

Jelly Fit for a Queen

Worker or queen? It is not a matter of birthright, but of the right food – at least in the case of honeybees. If a larva is pampered exclusively with royal jelly, it becomes a queen, the majesty of the hive. More than 50 years ago now, the young Ph.D. student Heinz Rembold, later to become a Max Planck researcher, discovered that it is not a secret ingredient in the jelly that determines the status of the bee, but its especially balanced nutrients.

The wife looked anxiously at her husband's face and neck. There was no skin showing at all on the neck, not even at the sides below the ears. The whole of it, to a point where it disappeared into the collar of the shirt, was covered all the way around with those shortish silky hairs, yellow black. The woman's eyes traveled slowly downward and settled on the baby. The baby was lying naked on the table, fat and white and comatose, like some gigantic grub that was approaching the end of its larval life and would soon emerge into the world complete with mandibles and wings." That is the somewhat spine-chilling end to the short story entitled *Royal Jelly*, written by Roald Dahl in 1953 and published in the anthology *Tales of the Unexpected*.

The story begins with the family's new baby refusing to take a bottle and becoming weaker and weaker. The father, a beekeeper, reads an article about royal jelly in one of his apiarist magazines and discovers that bees feed the larvae that are destined to become queens on the concentrated jelly alone. In just five days, the larvae put on 1,500 times their original weight, says the report. This is the equivalent of a seven and a half pound baby weighing in at five tons after the same amount of time. The father is so impressed that he decides to mix some royal jelly into the baby's milk, which she then drinks greedily. He keeps the reason for this change a secret from his wife and takes over the preparation of the bottles so that he can continue his experiment of secretly enriching the milk with royal jelly.

At the same time, he himself starts consuming large quantities of the substance, expecting amazing results – after all, the thick, milky jelly is said to increase libido. That is just one of the many properties ascribed to the legendary "Queen's food," as the jelly is also known: it is claimed to boost the immune system, eliminate nervous exhaustion, improve memory, increase resistance to stress, improve physical and mental stamina, and numerous other supposed positive effects.

However, there is no empirical evidence that the mysterious substance is beneficial to humans, and all attempts to substantiate these effects have been inconclusive. To get to



The worker bees attend to the queen, for only she lays eggs.

the bottom of the issue once and for all, in the mid-1950s biochemist Adolf Butenandt gave one of his students in Tübingen the task of analyzing the ingredients of royal jelly for his Ph.D. thesis. As Butenandt had just identified the pheromones of the silk spider, it was suspected that such a pheromone might be responsible for determining whether or not a bee larva would develop into a worker or a queen.

Yet Ph.D. student Heinz Rembold, who would later become a researcher at the Max Planck Institute for Biochemistry in Martinsried, was skeptical. What benefit should a highly developed primate like a human derive from a substance that seemingly had one sole purpose, namely to promote the development of ovaries in bees?

He began by examining how queen bee larvae were fed. To do this, he investigated how a queen bee develops within a bee colony. The queen is characterized by her long abdomen, complete with ovaries and the spermatheca, where she

stores the sperm collected from the drones during her nuptial flight. The queen uses this sperm to fertilize the eggs that she lays in the brood cells of the female worker bees, then she closes off the flow of semen and lays unfertilized eggs in the drone cells. She leaves all the rest of the work to the worker bees – building the honeycomb, cleaning and preparing the cells where the eggs are to be laid, and caring for the eggs until they hatch.

There is only one single queen in each bee colony. If she is lost, the female worker bees react immediately by preparing so-called supersede cells, a type of queen cell in which the worker females lay normal eggs. These can develop into queens if fed only on royal jelly, which young female worker bees known as nurse bees produce in their pharyngeal glands. For three days, the bees feed their progeny on this rich substance, after which they change the menu for all the offspring except one queen cell larva to a mixture containing primarily pollen and honey. This change of diet is crucial in determining the status of these larvae, as it makes them into worker bees.

In the final stage of their development, the ovaries of the worker bees shrivel almost entirely, while the reproductive organs of the queen develop. This could be because royal jelly contains a substance that affects the gonads, and after the diet change, the worker bees no longer receive this substance. Researchers have long sought to identify this mysterious substance, but without success.

In his quest to find out how royal jelly works, Heinz Rembold analyzed its chemical composition and discovered a 60 percent share of water. About 10 percent of the dry substance is fat, 38 percent is a sugar-rich protein, while the rest is made up of low-molecular-weight substances such as sugars, amino acids, vitamins, mineral salts and the three substances pantothenic acid, bioppterin and neopterin, whose function was initially unclear. Later experiments, however, found that these three components had nothing to do with whether or not a larva developed into a queen or a worker.

Another attempt to discover the secret of royal jelly consisted in changing the proportions of the individual components to investigate whether this had an effect on the development of the queen. To this end, Rembold and his colleagues created a partially synthetic larval food. Half of this food consisted of royal jelly, while the other half was a watery solution of such other components as amino acids, mineral salts and vitamins, the propor-

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The fact that the future queen had a particularly rich diet containing royal jelly was already well known, but which component of this royal substance was responsible for later enabling the queen bee to reproduce [...] long remained an undiscovered secret. Rembold succeeded in shedding light on the subject: by artificially changing the composition of royal jelly, he was able to breed either queen bees or worker bees in the brood cells at will.

tions of which the researchers altered from experiment to experiment.

Of the larvae that Rembold and his colleagues fed on this mixture, only a certain proportion developed into queens, but the scientists noted that this proportion increased by 50 percent when they doubled the amount

of amino acids in the food. These results showed clearly that it is not a specific or mysterious, possibly hormonal, factor in royal jelly that enables the larvae to develop into queens, but rather the optimally balanced composition of the diet – and the fact that the nurse bees feed the queen bee larvae up to 10 times more frequently.

The secret of the caste system in honeybee colonies evidently lies in specific genetic programming of the larva development. This is controlled by hormones, probably primarily in the first phase of larval development. In this phase, Rembold suspected, the endocrine or hormonal system in the diencephalon of the larva is still in an embryonic state. It is only at this stage that royal jelly seems to play a special role. He thus concluded that royal jelly would appear to be nothing more than an optimally balanced rich food designed to meet the special needs of the developing larvae.

The future queen continues to eat this food until she hatches. Consequently, her endocrine system matures more quickly than those of the worker bee larvae, and in the same way, becomes active more quickly. The mix of nutrients in royal jelly protects the gonads in the female larvae from undergoing the atrophy process that takes place in the same phase of development in the less well-nourished worker larvae whose endocrine systems remain immature. That, and not some mysterious substance, Rembold concluded, was the answer to his initial question concerning the function of royal jelly.

Of course Roald Dahl, the author of the story quoted earlier, could not have known this, as the discovery was only made toward the end of the 1950s. However, the companies that sell royal jelly and products containing it do know the facts. In their advertising, they claim that the only reason why queen bees live for about six years while worker bees live only around six weeks is because their diet consists exclusively of the royal jelly, whereas worker bees consume only pollen and honey – despite the fact that, 50 years ago, Heinz Rembold had already proved that the mysterious royal jelly does not actually have any specific effect even on bee larvae. The supposed elixir of life would appear to benefit its suppliers alone: 50 g cost almost 10 dollars.

MICHAEL GLOBIG



In the mid-1950s, Ph.D. student Heinz Rembold analyzed royal jelly. He also used chromatographic columns to separate its components.

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