Queen bees face increased chance of execution if they mate with two males rather than one

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A Vollet. Proportion of diploid males in grey, and female workers in colour.
Credit: University of Sussex

Queen stingless bees face an increased risk of being executed by worker bees if they mate with two males rather than one, according to new research by the University of Sussex and the University of São Paulo.

A colony may kill their queen because of the quality of offspring, according to the paper by Professor Francis Ratnieks, from the University of Sussex, along with colleagues Ayrton Vollet-Neto and Vera Imperatriz-Fonseca from the University of São Paulo, published in a leading evolutionary journal, the *American Naturalist*.

Professor of Apiculture Francis Ratnieks said: "By studying test colonies, we found that queen stingless bees will have an increased chance of being executed by the workers in their colony if they mate with two males instead of the one male they normally mate with.

"The reasons for this are fairly complex but, in short, it's due to the genetics of sex determination in bees and the risk of what's known as 'matched mating.'"

Queen stingless bees are closely related to honeybees and bumblebees but are only found in tropical countries like Brazil.

While a queen honeybee might mate with ten to twenty males, queen stingless bees normally only mate with one male. According to this new paper, that may be to reduce the chance of execution.

In bees whether an individual egg becomes a male or a female depends on a single genetic locus, known as the sex determination locus. Normal males arise from an unfertilized egg and have only one set of chromosomes, from the mother, and so only one sex allele.

If the egg is fertilized it will have two sets of chromosomes, one from the mother and one from the father. The two sex alleles can be different,

in which case it is female, or the same, in which case it will be a diploid male—males who are a genetic dead end as they cannot reproduce and serve no useful function to the colony. What should have become a female worker, who will benefit the colony, is instead a useless diploid male.

Queen bee mating. Credit: Ayrton Vollet.

When diploid males are produced, the worker bees in the colony can tell that things are not right and they generally execute the queen soon after

adult diploid males emerge from their cells.

Diploid males are produced by 'matched mating' where the sex allele of a male the queen mates with is the same as one of the queen's two, different, alleles. In a matched mating, 50 percent of the fertilized eggs from that male's sperm will be diploid males.

If a queen bee mates with two males, although her chances of making a matched mating are doubled, the number of diploid males that could be produced decreases from 50 percent to 25 percent.

It turns out, however, that worker bees are just as likely to execute a queen who produces 25 percent diploid males as one who produces 50 percent.

Professor Ratnieks said: "If a queen mates with two males instead of one, her chance of being executed double. As a result, natural selection favours queens to mate with a single male in stingless bees."

Interestingly, the researchers found that if a queen were to mate with four males, this would actually reduce her chance of being executed.

If a queen were to mate with four males and there was a matched mating, only 12.5 percent of the offspring would be diploid males. This low proportion is not enough to cause the workers to execute the queen.

The researchers point out that for stingless bees to evolve from single mating to multiple mating, with 4 or more males, there would need to be an intermediate stage of double mating. As double mating causes higher queen execution, natural selection does not allow this first stage to occur. Stingless bee queens seem to be stuck on single mating.

More information: Ayrton Vollet-Neto et al. Queen execution, diploid

males, and selection for and against polyandry in the Brazilian stingless bee Scaptotrigona depilis, *The American Naturalist* (2019). DOI: 10.1086/705393