asia. Most of the scientific information on honey bees however comes from studies on *Apis mellifera* – a familiar sad tale about the neglect of natural history in the tropical regions.

The most important thing about the honey bees is of course that they are highly social. They live in large groups, in intricately organized societies and cannot survive alone. A typical hive consists of a single queen bee, the only reproductively fertile female in the colony, anywhere from 10 to 50 thousand sterile female worker bees and about 500 to 1000 males or drones, all of the latter being repro-

ductively fertile. The home of the honey bees is the nest, an architectural masterpiece consisting of tens of thousands of hexagonal cells entirely made of wax secreted by tiny glands in each worker's abdomen. How so many different bees working simultaneously and with neither the benefit of learning nor that of a foreman, can produce such a perfect structure is a mystery that will take decades if not centuries to unravel.

Life in the nest is more intricately organized than we fellow social creatures can ever believe, let alone achieve. The queen is an egg laying machine and a chemical factory. She is capable of laying upto 3000 eggs per day and, as one may imagine this keeps her occupied day and night. The only other thing she does can fortunately be done simultaneously and that is to keep releasing a host of chemicals that will guide, instruct or prevent the worker bees from performing various tasks as appropriate. When the eggs hatch, the hive would be any mother's nightmare with 10,000 or more hungry mouths to feed. But the worker bees are perfect match to this task, feeding every larva more than once a minute and, incredible as

it may seem, appropriately changing the quality and quantity of food depending on the age, sex and future caste of each larva. If this is mind boggling to the layman, it is even more so to the scientist, for it is not even clear how one formulates the right questions to begin to understand this challenge of nature to our intelligence.

The honey bees and their relatives have achieved to perfection what we humans are still struggling to do. Choosing the sex of their offspring is a simple matter to them. Firstly, the honey bee queen does not need to mate everytime she produces an offspring as most higher animals have to. She mates during just one period in her lifetime but with a dozen or so males, one after the other. Having securely stored millions of sperm from each of her mates inside her body in a tiny organ called the spermatheca, she returns to the hive well equipped for a life time career in egg laying. But this is not the end of the story because nature's mysteries never cease. In spite of having all these many millions of sperm in her body, she may choose to lay unfertilized eggs. These unfertilized eggs always develop into males while females are produced from fertilized eggs. With voluntary control over release of sperm for fertilization she achieves perfect control over the sex of her offspring.

In addition to feeding the larvae, there are many other tasks awaiting the attention of the workers. Workers build the comb and also enlarge, shape and repair it as and when required. When a larva has completed its growth, they cap its cell and when it completes development and comes out, they trim the cappings and clean the cell preparing it to receive a fresh egg from the queen. The worker bees take turns so that at any given time the queen is surrounded by several workers, feeding her, licking her, caressing her and, we might say, inadvertently acquiring those very chemicals which will control their own behaviour.

Grooming and feeding each other is another major task that engages the workers. It is because of this habit of feeding and grooming each other that chemical messages emanating from the queen are almost instantly spread throughout the colony. If the queen is removed for instance, the whole hive seems to know of this tragedy within minutes. Finally workers have to go out in search of food – their food being nectar and pollen – harvest it and store it in the hive. How is all this work coordinated? The answer seems to lie in efficient division of labour. Worker bees have age-specific duties so that at any give time each worker performs a single or a small subset of its lifetime's duties. This phenomenon called age-polyethism ensures that a worker bee begins her life as an adult member of the hive by cleaning cells. This job is done during the first two days of her life when she appears to be incapable of doing anything else. After about two days, her wax glands begin to work and now, building and nursing brood become her main tasks for the next week or so. This is followed by another change in assignment and the worker bee graduates into feeding and grooming nest-mates. At about 15 days of age, she moves towards the periphery of the hive and begins to receive pollen and nectar from incoming foragers and store these in appropriate cells. Only after she is about 3 weeks of age does a worker ever venture out of her hive to begin her tireless task of scanning her new world of about 100 sq. km in search of nectar and pollen, the prime needs of the hive. For this worker, whose journey through life we have been following, the story must end soon for, one day in the next two weeks or so she will either fall dead of exhaustion or fulfil her larger role in the ecosystem by falling prey to some bird.

Few people realize that honey bees are the only creatures in the world other than man who communicate by means of a set of arbitrary conventions



Figure 1. A portion of a colony of honeybees. In the upper lefthand corner the mother queen is surrounded by a typical retinue of attendants. She rests on a group of capped cells, each of which protects a developing worker pupa. Many of the open cells contain eggs and larvae in various stages of development, while others are partly filled by pollen masses or honey (extreme upper right). Near the centre a worker extrudes its tongue to sip regurgitated nectar and pollen from a sister. At the lower left another worker begins to drag a drone away by its wings; the drone will soon be killed or driven from the nest. At the lower margin of the comb are two royal cells, one of which has been cut open to reveal the queen pupa inside (original drawing by Sarah Landry. Reproduced from the insect societies by E. O. WILSON, Harvard University Press Copyright © 1971 by the President and Fellows of Harvard College.

that may be called symbolic language. It is not uncommon for a worker bee to suddenly encounter a large tree in bloom offering several thousand times the quantity of pollen and nectar that she can carry back to her hive in one trip. Honey bees would never be able to maintain such large populations of young and adults in their hives if it were not for their unique capacity to fly back home and inform their nest-mates of their find and thus bring hundreds if not thousands of them to the spot within a few hours. It took

many years even for scientists to accept that a honey bee worker can, by means of the dance language, convey to her fellow workers the distance and direction from the hive of a new source of food. This amazing chapter in the mysteries of nature was discovered by Karl von Frisch who was rightly honoured with the Noble prize for his momentous discovery. When a worker bee finds a source of food close to the hive, she returns home, releases a scent to attract the attention of other bees and performs the "round dance" by simply running repeatedly in circles. the bees following her and running behind her decode this message to mean "there is food nearby, go and find it". Equipped with some clue about what the dancer might have found provided by the smell of pollen sticking to the dancer's body, the dance watchers fly out and systematically scan the surrounding 100 square meters or so of their hive for that kind of food.

But when a worker bee finds food, say about 2 km away from the hive, it is not much use coming back and telling her nestmates "there is food, go and find it". So now she performs a very different kind of dance called the waggle dance in which she rapidly runs on the surface of the comb either facing straight up, straight down, or at some angle to the vertical, wagging her

abdomen and at the end of this she runs back swiftly to the position where she started without shaking her abdomen and repeats the whole process over and over again. The bees following and running behind her now decode this message in a much more sophisticated manner. The smell of pollen or nectar sticking to the dancer's body will once again tell them what to look for, the number of seconds for which she performs the waggle each time tells them the distance of the food from the hive and more importantly, the angle between her waggle run and the vertical (gravity) corresponds to the angle between the sun, the hive and the food source. Equipped with this information, the dance followers can home in within a few meters of the food source. The more one thinks about this, the more remarkable it seems. The bee must somehow measure the angle between the food, the hive and the sun and remember it. The task is made even more difficult because the bee has not flown straight from the hive to the food. Instead, she has taken a long meandering trial and error pathway and accidentally chanced upon the food source. Yet by recording every little turn she had made during the search flight into a supercomputer—her tiny little brain about the size of a pin-head—she is able to instantly calculate

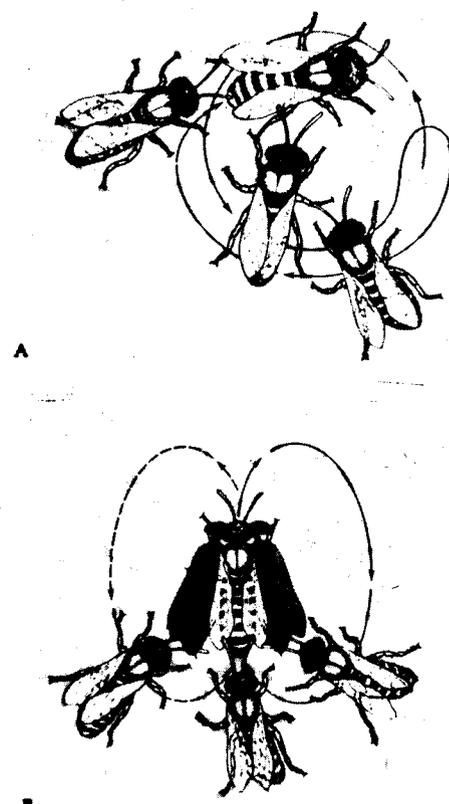


Figure 3. Dancers and their followers. A - Round dance and B - Waggle dance (Reproduced from Ethology by Gould, J.L., W.W. Norton and Company, 1982).

what the angle would have been if she had flown straight to the food source. But she has to do more than that on reaching the hive. She must use that angle to orient her body with respect to gravity while dancing. As it happens, her behaviour is more remarkable still. The sun's position she "knows" keeps changing and an hour may have elapsed since she last saw the sun. Incredible as it may seem, she makes corrections in her calculations and dances at an angle that corresponds to the present position of the sun which she has not seen. The dance followers too, if prevented from going out immediately after watching a dance can correct for the changing position of the sun and fly out to the correct spot. Is there any doubt that the honey bees can perform more sophisticated calculations than any untrained and many trained humans are capable of?

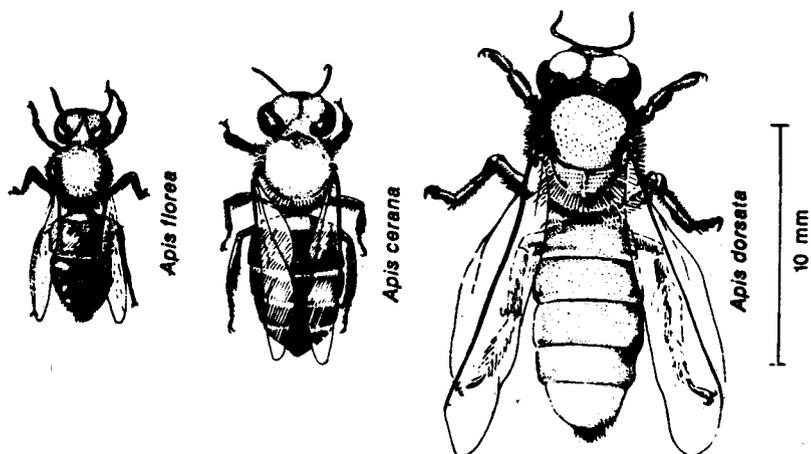


Figure 2. Workers of the three tropical Asian species of honey bees (Reprinted from the Ecology of Temperate and Tropical honey bees societies by T.D. Seclay. *Am. Scient.* 71, 264-272, 1983).

Let us now get back into the nests and help ourselves to a different kind of mystery. How are new hives produced? Workers are in plenty and can be partitioned but there is only one queen and we need at least one more to produce a new hive. That brings us to the question of how queens are produced. Any larva that is fed on a special diet consisting mainly or entirely of secretions from the hypopharyngeal and mandibular glands of the workers, called bee milk or, more

appropriately, royal jelly, will develop into fertile queens. The diet of a larva destined to be a worker consists of a very small quantity of royal jelly and that too only at the very beginning of her larval life for, she will soon be weaned on to a mixture of pollen and honey or the so called bee bread. So the control must be in the hands, or more correctly in the mouths of the workers! True, but the master control is still very much in the hands or again in the mouth of the queen whose

mandibular glands produce a substance that chemists find it easy to call by the name 9-keto-trans-2-decenoic acid but lesser mortals prefer to call by the name "queen substance". As long as a threshold concentration of the queen substance is maintained in the hive, workers are, as if by magic, prevented not only from feeding the queen producing diet to any larva but even from constructing the special large royal cells needed to house queen-destined larvae in the first place. But when the queen dies or is weak or when she "desires" to produce new queens – for that must be her ultimate goal – the concentration of the queen substance drops and the workers get busy constructing royal cells at the bottom of the comb and later when the eggs laid in these cells hatch, in feeding them royal jelly.

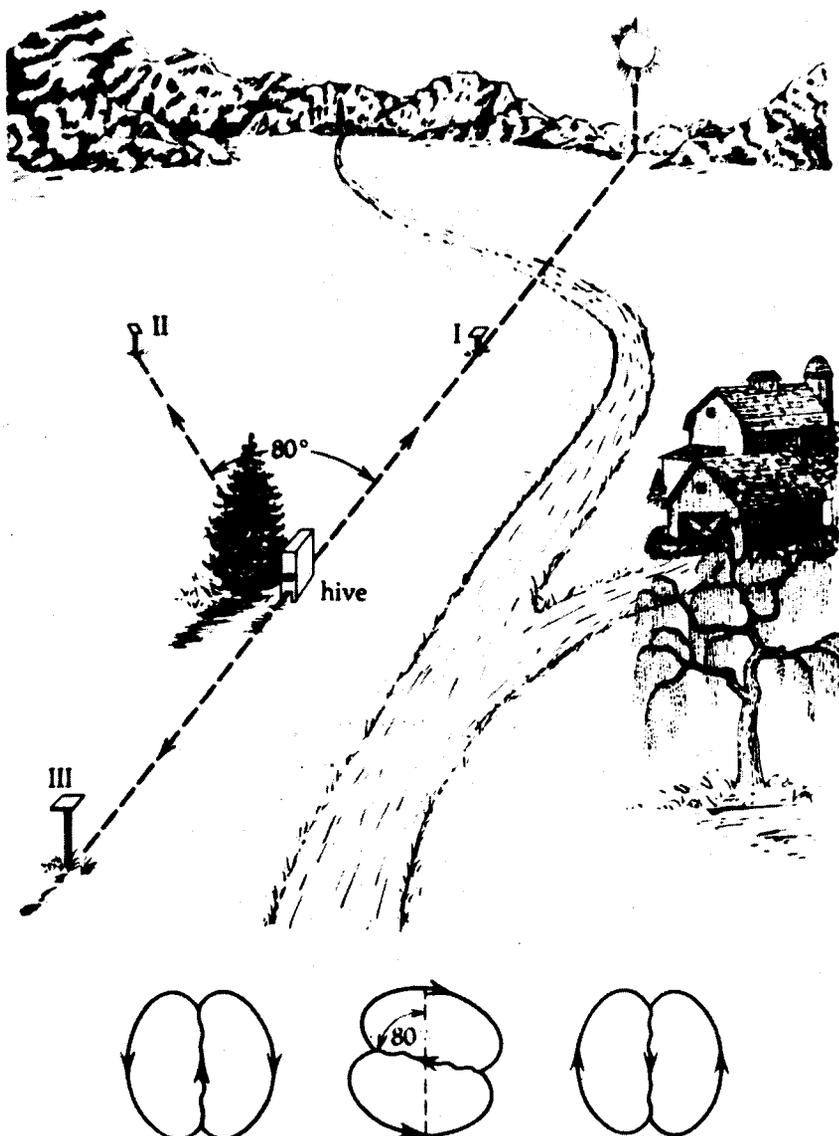


Figure 4. The Waggle dance orientations illustrated for three different positions of the food source. When the food is in the direction of the sun as in I, the dance is directed upwards and if the food is in the direction opposite to the sun the dance is directed downwards. When the food is 80 degree to the left of the sun, the waggle run is oriented 80 degree to the left of vertical. (Reproduced from Ethology by Gould, J.L., W.W. Norton and Company, 1982).

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When the new queen completes her development, in what must appear to us as an outstanding example of a mother's concern for her daughter's welfare, the old queen leaves the hive with all its wax, honey and brood and departs with a few thousand workers to find a new place and build a new hive all over again. But we should be cautious in interpreting nature. The old queen leaves just a little before her daughter comes out of her pupal case. This is achieved through communication between the mother queen and her yet to be born daughter by means of sounds they both produce. the mother seems to ask "are you quite ready to come out, shall I leave?" and the daughter seems to say "not quite yet" or "oh! yes, please be sure to leave before I come out". But why all this fuss? Because, if the two queens,

mother and daughter, happen to meet, all parental instincts disappear into thin air and they fight each other until one of them dies. Such is nature's way of ensuring that there would never be two queens in a hive. Even if the mother has departed before the daughter's arrival, the new queen's first job is still a macabre one. Workers normally rear not just one but a few larvae into queens to ensure that at least one of them successfully develops and takes charge of the colony. The queen that emerges first systematically searches for and kills all her remaining, as yet unborn sister queens.

While all this is going on the old queen and her swarm of workers have settled on a branch or some safe place not very far away. From this swarm dozens of scout bees go out in all directions in search of a suitable site to build a new hive. Having found one they return and begin to advertize their find by using the same dance language that foragers use to communicate new food sources. But here there is one problem. If many foragers dance to indicate many different sources of food, the hive has enough workers to send to each site. But now all the bees have to go to a single new site to build their hive. In what must either be the closest that insects have come to acquiring intelligence or in what must be one of the most complicated forms of instinctive programming, the bees somehow come to a consensus and the whole swarm flies to the agreed site.

The amazing world of honey bees provides an endless series of fascinating and often mind-boggling stories but if one were forced to choose one above all the others it surely would be the worker bee's sacrifice for her colony. Valour, bravery, sacrifice and kindness are undoubtedly the hallmark of the human species but it would be a grave mistake to think that we represent the pinnacle of altruism. That distinction clearly goes to the honey bee and its relatives in the magnificent world of social insects. Not only do worker bees spend their entire life striving for the welfare of the colony and die without reproducing, but they often commit suicide to protect their colonies. There must be few amongst us who have not experienced the quick, unhesitating sting of the honey bee and yet not many of us realize that the sting of the honey bee is a marvel of nature. It is armed with barbs pointing backwards so that when firmly lodged in the offender's skin it cannot be withdrawn. When the bee attempts to fly away after stinging, the sting, the poison gland and a good part of the bee's digestive system are torn away and remain hanging onto its victim. This certainly ensures that sufficient bee venom is injected into the victim but for the worker bee it is certain death. It is unlikely that bees think or have feelings. But that they can behave in the way they do without the benefit of thought or feelings is an even greater sobering thought for some one who likes to wonder about how nature programmes animals to behave.

#### Further Reading

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Published by Indian Institute of Science, Bangalore 560 012 and Printed at Phoenix Printing, Bangalore 562 107

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