Bee Colony Collapse and Biodynamic Strategies to Restore Bee Health

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As reported by The New York Times and Reuters, according to the annual survey published by *Bee Informed Partnership,* a consortium of research laboratories and universities, in May 2015, approximately 5-6,000 beekeepers managing about 400,000 colonies in the U.S. reported losing 42.1% of their bees during the previous 12-month period, an increase of almost 25% above the losses reported in the two years before, and the second highest since surveys began in 2010. Most ominous was the fact that honeybee deaths during last summer were even greater than during the winter, for the first time ever. Poor nutrition, the varroa mite and pesticides, among them especially neo-nicotinoids, were listed as possible causes for the disappearance of the bees. Cynically, Bayer Crop Science, the biggest manufacturer of neo-nicotinoids, hailed the results of the survey because winter bee losses seemed to have stabilized at relatively lower rates, even though any losses higher than 18.7% are generally considered economically unsustainable for commercial pollination services estimated to be worth 10-15 billion dollars per year.

What is Bee Colony Collapse? Bees can die from a variety of causes: disease, natural disasters (sudden weather changes, storms, fires), lack of food, human interference (exterminators, destruction of natural habitat, toxins). However, bee colony collapse (BCC) is a radical and new phenomenon first called by that name in 2006 when it was discovered in North America and in Europe that whole colonies were simply disappearing, leaving behind intact hives , combs filled with brood, and plentiful food stores.

The main reason governments, industry and scientists are currently paying attention to BCC is because of the economic importance of honeybees as pollinators. According to the Agriculture and Consumer Protection Department of the Food and Agriculture Organization of the United Nations, the worth of global crops with honeybee's pollination was estimated to be close to $200 billion in 2005. Shortages of bees in the US have increased the cost to farmers renting them for pollination services by up to 20%.

Many causes are blamed for BCC: pesticides, primarily neo-nicotinoids; infection with mites (Varroa and Acarapis) and other pathogens; genetic changes; loss of immune sufficiency; loss of habitat due to monocropping and competing uses (urbanization and commercial development); malnutrition; and changes in beekeeping practices especially in the U.S. (mobile beekeeping).

Most assessments, however, ignore the quintessential role of bees in maintaining the ecological health of the entire planet. Notable exceptions to this narrow perspective can be found in the work of certain evolutionary biologists such as Jürgen Tautz and his colleagues in Germany, and in the development of biodynamic bee sanctuaries that have sprung up in Europe and North America in response to Rudolf Steiner's warning ninety years ago that the honey bees would disappear from the face of the earth with disastrous consequences for the natural and human ecology unless agriculture shifted its focus from industrial bee management and production for profit. The dire facts surrounding BCC today make Steiner's prediction and call for action ever more urgent today.

Jürgen Tautz characterizes honeybees as one of most successful species in the history of evolution, and a species that has coevolved with the flowering plants that depend on them for their own survival. For ca. 4.5 billion years life has developed on earth according to fixed rules of reproduction. 3.5 billion years ago single-cell life forms emerged capable of extracting matter and energy from the environment for reproduction and genetic increase. 600 million years ago multi-cell life forms emerged built on the principles of specialization and cooperation. Flowering plants have existed for 130 million years, and 30 million years ago bees evolved to achieve the super organism guaranteeing the immortality of its genetic substance through specialization.

In 1793, German botanist Conrad Sprengel discovered the role of honey bees in flower reproduction. Two generations later, Darwin not only confirmed Sprengel's insight experimentally (by covering flowers with nets to exclude insects with predictable results), but showed that flowering plants had evolved to compete for pollination by offering different levels of pollen and nectar quality and temperatures. Plants adapted to remove sensitive sexual organs to the interior of the efflorescence as protection against wind, weather and predation by some classes of pollinators (such as the rose beetle who simply eat the sexual organs). Flowers developed optical and aromatic qualities to increase their attractiveness to honey bees in particular. Thus, while honey bees are not the only pollinators – butterflies, flies, beetles, solitary bees, wasps, bumble bees also contribute to pollination – none perform this task as effectively and with the same level of mutual benefit for the plants and pollinators as do honeybees. The eight species of honey bees (apis mellifera=honey bearing bee), of which six are of European origin and two Asian (in contrast to no fewer than 4,000 different species of non-honey bearing bees in North America alone), pollinate 85% of all flowering plants (90% in the case of fruit trees) world wide. Altogether, apis mellifera pollinate 170,000 plant species, and of these 40,000 indispensably so, in other words the plants would be doomed to extinction without honeybees. This statistic makes clear the profound role and significance of honeybees to plant ecology world wide. A single bee colony can visit 1 million flowers every day over a land area of 400 square kilometers, with each individual bee visiting 3,000 flowers per day, at distances of 10 kilometers in straight flight.

Honey bee colonies are structured in what has come to be known as “super organisms.” In the early 19th century, German beekeeper Johannes Mehring came to the insight that any given bee colony really constitutes a single being (he called it an “Einwesen” or “ das Bien”), with the worker bees representing the metabolic organs, the queen its female and the drones the male reproductive organs, and the comb in which the bees raise their brood and store their food, the bone-like cell structure comparable to the spine and skeleta of vertebrates. Later in the century, American entomologist William Morten Wheeler on the basis of his work with ants, coined the term “super organism” to describe the self-organization of state-building hymenoptera (winged insects). Jürgen Tautz takes the comparison even further to point out that bee colonies share many characteristics of mammals which makes them evolutionarily superior to most vertebrates. Among these characteristics, Tautz points to the fact that mammals have extremely low reproduction rates – so do bees; mammals produce mother's milk in specialized glands – bees feed their brood with sisters' milk produced in mammary glands located in their mandibles; mammals protect their gestating offspring in a physical uterus – bees gestate their young in a social uterus (in the comb); mammals produce a body temperature of 35 degrees Centigrade – so do bees; large-brained mammals excel among vertebrates in cognitive capacity – honeybees exceed most vertebrates in their capacity to learn and communicate with each other in the super organism.

How is the super organism of the bee colony actually organized? How do the thousands of individual bees inhabiting the hive actually know what to do? How are decisions made and communicated? What motivates worker bees to forgo reproduction, leaving the function and privilege of genetic transfer to the queen? As a Darwinian biologist, Tautz painstakingly emphasizes that while bees act "as if" a central intelligence informed their behavior, the driving force behind their actions is "instinct" working through the genes. Decision making processes are decentralized and emerge phenomenologically as bees interact through smell, touch, and vibrations communicated through the cell walls of the combs.

Rudolf Steiner, the founder of Biodynamics, takes a different view. To him, what Mehring called the "Bien," Steiner refers to as "Spiritual Bee," by which he meant an overarching conscious intelligence informing all of nature. Different animal species are informed by "group souls" in a hierarchy of spirit that has its pinnacle in the creative fiat of the Divine (from Latin, "Let it be done!", corresponding to the Creative Logos as described in the biblical creation story in the book of Genesis and again in the Gospel of John). Similarly, the ancient Greek philosopher Aristotle argued that "the whole is greater than the sum of its parts" (*Metaphysics*), and that that sum derives from the formative forces shaping the elements of earth, fire, air and water into the physical, natural phenomena. So every created thing or being in nature embodies its own telos ("indwelling purpose") which it is meant to express in the course of its life. And so in regard to the bee super organism, a bee colony as a whole on the basis of informational flows can make decisions beyond what individual bees are capable of deciding on their own. Inversely, environmental conditions in the particular hive shape the characteristics of individual bees and direct their actions and behaviors. For instance, the pheromone emitted by the queen bee retards the reproductive capacity and activity of the worker bees; on the other hand, when the queen dies or is lost in her mating flight, the absence of her pheromone stimulates a select number of worker bees to lay eggs which, however, produce only males that can carry the genetic material of the hive beyond the colony to guarantee the genetic survival (or immortality) of the larger bee community.

Let us look in some more detail at a typical bee hive. On average, apis mellifera live in colonies numbering 20,000 in winter, 50,000 in summer. Most honey bees now are domesticated, residing in wooden caves provided by their human keepers. While the smallest of all domesticated animals, the honey bee because of its pollination capacity, is of the greatest economic and ecological significance of all domesticated animals. During the summer season, the bees collect nectar to make honey, pollen to produce a protein-rich food, transporting the nectar in a special honey belly at back of their trunk, the pollen on their hind legs, as well as propolis which are plant saps collected from buds, fruits, leaves and flowers for use as sealants in hive construction and for medicinal purposes. The propolis is carried to the hive by the bees in a special pouch on their mandibles. The bees also build sexagonal cells from wax sweated from six glands located on their abdomens. In the cells the bees store nectar which they transform into honey by fanning, pollen which they ferment by mixing it with enzymes, and they use the combs as brood chamber, and as communication device. All worker bees are sterile females, male drones function exclusively to fertilize the single nubile female (not the queen in their own colony, but one encountered during feral mating with queens from other hives). Every colony has only one queen, recognizable by her long hind body. The queen lays up to 200,000 eggs per summer. The eggs metamorphose into larvae which pupate (Latin: doll, girl, puppet) in their cells and are fed royal jelly, a secretion produced by the worker bees in the hypopharanx and fed to the brood for a limited time as well as to the adult queen for as long as she lives. Fertilized eggs produce females, unfertilized eggs produce males. The worker bees who live a total of four to six weeks, cycle through sequential tasks: cleaners, builders, brood nurses, guardians and, finally, collectors. In summer the bees produce a few young queens by constructing larger, round-shaped rather than hexagonal, queen cells, and feed the pupae with the special royal jelly. Bee colonies multiply by swarming, with the old queen leaving the hive with a large portion of the colony. Bees survive the winter as a complete colony, contracting to a tight cluster and warming themselves through wing vibrations, with the required energy supplied from honey stores. Bees sting in self defense when threatened but not when approached gently.

The communication system of honeybees is a marvel of special interest. Rudolf Steiner held that bees communicated in the dark hive by taste and smell rather than by sight. Jacqueline Freeman, a biodynamic farmer who fosters a bee sanctuary in southern Washington, describes bee communication with each other and with the outside world (including the beekeeper) as vibrational, effected by the hum emitted by the bees which she describes as an inverted Om. She points out that the hum is not heard by the bees – they do not have ears – but rather is felt in their bodies. In her own perception, the hum of the bees is communicated as language: they speak to her and teach her of the wisdom the bees share to help us reach the next level of human evolution.

Jürgen Tautz has employed time lapse photography, microchips placed on the bees bodies, and other technical means to measure and document how bees experience the world through their visual and olfactory senses and how they communicate their experience to each other. Bees require knowledge to survive in competition with other organisms to harvest food sources from flowering plants. This knowledge can be based on genetic predisposition, on experiential learning, and on communication. How do bees learn? Colors, for example, do not exist outside of the perceptual world of living beings. They are created in the nervous system in response to electromagnetic waves, to which light belongs, depending on the sensory possibilities, and the significance of the produced categories for the survival and reproduction, of the organism. Bees can see colors, but they experience them differently from humans, and they have a highly developed sense of smell. They instinctively prefer blue and yellow, but learn to distinguish between color levels. The two compound eyes of bees each feature 6,000 lenses producing as many simultaneous images while the human eye features 1 single lens producing one image. Bees see ultraviolet light, i.e. short waves, while humans see long wave light. Bees therefore see black where human see red. In the course of evolution, flowering plants have developed reflective patterns on their coronas, which mirror ultraviolet light visible to bees but not to humans, which means that bees can see optical patterns that are invisible to the human eye. In speedy flight (30km/hour), bees do not see color at all, that is, their color sense is shut off until they reach their target at which point their sense of color is turned back on. Bee see in slow motion; while for humans rapid movements appear blurred, for bees they remain distinct, which means that they can see moving objects (swaying flowers, drones following the queen, and the like) clearly. Likewise bees possess olfactory capacities that are 1000-fold more powerful than the human, made possible by olfactory organs seated in individual cells located on the underside of their feelers (as are sensilla for touch, humidity and temperature). Thus flower aromas attract bees over long distances, and bees use air currents streaming toward them to identify aroma targets.

Unlike butterflies or flies, bees stay with the flower they began their daily work with. Bees quickly learn the patterned combination of color and aroma to identify a particular flowering. A single exposure to an aroma suffices for a bee to identify a target; color and patterns require 3-5 exposures. Experiments demonstrate that the learning capacity of bees matches that of the lower vertebrates, including mammals, distinguishing abstract conceptual pairings such as right-left, symmetric-asymmetric, equal-unequal, more-fewer. Bees are able to abstract rules and apply them to new situations. Tautz e.g was able to teach his target bees signs enabling them to negotiate unfamiliar labyrinths equipped with such signs. Bees are able to identify different localities and time schedules with specific decisions and activities, such as planning a work schedule to harvest different quantities of nectar at different times and sites, depending on the productive capacity of the target flower. Are these responses not signs of true “bee intelligence?”

By its very nature, the bee super organism is tied to a secure locality, and most bees stay at home much of their lives. But to harvest material and energy flows, bees must venture into a hostile world to find flowers and find their way back to the colony. For their orientation, bees make use of terrestrial aids using sights and smells from trees and bushes as landmarks in practice flights to map the hive surroundings, and celestial aids such as the sun and polarization pattern of bundled sunlight on overcast days. Assessing the position of the sun and polarization patterns includes awareness of compass changes arising from the earth's diurnal rotation. The bees' sense of time also allows them to gauge the time of day when flowers are opened and produce nectar and to visit accordingly. If a food source is exhausted, it is struck from the bee's memory; on the other hand if bad weather prevents harvesting a known food source, bees are able to remember the location for up to a week.

If a bee finds a plentiful food source, she returns up to ten times to determine the quickest and straightest route; after that she returns to the hive and informs her co-workers through her dance.
Bee master Karl von Frisch (1886-1982) observed that if a food source is within 50-70m from the hive, the bee performs a round dance; if farther away, the bee performs a waggle dance, throwing her lower abdomen from side to side at a rate of 15 times/second alternating from side to side; then the bee runs in an arc back to the starting point of the waggle dance and repeats; next time she runs in the opposite direction back to the starting point and repeats again, the whole dance cycle being carried out in an area of no more that 2-4 cm on a selected area of the comb. Time lapse video recordings have shown that the circular movement is actually an illusion created by the rapid body oscillations produced by the

wing muscles pulsing while the wings are uncoupled. The frequency of the pulses correspond to 230-237 wing beats per second moving the body forward as a leg is lifted to gain better footage. As the leg is lifted, the rim and wall of the cell responds with a felt oscillation. Groups of worker bees surrounding the dancer imitate the dance with stereotypical exactness. The dancer indicates the direction of the food source by positioning herself at an angle, where one vector points to the position of the food source, the other vector to the position of the sun indicated in the dark hive by the deviation of the sun's position relative to gravity (the cells of the combs being precisely perpendicular). When the informed worker bee emerges from the hive, she factors in the position of the sun to establish the direction of the food source. A newly recruited worker may need 30 times as much time to find a signaled food source than the experienced worker bee. Therefore, mixed groups of up to ten bees fly together, the experienced bee circling the target with swooping flight maneuvers and emitting an aromatic substance from the Nasanov gland located at the tip of her abdomen.

In the world of honeybees, reproduction occurs in two ways, sexual mating and swarming. Again, I turn to the research carried out by Jürgen Tautz and his colleagues for the information. Normally sexual reproduction couples the two genders to produce offspring which again couples for reproduction. In the case of bees, however, only the queen couples, with up to 20 drones from among thousands of males she encounters on her maiden flight to a gathering place (lumen) several hundred feet in the air, to produce 2-3 daughters annually which will reproduce in the old, or in a new, nest. The queens reproduce for several years, the drones only once, and numerically speaking offspring production is extremely low among bees. In most other species, the numerical relationship between male and female is the opposite: few males can fertilize many females. Where the reproductive rate is low, genetic survival requires protective care of the young from birth to sexual maturity (as is the case of humans as well as bees), provided by the mass of sterile (female) worker bees.

Reproduction by swarming occurs when the old queen leaves the hive with about 70% of the worker bees when a young queen is ready to reproduce. Her bridal gift includes 30% of the worker bees (the youngest and oldest) plus ready-made combs filled with honey and pollen. In moderate climates like ours, swarming normally occurs between April and September, leaving behind enough brood to replace the departed workers. Preparation for swarming is indicated by the construction of queen cells at the lower edge of the combs, or in the middle of the brood nest, colonized with eggs. When the first queen larva is developed sufficiently to pupate, the cell is lidded, and the old queen leaves the hive a few days before the new queen emerges. Accompanying worker bees fill their crops with honey to last for 10 days, during which time the swarm must have found a new permanent abode. Just before swarming, the bees emit high frequency vibrations and scratch and bite the queen to make her move. A bee fall emerges from the hive and collects near the hive in a tight cluster, sending out scouts to look for a new home. If the remaining population is not strong enough for further division, the workers destroy the remaining queen cells and repeat the cycle later.

The remaining daughter super organism develops its own genetic signature by the new queen mating with multiple drones on her maiden flight. Even a colony that occupies the same nest over time, alters its genetic makeup with each new generation. The super organism is the same and yet different. The primary swarm around the old queen retains its genetic identity until the old queen is replaced.

For the queen bee the cycle from embryonic development to reproductive mating is one month; however, normally a whole year passes before a new queen is produced, extending the life cycle of the queen bee to nearly 12 months. The queen bee continuously lays eggs which develop into sterile females, unless the worker bees start building queen cells and feed the eggs laid there with royal jelly, thereby actively manipulating the generational succession through their action. By division into daughter colonies, the super organism effects a different and simplified life cycle rhythm, bypassing the 4-fold life cycle phases of the individual organism from egg, to embryo, pupa and adult. Genetically, sexual reproduction is the indispensable requirement for evolution. The honey bees avoid death of the super organism through reproduction by colony division, while also retaining genetic evolution through sexual reproduction through the mortal queen. The immortality of the super organism is made possible by the continuous replacement of its members, every 4 weeks to 12 months of its worker bees, ever 3-5 years of its queen. Drones live 2-4 weeks. At a population of 50,000 and a daily death rate of 500 (1%), the entire colony is replaced within 4 months, except for the queen. A new queen, however, changes the genetic make-up of the colony entirely; this happens either when a new queen is raised to enable colony division by swarming, or when an emergency queen is raised in case of disaster.

Honeybees leave the autonomous world of the hive to collect matter and energy for their survival and to support annual colony increase. Solar energy provides plants to produce organic substances harvested by bees. Flowering plants and bees support each other in the most important task (telos) of all living organisms, which is reproduction. Through pollination the bees accomplish the sexual reproduction of plants. The “fruits” of bee colonies are the production of branch colonies. In this sense the sexual organs of the super organism (queen and drones) are the “seeds” of the bees.

We have noted the honeybees productivity as pollinators, but what about bee productivity in regard to nectar, pollen, propolis and wax? Tautz estimates that only 15% of worker bees can carry nectar and pollen simultaneously; the rest are specialists, carrying one or the other, or performing other tasks in the hive. 5-20% of out fliers are strictly scouts informing the colony of new food sources or a new hive cavity. A strong colony produces an average of 300 kg of honey in a summer, 85% of which is consumed to energize temperature regulation in the hive, with 15% left for winter storage or harvest by bee keepers. On average, a bee returns 50 times as much energy to the nest as she uses per flight, about 50 kg per bee lifetime. 1 mg of honey is calculated to provide 12 joules of metabolic energy.

Temperature regulation in the hive is indeed one of the most critical tasks carried out by designated heater bees who insert their upper torso into open cells and, with their wings uncoupled, rev up their wing muscles to create heat transmitted to surrounding brood cells. Amazingly, the social roles of the honey bees are modified by temperature levels in the brood stage. Bees raised in cooler temperatures tend to be employed inside the hive, those raised in maximum temperatures of 36 degrees Centigrade tend to focus on outside work, nectar collection, scouting, communication (dance), and display higher levels of learning capacity. Summer bees live an average of 4 weeks and tend to be raised at higher temperatures. Winter bees can live up to 12 months and can becomes active in the second season as collector bees: they are raised at lower temperatures. Temperature regulation in the hive also includes cooling, as needed. Selected worker bees can be seen standing at the hive entrance fanning air into the opening; inside other workers fan to transport the fresh air to the center of the hive.

What about wax production? The honey comb is an integral organ channeling matter, energy and information throughout the super organism, effecting the homeostasis of the colony. Worker bees spend 90% of their life on the comb. 12-18 day old worker bees produce most of the wax from 8 glands on their bellies, kneading the wax with their mandibles while adding glandular secretions. When building a comb in a new location, a colony builds an average of 100,000 cells and investing 7.5 kg honey in metabolic energy.

The comb starts with wax randomly placed on the roof of the cave and developed into a hexagon of geometrically perfect cell walls exactly 0.07mm thick, angled at exactly 120 degrees, and sloped slightly toward the cell floor. The distance between neighboring combs is 8-10mm, allowing two bees to pass each other back to back. The combs are precisely perpendicular to the cave floor, made possible by the sensory apparatus in the joints of the bees registering gravitational pull. The perfect geometric design of the cells which has elicited the awed admiration of artists, philosophers and scientists alike, is actually a function of the crystalline structure of the wax assuming hexagonal shape when heated to temperatures of 37-40 degrees C by the bees. How did the bees learn to make use of this phenomenon? Goethe would surely call it an “Urphaenomen” (primordial phenomenon) reflecting irreduceable laws of cosmic forces shaping the material world. (Tautz would call it the fixed rules of evolution). The inherent geometry of the cells is modified statically and dynamically by the bees, using propolis (i.e. sap scraped from plants) to manipulate the cell design as needed. Beekeepers and scientists have been puzzled by how the bees starting the construction of a comb from opposite sides can meet in the middle of the comb with a perfect seam. Jacqueline Freeman proposes an answer, reporting that she has observed bee construction crews hanging from the top bars of the hive, measuring the perfect arch of the comb-to-be with their bodies, just as the architect of a house might measure out the foundations with the measure of his feet.

What I have intended with this abbreviated description of the complex and mysterious world of honey bees is to instill an appreciation of their ecological role beyond the economics of pollination. Certain themes emerge:

1. The honey bee super organism represents a preeminent example of a complex adaptive system. As defined by John H. Holland (1929-), an adaptive organism features mutually responsive actors, with decentralized controls arising from competitive/cooperative individual decisions in a self-organizing and -regulating, homeostatic system exhibiting emergent phenomenological characteristics, including communication, specialization, spatial and temporal organization, and reproduction. In biological, adaptive systems the whole is more than the sum of its parts, and the whole shapes the actions of its parts. In the bee super organism homeostasis occurs on the level of the individual bee and on the level of the whole colony. Collective activities achieving balance of the whole include comb construction, climate control and hygiene. The socio-physiology of the colony massively shapes the characteristics of individual bees. Temperature regulation is effected through heating and cooling, optimal cell design and distribution of cell space for brood, feed storage and heating, in response to external temperature levels and to internal communication (dance). Faced with new tasks or emergencies, super organisms respond by increasing the activity level of current workers, reassigning

workers to new tasks, or recruiting new workers.

2. Presence of honey bees is absolutely essential for biodiversity, and without honey bees sustainable management of renewable resources is not possible. As Albert Einstein is supposed to have said, “if the bees disappear, we have three or four years to live: no bees, no flowering plants; no plants, no agriculture; no agriculture, no food.” Supporting the honeybees supports human existence.

3. As biodynamic beekeeper, Günther Hauck, urges we must shift beekeeping from a functional, profit-oriented, mechanical approach to spiritual, organic practices on the basis of reverence and awe for life's inherent mystery. Holistic organic biology provides the framework to unlock the secret life of bees with modern physical and molecular methods; however, beyond the language of science, we must learn, as Jaqueline Freeman urges us, to grasp the unitary intelligence of bees by listening to the bees themselves with empathy, love, intuition, and imagination.

4. Fundamentally, best management practices need to shift in the direction of allowing the bees to exist in keeping with their own nature, or (to speak with Aristotle) express their “telos” or indwelling purpose.

5. A handful of simple but far-reaching recommendations sum up the biodynamic approach to beekeeping:

- Stop mobile beekeeping and urge industrial-scale orchardists to plow up some of their acreage to provide the plant-based diet bees require to maintain themselves year-round. Urge farmers and gardeners to create bee sanctuaries on their own acreage, however large or small.
- Stop the practice of replacing queens with artificially raised females and ensure genetic diversity by allowing bees to mate ferally.
- Stop using pesticides such as neo-nicotinoids to control bee infestations with Varroa mites and other pathogens; instead strengthen bee immune self-sufficiency by cautious applications of the remedies employed by the bees themselves, such as formic and oxalic acids, both (as Rudolf Steiner understood) essential to all life processes.
- Stop feeding bees with high-fructose corn syrup and other synthetic nutritional substitutes. Instead feed the bees first by allowing them to nourish themselves from their own honey and pollen stores before removing any of these for profit.
- Stop using wax foundations and conventional box hives, and instead allow bees to build combs from their own bodies and house them in structures that imitate natural bee caves such as top bar hives and Warre hives, tree stumps, straw skeps, or hives made from mud and manure.
- Ask the bees: Look to see what they do naturally and as much as possible emulate their practices!

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