**Bee Breeding is very involved.**

**Michael Birt**

Why is breeding better bees so involved? After all, every other food-producing animal that man keeps has been improved out of all recognition, but not bees. The answer lies in the breeding system and genetics of honey bees and in their method of sex determination. Because honey bees are such highly evolved social creatures, the various groups within the colony each has its own distinct function: the queen is the only complete reproductive female and the drones are adapted as sperm providers and really have no other function. Also, the mating system has evolved over millions of years to ensure out breeding.

A queen can mate for only a very short period, probably 4 weeks maximum, at the beginning of her life. She mates on the wing, quite high up in the air and will travel up to 1 mile on one, or occasionally more, mating flights. During the flight she will mate with usually 10 – 20 or more drones, these having collected in large drone congregation areas numbering thousands of insects from many colonies. She will retain about 10% of the sperm she receives from each drone and this will be stored and nourished in her spermatheca, a small round, white structure above the vagina, from which the sperms are released when needed to fertilize an egg, and which will store and nourish around 5 to 6 million sperm. These will have to last her for the rest of her life. She will use 200,000 of these sperm each year so her supply should last her quite easily, even if she lives for 5 years or so. The drones can only mate once and die immediately.

So far, so good, we are beginning to see some of the problems, and a major one is that honey bees will not mate naturally under any other conditions. The method they use is well suited to their lives: mating with many drones, each of which can only mate once, brings a whole range of different characteristics into the colony contributing to the colony make-up and conferring many advantages. Not all will be favourable of course and some will suit the bees but not the beekeeper. The other major advantage of the mating system is the avoidance of closely-related drones as mates.

All the characteristics of a honey bee are passed on from one generation to another by the genes of the individuals concerned. I think we are all very familiar with this concept and the fact that genes are made of DNA. The genes form chromosomes, which are rod-like structures only visible when cells are dividing, and in the honeybee there are 32. We talk of them as 16 pairs, because the members of each pair (homologous chromosomes) resemble one another in shape and size and can be thought of as similar to identical twins. The genes are also in pairs or series (called allelomorphs or alleles for short) and at a particular place on a particular chromosome there will be 1 gene from the appropriate pair or series. The genes in the pair or series will control one characteristic, eg. The synthesis of one protein within the body of the bee, but the alleles themselves may not be identical and may produce different effects.

Now back to our sex determination. There are a number of sex genes carried on a particular chromosome and although there are many of them, (nobody seems sure how many, some say about 18, others say over a hundred), an individual egg or sperm will only carry one from this series.

If an egg remains unfertilised, so developing into a drone, it will not receive the chromosomes and genes from a sperm so it will only have 16 chromosomes. As the egg develops into an embryo, and finally an adult drone, the cells divide and every cell in the body of a drone will contain only 16 chromosomes. For those of you who like long words he is described as hemizygous. He will therefore inherit, from his mother, 1 sex gene out of the series. This is what determines that he is a male. Females, on the other hand, develop from fertilised eggs. An egg and sperm fuse, each contributing 16 chromosomes giving 32 chromosomes and all cells in the body of that individual will have 32 chromosomes. Now we come to the clever bit, because, if the two sex alleles in this individual are different she will be a female but if they are identical a drone will be the result. We call the full complement of chromosomes (32) the diploid number and the half complement (16) the haploid number. All females are therefore, said to be diploid and all normal drones are haploid, but our drone with 2 sex genes is called a diploid drone. He has 32 chromosomes but the 2 identical sex genes mean that he will develop as an identical drone that will be infertile. He will therefore, be eaten by his sisters as soon as he hatches from the egg. Clearly, if a queen were to mate with just 1 drone that carried the same sex gene as one of hers, up to half of her fertilised brood would die and this would seriously deplete the colony. Mating with many drones minimises this effect.

Incidentally, some people struggle with the idea of a series of genes but, while one queen or worker can only carry two from that series and a normal drone carries one, the rest of the genes from the series are distributed throughout the honey bee population.