The History of Bee Breeding

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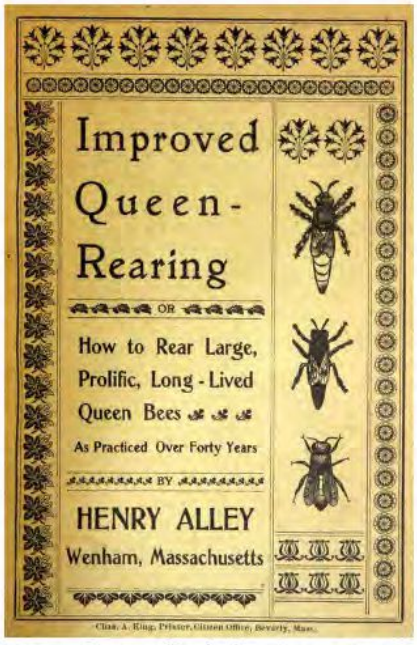
In order to discuss bee breeding intelligently, I am going to have to go back a little ways. Not all the way to the Big Bang but about 125 million years ago, to the Cretaceous period. This time is known for its huge dinosaurs, like Tyrannosaurus and Triceratops. It was the age of flowering plants, as well, and their spread was no doubt enhanced by the presence of bees and other pollinators. Magnolias, figs, and many other leafy trees were in abundance while some gymnosperms like *Bennettitales* became extinct.

Different insect types became more numerous and the first ants, termites, aphids, and gall wasps appeared. We know of them due to the abundance of amber deposits, in which many examples of prehistoric insects are miraculously preserved. Bees and wasps most likely descend from a common ancestor, but bees are distinguished by their special adaptations for collecting, carrying and storing pollen. It is fair to say that bees are vegetarian wasps. Even today there are many bees that could easily be mistaken for wasps, like *Hylaeus*.

Fossilized Bees

By comparison with existing honey bees, several fossil species have been identified and named as *Apis*. The first were found in France and Germany in the early 1900s, including *Apis henshawi*, whose wing vein patterns resemble *Apis dorsata* (the giant honey bee of Asia). These date from the Oligocene period, about 30 million years ago. More recently, a fossil honey bee was discovered in the US and named *Apis nearctica* (Engel et al. 2009). The modern species fall into three distinct groups, commonly referred to as the honey bee, the giant honey bee and the dwarf honey bee. The most widespread of these is *Apis mellifera*, originally found in Africa, Europe, northwest Asia, and so on. It was brought to the Americas and Australia. The other honey bees, including *Apis dorsata, cerana, florea* and the rest are mainly found in Asia. Of the living species, only fossils have been found for *A. mellifera*, dating it back to the Pleistocene. This period, which began about 3 million years ago, is when the first humans are thought to have appeared, aptly named *Homo erectus*. These early people may have already been using honey and the products of the hive.

The honey bees of today are divided into about seven species, depending on whom you ask. The hive bees are mainly *A. mellifera* and *A. cerana*; others are hunted and robbed for their honey and brood. *Mellifera* is the most widely used and can be further classified into geographic races, or subspecies. Most authorities contend that *Apis* originated in Africa, like early humans. They radiated out over the globe, and became differentiated into the various races, again paralleling the development of the human species. While all of the races probably had a common ancestor, they changed over time as a result of living in different regions, being subjected to a variety of different environmental pressures such as climate and predation, while undergoing various mutations and genetic drift. The existence of the same or similar species in different parts of the globe, but which were quite different from each other in various ways, inspired Darwin to write his *The Origin of Species*.



Cover from Alley's book on Queen rearing

The honey bee provides a perfect example of this phenomenon, since the various races are all the same species, and yet they have quite unique characteristics by which they were originally recognized, traits which persist in many cases to this day. Unfortunately, most of the original types have been crossed so there are large populations of bees which no longer resemble the original regional races from which they were drawn. Most of the original honey bee races had clear distinctions which have been thoroughly described.

Bees in the New World

The history of the importation of honey bees to the New World provides a framework to describe these types and further, to illustrate the history of bee breeding in general. As most beekeepers know, the honey bee was not present in the Americas when the Europeans first arrived. There are honey-collecting bees in South and Central America, the so-called stingless bees, but these are quite different from the true honey bee, despite being domesticated and worshipped by many cultures. However, the Spanish brought the first honey bees to the Americas around 1600.

Beekeeping was carried out in the old fashioned way for centuries, right up to the 1800s. Little was known about what went on inside the hive, which consisted of a box, basket or clay pot, depending on the beekeeping technique of the region. Skeps or basket hives were common in western Europe, box hives were found in the east. In northern Africa, bees are still kept in clay hives and in much of the continent, hives are made of logs. However, when the frame hive was invented and widely adopted, beekeeping experienced a revolution in the real sense. Of course, this closely paralleled the industrial revolution, the advent of mass production, factories, and interchangeable parts. The modern hive was perfected, stan-

A picture of Alley's apiary.

dardized, and the attention of beekeepers was turned to the bees themselves. The shortcomings of the European black bee *(A. m. mellifera)* were inescapable, and word began to spread of the merits of the Italian bee *(A. m. ligustica)*.

The Italian Honey Bee

This variety of the honey bee, also called Ligurian bee, is found in small districts amid the Alps, embracing portions of Switzerland and Northern Italy. They are a striped golden color, and were described by Aristotle, Virgil, and other ancient writers, as the most valuable kind then known. But for centuries they were unknown outside of the districts above named, the surrounding mountains covered with perpetual snow being impassable by their wings.

They were accidentally discovered, during the wars of Napoleon, by Captain Baldenstein, who carried the first colony across the Alps in 1843. In 1853 they were introduced by Dzierzon into Germany, and into the United States in 1860. There have been many importations since.

> We were slow to believe all the good things said of them by German apiarians, until convinced of their superiority by the universal testimony of prominent American bee-keepers, coupled with our own experience. (from *The Bee-Keeper's Text-Book*, by N. H. & H. A. King. 1866)

Beekeepers and researchers began to explore other regions, to identify and evaluate the various strains of bees. It was soon discovered that the honey bee varied considerably from region, having particular characteristics that fit with the various environmental conditions where it found itself. But, as these different bees could all produce viable crosses, it was clear that they were all members of the same species, *Apis mellifera*. Many of these varieties were imported into the United States during the beekeeping boom of the 1880s. Frank Benton gives an excellent overview of the situation in his *Instruction in Apiculture* issued by the Government Printing Office in 1899.

The German Bee

Benton describes the common brown bee, or German bee, which was initially brought to North America, and the Italian which was found so superior that the process of Italianization was begun in earnest. In order to meet the demand for Italian queens, there arose a whole industry of breeding queen bees and sending them through the mail. Additionally, Benton mentions the Egyptian, the Cyprian, the Syrian, the Palestine, the Carniolan, and the Tunisian varieties and gives thorough descriptions of the pros and cons of each of these. His description of the German bee leaves little doubt why it was replaced:

> The disposition which bees of this race have of flying toward one who approaches the apiary and stinging him, even though the hives have not been molested, their way of running excitedly. over the combs and dropping in bunches when they are handled, besides stinging the backs of the operator's hands, unless the whole colony has first been thoroughly subdued and the bees induced to gorge themselves with honey, or are constantly deluged with smoke, are very annoying to the novice who undertakes to perform necessary manipulations with them, and may even so discourage and daunt him as to cause the neglect of work of great importance to the welfare of the colony.

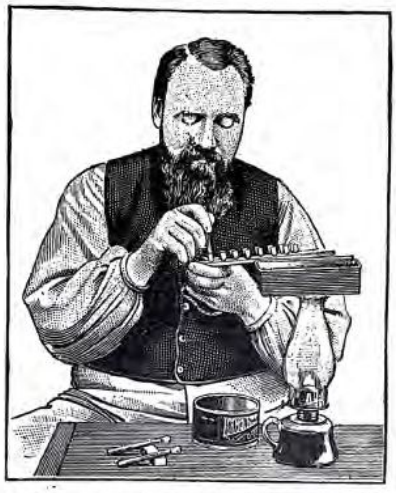
Each of the races was described in minute detail and their various qualities were enumerated by other authors as well. For example, Frank Pellett refers to the Caucasians as the "gentlest race known" and states their drawbacks as the excessive use of propolis, tendency to build burr combs and swarm too much.

Practical Queen Rearing

There is probably no better book on the basic techniques of bee breeding than Frank Pellett's *Practical Queen-Rearing* which was written a hundred years ago. In one hundred pages he covers all that a person needs to know to raise queens successfully on a small or large scale. The first problem that one encounters when one begins to learn about queen rearing is that there are so many methods. This can overwhelm the beginner so much that she has no idea where to begin. Pellett reduces the methods down to a manageable number but the fact remains that there are a number of good ways to go about it. Therefore, it matters less which method you use than the results you get.

The earliest methods of queen rearing simply involved removing the queen from the hive and reaping whatever queen cells the bees produced in their effort to restore the colony to its former state. This method works well enough, but natural cells are quite difficult to handle. Additionally, there is no sure way of guessing the age of the queens, though they will generally hatch at about the same time. Langstroth modified this method by using three colonies. He would retain one queen, which was moved from hive to hive, after the queen cells were harvested. In this way, the colonies would

An ad for Coleman Apiaries



A picture of G. M. Doolittle at work.

continue to provide queen cells for him over a long period of time.

Quinby modified this plan by devising the technique of using very small hives called baby nuclei. A piece of brood and enough bees to care for it were installed in these miniature hives and they were charged with raising a queen for themselves. Even though this method works, it was generally observed that better queens would be raised in large colonies. The baby nucs are still used by many large-scale queen producers, but they raise their queen cells in populous colonies, which are then installed into the nucs. These populous colonies are generally called "cell builders" and may or may not have queens of their own. Additionally, some breeders use separate colonies called "cell starters" if they find that the builders fail to reliably start as many as they can comfortably care for.

I am not going to cover queen rearing in detail, but we cannot move on without mentioning G. M. Doolittle. Doolittle was born in Onondaga County, New York, in 1846 and spent most of his life in Borodino, overlooking Lake Skaneateles. He never had a very large number of colonies, like his neighbors Quinby and Hetherington, but was known as a master of the craft. His book *Scientific Queen Rearing* forms the basis of all modern queen breeding. He emphasized the fact that the best queens are obtained by mimicking Nature. That is, they are raised under the conditions of supersedure, where the colony is raising new queens in the presence of the old one. Doolittle was the first to use cell cups mounted on wooden bars, into which day-old larvae are placed by the beekeeper. In his words: "It came to me — why not dip the cells, the same as my mother used to dip candles?" His system has been modified by many over time, but hardly improved upon.

Brother Adam and the Buckfast Bee

In the early part of the Twentieth Century, England was plagued by a scourge given the name Isle of Wight Disease. The full gamut of speculation was run as to the causes and cures, much as we have seen with the more recent bee declines. One thing was clear, the English bee was particularly susceptible. A young beekeeper going by the name of Brother Adam, working at Buckfast Abbey in southwest England, imported a large number of Italian queen bees. These he crossed with native stock to produce a vigorous hybrid he called the Buckfast Bee. This stimulated his curiosity and led him to travel extensively to become familiar with the many varieties of honey bees unique to various regions. He was also keen on bringing them back to produce additional hybrids. He wrote about these travels in his book *In Search of the Best Strains of Bees*.

> Breeding of honeybees has a long tradition where racial considerations have, and still play, an important role in the breeding strategy. The ambition to preserve specific race characteristics were less pronounced in the successful breeding program developed by the Benedictine monk Brother Adam at the monastery Buckfast Abbey in the UK in the early 1900's. His breeding strategy specifically produced hybrid bees with the intention to find beneficial phenotypic characteristics, rather than race typical features. The ambition was to breed productive bees, but also to breed disease resistant bees. (From *Breeding Disease Resistant Honeybees*, Ingemar Fries & Anders Lindström)

It must be made clear at this point that the aim of preserving local native races may be at odds with the goals of professional beekeepers who wish to propagate industrious, healthy and profitable colonies. Retaining these native types where they still exist should not prevent experimentation with hybrids, especially in regions where honey bees never were native. There is nothing particularly special about the so-called races, arising as they have from chance combinations in isolation from each other. As Brother Adam so wisely stated: "Nature never breeds for the perfection of the factors we desire for our commercial needs." Additionally, he warned against excessive line breeding as a means of producing "pure stock" as this approach can lead to inbreeding depression and loss of vigor.

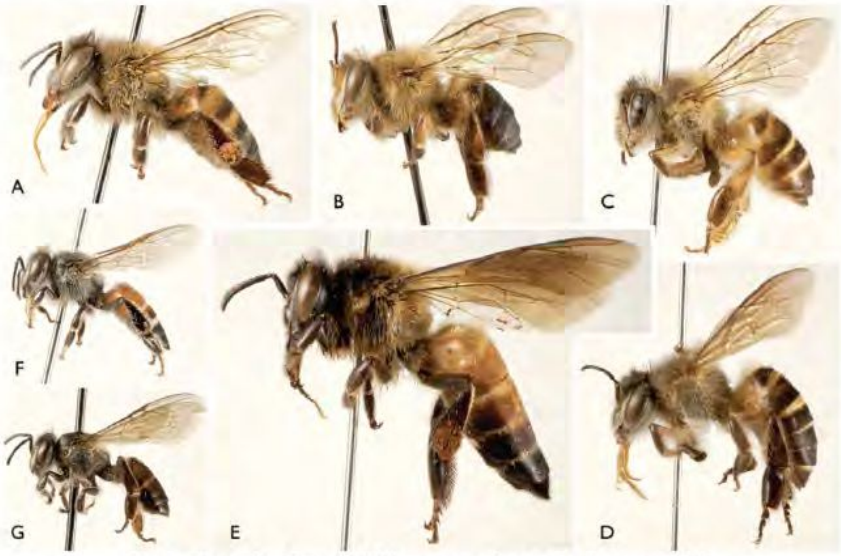
Breeding for Disease Resistance

The next major steps forward in bee breeding followed closely on the heels of Brother Adam's insistence that disease resistance can be selected and bred in honey bee lineages. A project was started in 1932 by O. W. Park at the Iowa Agricultural Experiment Station to see if a line of bees could be developed that was resistant to American Foulbrood disease, a bacterial infection which is fatal to colonies and highly contagious. Park and Frank Pellett moved the project to Weslaco, Texas where they set up an isolated mating station amidst 25,000 acres of citrus trees. In 1949, after working on the project for over 15 years, the results were as follows: of colonies inoculated with comb inserts containing 75 cells of foul brood, only 2% of the resistant bees developed the disease.

An ad for Nutmeg Queens

An ad for Pure Italians

An ad for Dadant's Starline and Midnite Hybrids



Modern honey bee diversity (all bees are workers and to the same scale)
(A) Apis mellifera (B) A. koschevnikovi (C) A. nigrocincta (D) A. cerana
(E) A. dorsata (F) A. florea Fabricius (G) A. andreniformis (Engel et al. 2009)

Honey Bee species, used by permission of Michael S. Engel, Ph.D.

Following the Brother Adam's lead in another direction, G. H. Cale, Jr. began to develop hybrid lines following the principles worked out in the hybridization of corn. Distinct inbred lines were created and then crossed in an effort to produce heterosis, or so-called "hybrid vigor." This approach led to the creation of the Starline and Midnite bees that were bred and sold by Dadant well into the 1970s. Despite the publication of articles such as *A story of success—the Starline and Midnite hybrid bee breeding programs*, the hybrid bees disappeared in the following decade. I suspect that the high cost of maintaining such an ambitious project could not be recouped through sales of the hybrid queens.

Space does not permit a lengthy recounting of the attempt in Brazil to produce a more productive tropical bee by introducing bees from Africa. Suffice it to say that we learned more about the potential, effects, and consequences of hybridization between very different subspecies. For an in-depth analysis see: *The African Honey Bee: Factors Contributing to a Successful Biological Invasion,* by Stanley Scott Schneider, et al (2003).

The Era of Varroa

The quest for a better bee receded somewhat until the arrival of the varroa mite. Following Rothenbuhler's writings on the foulbrood work, the concept of hygienic bees was repurposed. A hygienic bee is one that successfully cleans the combs leading to a reduction in pathogen levels and the resultant diseases. Hygienic bees are beneficial against a variety of ailments, from chalkbrood to mites and nosema. Better still, assays were developed that did not involve the inoculation of healthy bees with potentially fatal disorders. Marla Spivak promoted the technique of killing brood with liquid nitrogen in order to observe variations in the bees' enthusiasm for getting rid of dead brood. Equally effective, if more tedious, is the method of killing pupae with needles, which the bees then uncap and remove, again reflecting their hygienic habits.

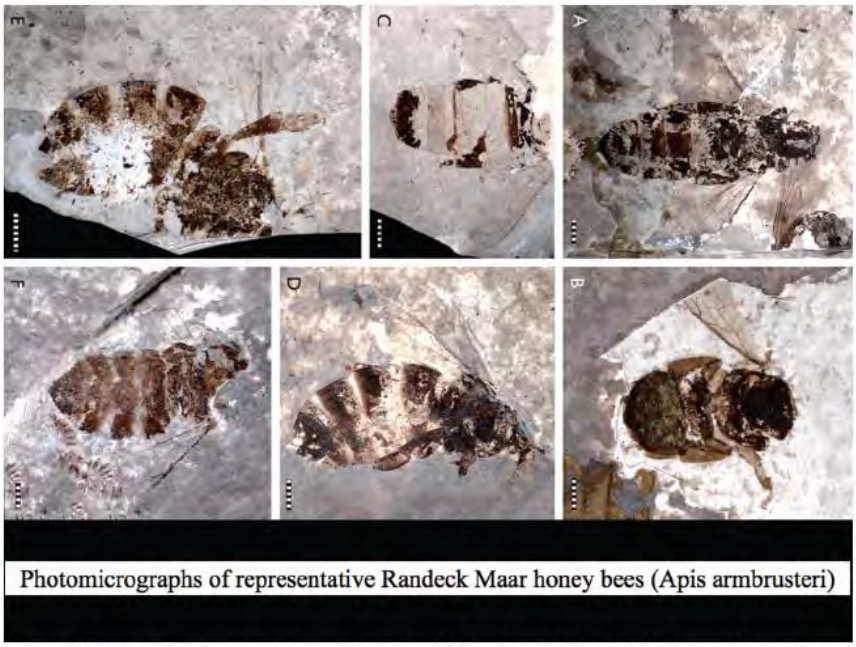
But varroa have been a lot harder to get rid of than some of the other problems with which beekeepers have had to contend. Various mite-killing chemicals have been discovered, used, and then abandoned as the mites become resistant to them, reducing their effectiveness. It became obvious early on that miticides could not be the long-term solution.

It is safe to say that the Russian Honey Bee Breeding Program borrowed ideas from everything that had been done before. In the manner of Brother Adam, the globe was circled to find bees with the highest level of natural resistance to mites. These were found in the Primorsky region of Northeastern Russia. The Russian bees had lived with mites the longest and presumably had the longest time to evolve mite resistant traits. Dr. Tom Rinderer and his colleagues began importing queens into the US in 1997 and by 2002, 362 queens had been acquired. In order to avoid inbreeding, 18 distinct lines were produced which were selected for resistance to tracheal mite, varroa mite, and good honey production. This led to the formation of the Russian Honey Bee Breeders Association in 2007.

**Natural Queen Cells,
photo by Peter J. Borst**

The 21st Century and Beyond

To conclude, I would like to mention the great efforts and success of Danny Weaver. He has shown that hard work, sacrifice and science can merge to produce real results. Danny was an early promoter of the project to sequence the honey bee genome. Meanwhile, he quit doing mite treatments in order to develop a large population of bees that could survive and prosper despite the presence of the ubiquitous varroa mite. Beginning in 1967, Weaver was for many years



Photomicrographs of representative Randeck Maar honey bees (Apis armbrusteri)

Fossil Honey Bees, courtesy of Torsten Wappler, Universität Bonn, Germany

the only source of Buckfast queens and bees in North America, developed long ago by Brother Adam against the tracheal mite, which seems small compared to varroa, but which nearly wiped out beekeeping in the British Isles. The Weavers are at the forefront of the quest to produce a bee which is a composite of positive qualities, adaptable and capable of being challenged by today's beekeeping needs, and not in need of an expensive life support system.

The effort to find, breed or create a better bee continues. Stay tuned. (A follow-up article on the *Future of Bee Breeding* is in the works).