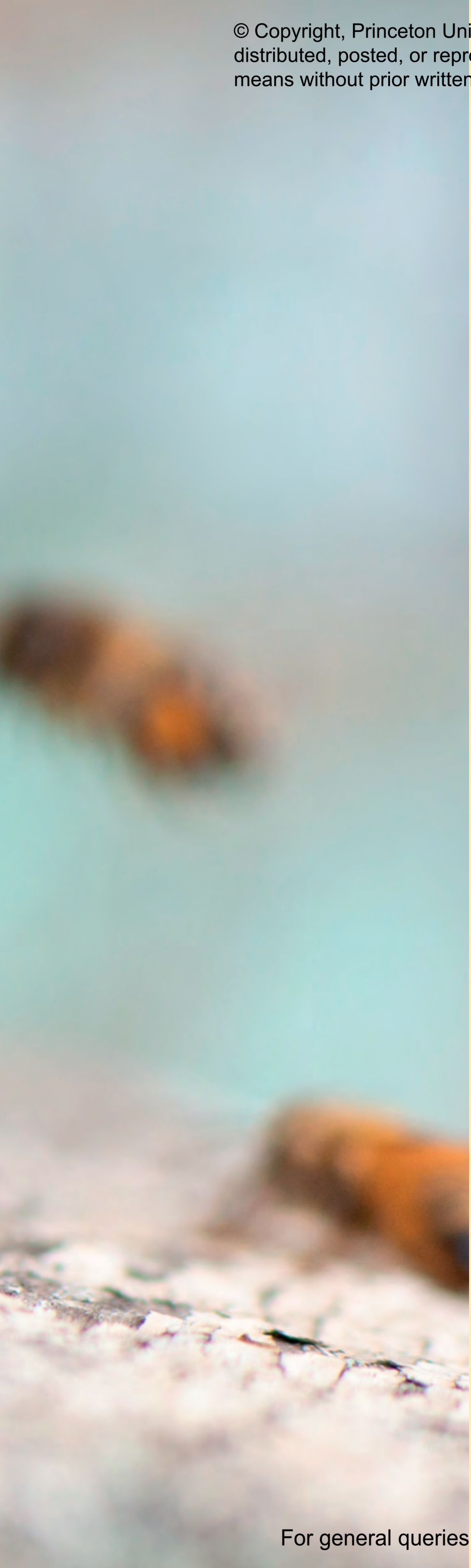
© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.



Contents

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

they don't have the burden of caring for their offspring. They sneak their eggs into another bee's nest, and—when the cuckoo eggs hatch first—the young cuckoo larvae kill and eat the host bee's eggs. Still not satisfied, the cuckoo larvae then eat all of the honey and pollen the nest owner had collected for her own family. When the raiding cuckoo bees finish pupating and emerge as fully formed bees, they go on to mate and start their sneaky plundering cycle all over again.

Solitary bees are everywhere, yet rarely seen, as they go about their remarkable lives in their own private microcosmos. But their fanbase is growing, especially among farmers and backyard gardeners who have seen their fruit trees and cover crops flourish as a result of their discreet handiwork. Commercial alfalfa growers are so pleased with native bees that they now use large bee boards drilled with thousands of artificial nest cavities to lure leafcutter bees to their crops. Fruit farmers do the same to attract the blue orchard bee.

Smaller versions of these "bee hotels" can be purchased or easily made by the home gardener, by creating a nesting container out of an aluminum can, a cinder block, a bucket turned on its side, or PVC pipes, or by constructing a wooden frame and then packing the vessel with hollow tubes. The tubes can be straws, plant stems, bamboo, or carboard tubes, anywhere from one-sixteenth to half of an inch (13 mm) with one end plugged and the open ends facing out of the container. The tubes should be anywhere from 5 to 8 inches (13 to 20 cm) long. Plants with hollow stems that work well in bee hotels include asters, sunflowers, honeysuckle, bee balm, sumac, and wild rose.

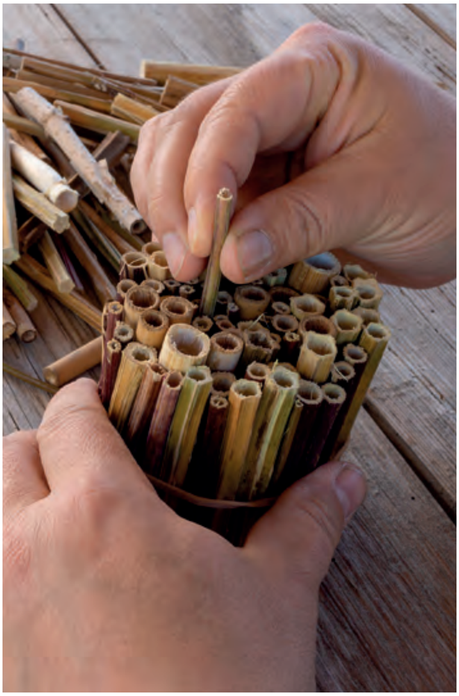
Bee hotels often have other types of rooms and suites to attract a variety of native bees, such as pine cones, small logs with drilled holes, stacks of sticks, or wads of dry grass.

Bee hotels should face the morning sun and be placed waist-high above ground, attached securely to a fencepost, building, or tree so they don't shake in the wind. The chances of native bees moving in will go up if the hotel is placed within 100 feet (30 m) of flowering plants. If the native bees like the hotel, they should move in by spring and should be sealing their nests by the end of summer. Once they emerge the following spring, it's a good idea to put fresh tubes in the bee hotel and clean the old ones with a solution of half a cup of bleach to a gallon of water (roughly 100 ml to 4 liters) to prevent diseases from building up in the tubes.

"Bee hotels" are easily made at home using recycled (such as the food cans and olive oil canister here) and natural materials (such as hollow stems, dried grass, and pine cones). A good variety of natural materials should attract a good variety of bee species.

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.



For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

In the process known as festooning, bees work together, leg to leg, in hanging grape-like clusters (festoons), to create the honeycomb.

Life cycle of the honey bee

At the height of summer, a vibrant hive may contain anywhere from 20,000 to more than 50,000 honey bees. Bee colonies are matriarchies, made up of tens of thousands of female worker bees, several hundred male drones, and just one queen mother. The queen is the lifeblood of the colony because, as the only fertile female, she's the only bee in the colony that lays eggs. Yet she's not the ruler, because a hive is a collective body that makes group decisions, including whether to overthrow their queen if her egg production starts to lag.

Beekeepers must be able to distinguish between the three types of bees inside a hive because they all have different functions and collaborate to keep the colony healthy. Populations of drones and workers fluctuate during the year in response to the colony's needs and the weather, so it's important to be able to look inside a hive and quickly assess if the colony is in sync or in trouble.

Workers

The worker bee has always been a she. Everything that needs getting done inside a hive, from cleaning to nursing to wax building, is done by the females that comprise over 90 percent of a bee colony. Worker bees are also the foragers, gathering all the pollen, nectar, and water for the colony. Every bee pollinating a flower is a female.

Adult worker bees are infertile females, whose ovaries have shrunk in response to the presence of the queen's pheromone. If a colony loses its queen, a worker's ovaries can develop and allow her to lay eggs, but because she is infertile, she will produce only male drones.

Worker bees are up to three-quarters of an inch long (12–15 mm), with four wings that can hook together, five eyes that can see polarized light, and two antennae that serve as their sense of touch, smell, taste, and hearing. They have brushes and baskets on their legs for collecting pollen. Their stingers are barbed and remain behind when they sting, eviscerating the honey bee as the stinger tears away from its abdomen. Because of this, honey bees will avoid stinging unless they believe their nest is under attack and self-sacrifice is absolutely necessary. Before they sting, they give several warnings—buzz flights or headbutts—to get the perceived intruder to move back.

A worker bee lives for up to six weeks during the busy seasons of spring and summer yet can live for several months overwintering in the warm cluster inside the hive. She begins life

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

as an egg deposited at the base of one honeycomb cell: a small white pin about the size of a grain of rice. Within three or four days, she hatches. For her first few days of life as a larva, she's fed a diet of royal jelly, a protein-rich milky-white secretion from worker bees. Unlike developing queens, which are fed a constant diet of this jelly, worker bees switch to feeding their developing sisters a combination of honey, pollen, and enzymes they mix into "bee bread." Around the eighth or ninth day, workers seal the larva's cell with a layer of wax. Inside, the larva transforms into a pupa and metamorphizes into an adult. At the three-week mark, the new worker bee chews her way out of her cell, ready to go to work.

From the moment the worker bee emerges, she's on the clock. A worker bee spends most of her life in complete darkness inside the hive as a "house bee," promoted through a hierarchy of increasingly complex jobs. These promotions are preprogrammed, in that her body gains more capabilities as she matures, until after about a month indoors she's ready for her final assignment—foraging outside the hive as a field bee.

Worker bees begin their careers as janitors. Newbies clean the honeycomb, removing bits of wax and dirt from the cells, and polishing them so they can be reused for another egg or to store more honey or pollen.

After cleaning duty, bees transfer to nursing care. Nurse bees roam the nursery, feeding larvae the royal jelly they secrete from their hypopharyngeal glands located between their eyes and their brain and mandibular (lower-jaw) glands near their lower jaws—the "brood food" glands located in their heads. They also take nectar and pollen stored in the honeycomb, mix it together to make bee bread, and feed it to the developing bees. A single larva will be checked by nurse bees over a thousand times a day.

Some nurses are private nurses—they bring food and water to only the queen. Because the queen can't feed herself or keep warm at night, she relies on her daughters to bring her honey and cluster around her when the temperature drops, shivering their wing muscles to keep her warm. They do this by unlinking their flight muscles from their wings and gunning their muscular thoracic engines.

Construction is the next stage of life. At a week old, a worker bee's body starts excreting little wax flakes from under its abdomen. Other bees grab those wax flakes with their mandibles and chew them, mixing them with their enzymes until the consistency is pliable. Builder bees cluster together like dangling bunches of grapes and pass these blobs of wax up the line, and then sculptor bees take those blobs and shape them into stacked

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

Another example of cooperation in the hive: here honey bee workers exchange food—in the animal behavioral process known as *trophallaxis*. The exchange of food also serves as a means to communicate information via pheromones.

hexagons to make honeycomb. This assembly line process is called *festooning*.

After wax building, bees can choose from several career paths. There's warehousing, where they off-load nectar and pollen from the incoming foragers and store it in the pantry. Air conditioning is another possible job. On hot days, bees stand at the hive entrance and fan their wings to circulate cool air and keep a steady indoor temperature of around 95 °F (35 °C). Undertaker bees detect the scent of death and decay—oleic acid—to locate a dead bee inside the hive. They drag the corpse to the entrance and push it out or carry it out of the hive, flying with the deceased in its clutches and dropping it at a safe and hygienic distance from the hive.

Some bees join the security detail. Guard bees patrol the hive entrances, pushing out anyone who doesn't belong. Common intruders are wasps, ants, mice, lizards, birds, and even robber bees from nearby hives that take advantage of weak, defenseless colonies. There is one exception to the intruder rule. If a wayward honey bee comes to the door bearing a gift of nectar or pollen, sometimes the guards will wave her through.

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

Finally, after a worker bee has had enough indoor training, she enrolls in flying school. She joins a group of students for short practice flights, each time circling the hive in wider and wider circles memorizing landmarks. Her eyesight is extraordinary for such a small creature, and she's aided by five eyes that can see in a 300-degree range. There are two compound eyes on either side of her face, and three light sensors called *ocelli*—shiny bumps in a triangle formation on the top of her head that are smaller than the head of a pin. She uses her ocelli to sense changes in light intensity, especially the sun's movement that tells her which way is up, helping her orient her body in space when flying. Her fuzzy hair senses wind direction and her own speed. She can fly up to 20 miles an hour (32 kph), by beating her wings 230 times per second. Her speed slows to 12 miles an hour (19 kph) when she's carrying provisions back to the hive. She can transport loads that weigh as much as half her body weight.

Bees use their eyesight while navigating, but don't rely on it as much as some of their other senses, as sight isn't one of their strongest. They have a combined 7,000 lenses on all their eyes, each one angled slightly differently than its neighbor, allowing them to see a pixelated image of all those different views patched together. They can make out larger objects, such as their hive, in a range of up to 3 feet (90 cm). They see polarized light, which forms patterns in the sky as it moves and assists in navigation. And they also see ultraviolet light, turning flowers that look like one color to us into dazzling marquees with colorful stripes like arrows pointing to the nectar center. What we see as blue and purple flowers become mesmerizing white beacons to a bee's eyes, which is why they are attracted to so many plants in that color range. They are unable to see the color red.

Once it selects a flower, the honey bee unfurls a long, curled, hollow, tongue called a *proboscis* into the depths of a flower to suck up the thin nectar. She stores the nectar in a special area in her body, somewhat like a temporary stomach, called a *honey sac*. The nectar mixes with her enzymes as she returns to the hive, where a house bee begs her to regurgitate it by tapping her antennae on the forager's antennae. This prompts the forager to give the nectar to the receiving bee, who presses the substance on her own proboscis, removing moisture as she ingests it into her body. Then she passes the droplet to another bee, and so on, and so on, in a process of communal digestion called *trophallaxis*. Finally, the bees store it inside a honeycomb cell and fan it with their wings until the right amount of moisture has been removed. Nectar begins as 70 percent water, and when the bees are done passing it around

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

and fanning, it's honey with a water content of less than 20 percent. They then seal up the cell with a thin layer of wax to store the honey away to eat later after the nectar flow dies back.

Some foragers specialize and collect only honey or only pollen. Some do a little of both. Others fetch water. A honey bee collects pollen on the hairs on its body, and then uses brushes on its legs to sweep the pollen into hairy depressions on their hind legs called *pollen baskets*. They fly back to the hive with full baskets that look like lentil-sized saddlebags, where house bees are at the ready to help them off-load the pollen bits into storage cells inside their pantry.

Drones

Drones, meanwhile, are work averse. Their bodies are not designed for labor—they have very short tongues that can't reach nectar inside flowers; they lack stingers; their blunt-tipped abdomens have no wax-producing glands; and their legs lack receptacles to collect pollen. They take about three days longer to develop from an egg than worker bees. Drones are heavier and stockier than than the females, with heads that are almost completely covered by two enormous compound eyes. They need excellent vision for the one job they were created to do: track down a virgin queen and mate with her on the wing.

Drones spend their lives lounging about the hive, begging to be fed, depending on the females for protection, and waiting for the possibility that a virgin queen will fly by in springtime. If she does, her scent awakens the drones from their restful state, and they spill out of the hive to congregate high up in a big cloud. These drone gatherings are referred to as *drone congregation*

Male honey bees—drones—swarm together in specific aerial locations to mate with queens. Drones can gather in groups of up to 10,000 individuals.

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

areas, or DCAs, and they can be seen from the ground. They are neighborhood hangouts for all the drones in a certain radius, which will keep returning in the hope that one day they will get lucky. A virgin queen knows to follow these all-male gatherings, and when she reaches one, she slows down and flies through them, secreting the pheromone decanoic acid, a scent that lets the drones know she is ready to mate. Only the swiftest and strongest drones reach her, and she will mate with up to 20 drones a day, over several days. Unfortunately for the drone, however, he dies immediately after mating. His genitals extrude and rip away from his body, and the castrated male falls to the ground.

If the drones don't die during the spring mating season, they are certain to meet their demise in the fall. As the colony heads into winter, it's common to see drone corpses piling up outside the hive entrances, as the workers evict them to conserve food resources for the upcoming lean winter months. Workers turn on the drones, dragging and pushing them out of the hive where they will soon die of starvation and exposure. The females gang up on the males, tearing at their wings and legs, tussling at the entrance in a final turf battle. The males are considered expendable because the queen will simply make more drones the following year when colonies start rearing virgin queens and males are needed again.

The queen

The queen bee has only one job—to make more bees. Luckily, she's very good at it. After her series of mating flights, she returns to the hive with enough eggs and sperm stored in her body to lay eggs for the remainder of her life, which can last from one to three years. She can lay more than double her body weight in eggs—up to 2,000 eggs a day at the height of the season—ramping up when flowers are plentiful and scaling back in winter.

She can keep this pace because she has an entourage of worker bees bringing her food, water, and warmth around the clock. These attendants also encircle her as she searches the honeycomb for a suitable cell to lay an egg, clearing a path so she can get a clear view. One way to find the queen is to look for the "daisy"—a circle of bees, all with their heads faced inward toward the queen, forming what looks like petals on a flower. These are her bodyguards who part the crowds for her.

At about an inch (25 mm) long, the queen is narrower and longer than the workers and drones. She is easily identifiable by her extended abdomen where her eggs are stored, which accounts for most of her length. Without the need to fly outside the hive to forage, her head, eyes, and thorax are smaller. She has a smooth

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

Queen (or supersedure) cells—where larvae develop and mature into new queens—protruding from the honeycomb. Shaped like a peanut shell, the cells are around 1 inch (2.5 cm) long, and have a rough surface texture.

stinger so she can sting repeatedly if she needs to defend herself against a challenge to her throne.

Each queen has her own unique pheromone, a scent marker that gets passed around inside the hive letting the workers know their queen is alive and healthy. The queen pheromone is a cocktail of more than two dozen known chemicals that she secretes from her jaws as well as her feet. This chemical signal is picked up by the queen's attendants who constantly groom and feed her, who then touch the other bees with their antennae to spread the message. The queen also leaves scent footprints behind on the honeycomb.

Which bee gets to be the queen is a combination of good timing and survival. When a queen is aging or injured, or has died, her pheromone thins inside the hive and workers get the signal it's time to replace her. Workers choose several fertilized eggs to turn into queens, and while only one will eventually take the throne, the rest are considered insurance. The worker bees feed the chosen larvae a solid diet of royal jelly and begin constructing queen birthing chambers for each that look like peanut shells protruding vertically from the honeycomb. When the first queen is about to emerge after 16 days, she makes a series of high-pitched peeps, by

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

pressing her thorax against the comb and vibrating it. This "piping" sound is an audible pulse, sent as a vibration message through the honeycomb, and serves two purposes: it alerts the workers to help her chew her way out of her birthing chamber, and it is a battle cry to the remaining queens who are still in development.

Once the queen bites a circle into the tip of her wax enclosure and pushes it outward like a little trapdoor, she's free. Her first order of business is to kill her competitors. This is where her smooth stinger comes in handy, allowing her to sting repeatedly unlike the one-and-done barbed stingers of the workers. She follows the piping sounds coming from the remaining sealed queen cells and chews a small hole in the side of each so she can sting her rivals to death.

Sometimes, two queens release themselves at the same time. In that case, there will be a duel to the death. The two queens vying for the throne instigate a no-holds-barred wrestling match, seizing one another with their legs, grappling and biting, bending their abdomens to try to get the first sting. Their battle draws an audience that waits eagerly for the victor. As soon as a queen tears off a leg or an antenna, or stings first, the rest of the bees form a ball around the losing candidate and suffocate her.

Victory is not all that sweet, however, because the slim virgin queen is largely ignored by the colony until her pheromones change a few days later, signaling that she is sexually mature. Suddenly, the workers are highly interested. They follow her, vibrating with excitement, tugging on her wings to motivate her to leave the hive for her mating flight.

When the newly mated queen returns to the hive, her abdomen swollen and elongated, she remains fertile for the rest of her life. It takes only a few days after her successful mating flight for her to start laying eggs. She deposits one egg per honeycomb cell, along with a drop of sperm, to create a worker bee. If she deposits only an egg without fertilizing it, the egg becomes a drone.

It's the beekeeper's job to ensure that the factory inside the hive is humming along, that everyone is present and accounted for, and satisfied with their work environment. Which can be boiled down to one very important question: Is the queen happy?

The answer is yes if she's being followed by an entourage of adoring attendants, and if her laying pattern is on point, meaning she is distributing her eggs in wide, solid swaths in the warmest center of the nest. If her laying pattern is scattershot, or dwindling with each inspection, it could mean the queen is failing. Another way to tell if things may be off with the queen is by the bees' response upon opening the hive. Do they make a hum or a roar?

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

Relaxed bees ignore the beekeeper during hive inspections, too busy going about their chores to pay much attention to anything else. Unsettled bees with a troubled queen are jittery—they run instead of walk on the honeycomb, they tremble, or show defensive behaviors like crouching together and peering up from between the frames or headbutting the beekeeper's veil.

If there are excessive drone cells in the nursery, or eggs laid haphazardly with multiple eggs in one cell or sticking sideways from the cell walls instead of standing neatly upright at the bottom, that means a worker's ovaries have developed in response to a missing queen. The worker is trying to lay eggs to save her family but, because she's infertile, all she's doing is producing nonworker drones, which will inevitably lead to the colony's downfall.

Regular hive inspections help beekeepers notice a failing queen when there's still time to turn things around by replacing her. While hobbyists can see good queens last several years, many commercial beekeepers replace their queens annually rather than spend labor-intensive hours monitoring thousands of hives for queen health.

Beekeepers can buy mated queens from suppliers or raise their own. The benefit of buying is that it saves time and effort, especially in an emergency, when a colony has entirely run out of eggs, but the downside is that it's not a sure bet the new queen will do well in your microclimate. The advantage of the DIY method—taking developing queens from your strongest hive and placing them into your weak ones—is that it is a more reliable way to produce bees that are already adapted to your location.

Selectively breeding queens with strong genetics is the hallmark of a self-sufficient beekeeper. By keeping an eye on which colonies are mite-free, produce lots of eggs, and have bees that are gentle and make a honey surplus, the beekeeper can intentionally reproduce queens from their best stock and strengthen the entire apiary.

To do this, beekeepers use a grafting tool to carefully remove eggs from a strong hive and transfer them individually into specially designed cups on the underside of the top bar of a wooden "queen frame." The circumference of the cups spurs the bees to start building queen cells and to rear the larvae as queens. Workers start feeding the transferred larvae royal jelly and enclosing them in queen cells dangling from the cups. When the developing queens are finally sealed inside wax birthing chambers, the beekeeper can carefully remove one of these queen cells and put it into a hive that has been without a queen for at least one

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

A beekeeper holding a queen frame, where worker bees develop queen cells below the plastic cups. Inside these birthing chambers, larvae are developing and maturing into new queen bees.

day. The bees will start caring for the developing queen as one of their own, and if all goes to plan, a locally adapted queen will emerge after 16 days and right the troubled colony. Provided she mates successfully and starts laying eggs, the hive can restore its workforce and bounce back.

Breeding queens at home only works to strengthen hives if the beekeeper can keep good records and remember which colonies produced solid queens. One way to keep track is to mark queens on their thorax with a dab of colored paint or an adhesive number to record the year a new queen was introduced to a hive. Queen marking helps beekeepers be sure which queen is producing which results. Also, if an unmarked queen suddenly appears on the scene, beekeepers will know immediately that the colony has replaced their original queen.

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

Life in the hive: communication and survival

Life inside the hive is pitch dark, and what we would consider sweltering. The temperature is kept at an average 90–95 °F (32–35 °C), with 60 percent humidity. It's also quite noisy. A hive emits all types of sounds, depending on the group conversation inside. Standing next to a hive, you can hear a contented purring; a staticky crackling; sometimes a hive sighs; other times a worker inside lets out a high-pitched screech. If you rest your ear on the hive wall, you can hear a sound like chewing, and the ping of bees dropping to the floor, and feel the vibrations contained within.

Over millions of years, honey bees have developed ingenious ways of communicating in their dark sauna. Without the ability to hear audibly, they rely on scent, touch, and sound vibrations that are passed through the surface of the comb as an in-house PA system. For a species that must defend a hidden sugar cache from sweet-toothed invaders, its survival has depended on its ability to pass messages broadly and quickly to alert the colony to danger, food sources, and to the health of their queen.

The main way honey bees sense the world around them is through their antennae. These two swiveling bent appendages behave as their ears, nose, tongue, and fingertips, allowing them to recognize fellow hive members and talk to one another. Their antennae have taste receptors, as do their mouthparts and their feet. They use their antennae to feel the texture of flowers and decipher where different blooms hide nectar.

Their antennae are covered in thousands of sensory hairs that can detect air movement inside the hive from beating wings, and scent receptors on the tips allow honey bees to parse out the hundreds of unique odors their bodies release as messages, lures, and repellants. Each antenna contains approximately 65,000 olfactory receptor cells, and because their antennae can move independently of one another, honey bees also gain directional information about an odor. They experience a smell, but also the three-dimensional cloud-shape of it. They can "see" the scent hovering over a patch of flowers.

Honey bees have one of the most complex forms of scent-communication in nature, with at least 15 known glands that produce a menu of odors. One of the most important is the queen's pheromone, which is kept at a steady level inside the hive when her attendants touch her with their antennae and then touch their hive mates, which then distribute it bee-to-bee throughout the hive. This assures the whole colony that everything is all right with

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

This extreme closeup, head-on shot of a honey bee shows the antennae, huge compound eyes, and, at the bottom of the picture, the mandibles—the last used for a variety of tasks such as cutting, carrying, fighting, and grooming.

the queen. A weakening queen pheromone signals the workers to start building queen cells to replace her.

When confronting enemies, honey bees release an alarm pheromone when they sting that smells like ripe bananas. It's a rallying cry that attracts hive mates to assist in the attack. This is the primary reason beekeepers use smokers, to overpower the chemical alarm so the bees won't receive the call for backup. Honey bees have a second alarm pheromone that releases 2-heptanone from their mandibular glands, a chemical that temporarily paralyzes robber bees and other invaders, giving the honey bees time to drag the criminals out.

A lemony scent is used to summon workers to important areas, such as a food source or a nest site. Honey bees release the odor from the Nasonov's gland located in the tip of their abdomen and then fan their wings to disperse it. Honey bees use this aggregation pheromone to call foragers home after a rainstorm, or to gather the colony back together after a disruption, such as being relocated to a new hive by the beekeeper. Scout bees will direct a swarm to a new nest by zipping through the traveling cloud of bees and releasing the scent. The chemicals smell like lemongrass oil, which is why some beekeepers douse cotton balls or paper towels with this oil to try to lure swarms to empty hives.

Talking via odor is not unique to adult bees. Developing brood release a pheromone that helps nurse bees to distinguish between the hungry young larvae that need their attention and the cells that are already sealed with developing pupae. Drones release a scent that recruits other male drones to congregate in areas where there are virgin queens.

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

Although honey bees don't have auditory hearing, they can sense vibrations across the surface of the honeycomb and pick up sounds through "vibroacoustics." They can feel the piping and quacking sounds a developing queen makes before she releases herself from her cell, alerting them that an overthrow is coming. They can feel the buzz-running of their nestmates as the colony prepares to swarm. They pick up vibrations with their antennae and with thin membranes inside their legs that ripple in response to soundwaves. They even feel the 200- to 300-hertz frequencies produced by the vibrating flight muscles of their dancing sisters.

Dancing is one of the most remarkable ways that honey bees communicate. Animal scientists have discovered that the duration and intensity of their dance, plus the direction of their dance in relation to the sun, all serve as GPS coordinates to tell the other bees where to find flowers or a new nest site.

Austrian zoologist Karl von Frisch (1886–1882) was the first to discover and explain honey bee dancing in 1927, for which he later won a Nobel Prize. He got there by wondering why so many bees from a single hive gathered on the same plant to forage. He watched their comings and goings very closely and observed foragers returning to the hive and repeatedly walking in circles on the honeycomb, and then switching directions and doing it again. The movements seemed deliberate and urgent to von Frisch. By following the circling bees back to their food source, he was able to determine that this round dance was a type of message, a signal that food was relatively close to the hive, within approximately 165 feet (50 m).

However, when the bees did a more elaborate waggle dance, crawling in a figure eight and shaking side to side each time they crossed the middle of the eight, that meant the food source was beyond 165 feet (50 m). Von Frisch determined that the angle of a bee's dancing body represented the direction of the nectar or pollen source in relation to the sun, so if she turned right after crossing the middle of the eight, the flowers were to the right. A left turn indicated the opposite direction. If the bee flew up, it was an indication to fly in the direction of the sun. If she dipped down, the flowers were in the opposite direction of the sun. The longer the dance went on, the farther the distance to the flowers. A honey bee dances with more enthusiasm if her find is particularly sweet, and with less gusto if there are threats or obstacles to negotiate en route.

Sometimes, the audience disagrees with the dancer's message. If there's a danger that's been discovered near the flower source, workers will headbutt the dancer to get her to stop. Nestmates

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

will do the same thing to dancing scout bees, urging a move to a new location, if they prefer a different home than what's being advertised.

Without the ability to see in the dark, the audience picks up the dancer's information from vibrations on the dance floor and by touching her with their antennae as she shimmies. They also gather information by tasting the nectar and pollen samples dancers pass out to recruit others to bring back more. Subsequent studies of honey bees reared in isolation have showed that bee dancing is innate, not learned from observation. Honey bees, in other words, are born to dance.

Keeping the hive happy

Successful beekeepers understand how their honey bees interact with their unique environment and keep their hives happy by giving them the right supports at the right time. The key is knowing how to read a colony and interpret what the bees are planning to do, then supporting their natural instincts, rather than trying to force the bees to conform to human will.

A colony's size and shape changes dramatically with the seasons, going from a small overwinter cluster to quadrupling in size once the nectar starts flowing. If a colony can be spared the work of having to warm a drafty hive or cool a crowded one, the bees will have more energy for honey and brood production.

For honey bees to thrive, they must be kept healthy in a place that's as pristine as possible, free of chemical exposure, and with access to abundant year-round food and a reliable water source. They will need to be kept warm and well fed to ease the stress of getting through winter and monitored regularly for mites. And they need an attentive beekeeper who has the will, and the time, to keep careful notes on the health of each hive.

Beekeepers typically don't take vacations in spring and summer at the height of bee season, when they are monitoring their hives multiple times a month, moving their hives to croplands, or harvesting honey. To share a life with bees means a measure of personal sacrifice, adjusting and adapting to the bees' schedule. One of the biggest mistakes new beekeepers make is thinking honey bees are "plug 'n' play": that all they need to do is put the hive in the garden and watch the bees go to work pollinating the landscape. Excited about the honey, the new beekeeper harvests too much, before the colony has built up enough for its own needs, leaving the bees to starve over winter. Newbie mistakes are just one of the myriad reasons a hive can dwindle; besides beekeeper neglect, a hive could perish from poor nutrition, a weak queen,

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

Top left: The beekeeper has added a mouse guard to protect the hive entrance from invasion.

Top right: A polystyrene hive box helps keep the colony temperature at an even, warm temperature during the winter months.

parasites, pests, pesticides, or some combination of any of these.

The beekeeper who stays ahead of a hive's needs can eliminate potential pitfalls, strengthen weak hives, multiply strong ones, and help the bees produce excess honey so the keeper can harvest a portion. It's the beekeeper's responsibility to make sure the bees always have a clean, comfortable home with a strong queen and enough food, so they have the best shot possible to combat predators and diseases.

To do this, it's important to monitor the ever-changing size of the colony, to make sure the bees always have the right amount of space. This means adding more brood boxes and honey supers in spring and summer when the population is expanding, removing entrance reducers to permit more traffic, and replacing solid bottom boards with screened ones to increase airflow.

Hive equipment can't be used forever. An attentive beekeeper knows to throw out old honeycomb frames and hive boxes that have holes and cracks. Fresh wax is brilliant white and translucent, but it starts yellowing with age, and as it thickens over months and years, infused with propolis, pollen, silken cocoons, and larval feces, it will turn black and harbor mold and disease. It looks nasty,

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

and the bees tend to agree. They will get sick and/or leave.

Depending on location, an apiary may need a good windbreak, so if the hives are not positioned near large trees, fences, or walls, beekeepers can use tie-downs or heavy rocks to secure the hive covers. In places with lots of snow, the hives may need to be wrapped and insulated. In cold weather, honey bees hang together and shiver their wing muscles to keep warm, with those on the outer edge of the cluster constantly cycling back to the center, so the heat disperses evenly between all the bees. If the temperature inside the hive drops below 50 °F (10 °C), the bees can't travel far beyond the protective warmth of the cluster, and if stored food is too far away, they'll starve. Beekeepers can help them keep warm by placing large boxes over hives with insulating material, wrapping hives in blankets, or covering hives in black roofing paper to absorb heat. Some beekeepers put an empty super hive box on top of the inner cover with the escape hole screened, and fill it with leaves, newspaper, or cloth. Warm air rises from the colony through the screened inner cover hole and is captured in the absorbent material above.

Infrared cameras can reveal the relative size and warmth of the colony inside the hive. There are infrared camera attachments for cell phones, making it relatively easy to get a picture of what's going on inside without having to open the hives and sacrifice precious heat.

Honey bees also need enough food to get through winter. A colony should have at least one hive super filled with honey-laden frames placed directly over the brood, with more frames of honey and pollen on each side of the nursery. This is the time

Here the beekeeper is feeding their bees with a jar of homemade sugar syrup to help them through the cold, nutrient-poor winter.

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

to thicken their supplemental sugar water, in a ratio of two parts sugar to one part water and replenish it as soon as they consume it. If they are low on pollen, they can benefit from manufactured or homemade pollen patties.

As one of the oldest creatures on the planet, arguably honey bees have developed exquisite survival techniques. But there are ways to help them fight pests and predators, so they don't have to deploy them. If you see scratch marks near the hive entrance, that means the hive is too low to the ground and accessible to skunks, squirrels, and racoons, which scratch at the hive at night to get the bees to come out so they can eat them. Make sure your hive is on a stand, or cinder blocks, placing it out of reach. Metal mouse guards that cover the hive entrance, allowing just a row of small holes large enough for the bees to pass, can help keep out not only mice but also snakes and lizards.

Depending on where you live, creating a fenced-off apiary might be a wise decision in order to deter bears, mountain lions, bobcats, foxes, or vandals. Motion lights pointed away from the hives can also keep unwanted intruders away.

When it comes to battling pests and parasites inside the hive, there are many different types of natural and chemical treatments, which will be further explored in the upcoming chapters. However, there are a few things beekeepers can do to try to prevent these problems from occurring in the first place. The main one is to check the colonies regularly for mite infestations, but especially in the fall—when *Varroa destructor* mites are at their seasonal high. Beekeepers can use powdered sugar, or alcohol washes, on a sampling of bees to extract the mites, count them, and extrapolate the size of infestation. Other methods of keeping mite counts low include the use of a screened bottom board, so that the mites that fall through can't return. Because mites feast on larvae, some beekeepers encourage the bees to build excess drone larvae—by placing a shorter honey frame in a deeper brood box. The bees will build a hanging sheet of drone cells from the small frame and, once the cells are capped with developing drones, the beekeeper can slice it off. This will remove the drones, as well as all of the breeding mites feasting on drone larvae behind the closed cells, reducing the overall mite load. Instead of tossing away the drone bait, consider this: if there are chickens nearby, they will gladly tear open the drone brood and have a feast, with no danger caused to them from the mites.

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

Individual intelligence versus hive mentality

The bee's brain is roughly the size of a sesame seed. But there is a lot of intelligence packed in there, from the way they build mathematically uniform hexagon honeycomb, to how they make democratic decisions about when to swarm, to—as more recent studies have indicated—the capacity to count, to recognize human faces, and even to reverse their age.

In 2022, German zoologist Lars Chittka (born 1963) of Queen Mary University of London published *The Mind of a Bee*, which argues that the most plausible explanation for bees' ability to perform so many different tasks, and to learn so well, is that they possess a form of general intelligence; a bee consciousness that puts them on par with dogs and cats as sentient creatures.

Chittka and his colleagues trained bumble bees to roll a small ball into a hole for a sugary reward, leading to a viral video of "bees playing soccer." His team discovered the bumble bees could train one another to push the ball into the hole, yet even more surprisingly, the student bees could also find better solutions than their teachers; they didn't blindly follow instructions but used their own individual intelligence to score a goal faster.

This, Chittka argues, is exactly the kind of smarts a bee uses when foraging alone. It takes some amount of learning and memory to be able to fly miles from home, visit thousands of flowers, disregarding the poor ones in favor of the nectar-laden blooms, only to navigate back to the correct hive to off-load, then go back out again, remembering the previous route. Not only are bees memorizing their flight paths, but they are also constantly updating and relearning them, when one food source withers and another comes into bloom.

Behavioral ecologists study the ways in which honey bees interact with each other and solve practical or complex problems. Here, a bee returns to the hive and "dances" to communicate the location of a nectar source to other workers.

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

Perhaps bees memorize their routes by counting landmarks. In one of Chittka's bee experiments, forager bees were trained to fly past three identical landmarks—in this case, 11-foot-tall (3.5-m-high) yellow triangular tents—to a food source. Then he added more identical tents over the same distance. The bees tended to land closer to tent three, before reaching the food source, leading Chittka to conclude that the bees were going off memory, counting to three and stopping. When he reduced the tents to just two, the bees flew past the food source, presumably searching for an expected third tent.

There is an old beekeeper myth that honey bees can recognize their beekeeper's face. In 2004, visual scientist Adrian Dyer, then at the University of Cambridge, England, tested it out. He and his colleagues pinned black-and-white photographs of four different human faces onto a board. By rewarding the bees with sugar water, the team repeatedly coaxed them to fly toward a target face, even after moving it to different locations. When the sugar reward was removed, the bees continued to approach the target face up to 90 percent of the time. And the memories stuck; the bees could pick out the target face up to two days after being trained. It's also likely the bees were simply being trained to think the faces were "bizarre flowers," but the experiments caused a stir in both science labs and popular culture because they illustrated the flexibility of bee learning.

Later, in 2012, researchers took the plasticity of bee intellect even further, with a study saying that older honey bees may be able to reverse brain aging. When older foragers with typical age-related cognitive decline changed social roles and reverted to nursing care inside the hive, their brains started producing proteins associated with more youthful nurse bees, according to a study by scientists at Arizona State University and the Norwegian University of Life Sciences. Researchers found that when foragers returned to a social role designed for younger bees, their learning ability increased. Looking at the brains of these role-reversal bees, researchers found increased levels of antioxidant proteins that maintain and repair brain cells, including one similar to the human protein peroxiredoxin-6 that defends against inflammation associated with Alzheimer's disease and Huntington's disease. Scientists are now looking to the honey bee as a potential source of dementia research innovation.

Either together or apart, bees are smart. As for the collective consciousness of bees, one of the most astonishing examples of hive mind is what's known as swarm intelligence—how honey bees make a democratic decision to relocate to a new home.

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

When a hive is full, with no more space to store honey or eggs, it will divide itself in two. This is how bee colonies naturally reproduce in the wild. Managed beehives swarm, too, especially if the beekeeper hasn't provided enough room for the expanding colony in spring and summer. While this poses less of a problem in rural areas, where such swarms can return to the wild and rehome themselves in a crook of a tree or rock crevice, it creates more of a problem for the urban beekeeper whose swarms can settle inside house walls, under hoods of cars, on fences, in trees in public parks, and all sorts of inconvenient places that often make the local news.

Inside an overcrowded hive, the queen's pheromone spreads too thin, diluting as it gets dispersed among so many bees. When a colony starts swelling above 60,000 or 70,000 inhabitants, the bees are pushed so far away from the queen that they start to lose her scent. This triggers them to start rearing new queens from a handful of the eggs in the nursery. Once the new virgin queen emerges, half the colony will swarm away with the old queen to reestablish themselves in a new location.

When a colony is getting ready to swarm, the first thing it must do is put its queen on a diet, so she loses enough body weight to fly. Her attendants, who had been grooming and feeding her daily, start rationing the queen's portions. They start forcing her to move more, grabbing her with their forelegs and nipping at her to keep her going. Like personal trainers, they prod her to run all over the honeycomb, so she slims down.

Meanwhile, the queen's daughters have a feast. They gorge themselves on honey inside the hive, so they'll have enough calories stored to carry them through the move. The wax glands of young bees start activating, sensing they will soon be put to work building fresh honeycomb somewhere else. Tiny, transparent wax scales start protruding from the undersides of their abdomens, which they will chew and mold into building material.

Life inside the hive during a lead-up to a swarm is as loud as a subway rush hour, all the bees urgently running in a roiling cacophony of sound. If you put a microphone in a beehive as it's preparing to swarm, you will record what sounds like driving rain, with occasional motorcycles revving, flocks of angry seagulls squawking, and whining dentist drills. These are the sounds of scout bees, buzz-running over the comb, emitting high-frequency squeals to rouse their sisters into swarm mode. They shake their abdomens against the comb to create a vibration that other bees feel as pulses in their feet, rising to their knees, which are sent as nerve impulses to the brain. The scouts nudge, push, and alert their nestmates that it's time to go.

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

A honey bee working in the hive collects fallen wax scales produced by other workers to build comb.

Then, just before the swarm takes off, everything goes quiet. The bees stop moving and hang on the combs, as if exhausted and catching their breath. If you happen to be standing outside a beehive at this very moment, you will suddenly see tens of thousands of bees pouring out of the hive and rising into the air, a moving inkblot in the sky, with their hungry queen safely hidden in the middle of the swarm.

The colony will land in a clump not far from the hive, typically on a fence or a tree branch, and hang there for several days deciding where to go next. Scout bees leave the cluster to go house-hunting for a permanent home, and when they find a spot they like, they return to the swarm and dance to advertise the address of the tree cavity or rock crevice they found. Dr. Thomas D. Seeley (born 1952), professor at the Department of Neurobiology and Behavior at Cornell University, followed individual bees as part of his research for a book on swarm intelligence, titled *Honeybee Democracy* (2010). He discovered that many scouts go house-hunting at once, and they fall in love with different properties. They dance on top of the bee cluster, each scout campaigning for the home they like the best. The audience takes the information, goes out to inspect the homes, and then picks their favorite. They return and dance with the scout whose home they prefer. Over time, whichever scout assembles the largest dance crew, and thus the largest number of votes, wins. And the colony flies off once again, typically within a week of leaving its hive, to the chosen spot.

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

Top left: A honey bee swarm can be a disconcerting sight, as on this fencepost, but is a perfectly natural part of a colony life cycle. Top right: Here a honey bee swarm has created a colony in an abandoned black woodpecker nest in a tree. Bottom: A swarm hanging from a tree.

If the colony's new home is away from human eyes, then people are none the wiser. But if it moves into the walls of a building or a public place that interferes with people, that's when it's time to call a beekeeper, not an exterminator. Local beekeeping clubs keep lists of *swarm catchers*—area beekeepers who will remove outdoor swarms or cut them out of walls and collect the bees. Typically, the service is free in exchange for the bees. An exterminator, on the other hand, will kill the bees with chemical spray and bill for it.

One way to prevent a hive from swarming is to split a crowded colony in two before the bees take matters into their own hands. There are signs to look for in a hive that wants to swarm. Look for small, open cups near the bottom of the frame, with the cup openings pointed downward. These are signs that the bees have begun building peanut-shaped queen cells that protrude from the comb.

Now is the time to divide the hive by removing the original queen and half of the colony into an empty hive, along with some frames of honey and pollen. This way, the beekeeper has preempted the future swarm by moving it before it is left on its own, eliminating the need for the swarming bees to search for a new home. The bees left behind in the source hive will quickly realize their queen is gone, select some eggs, and start feeding them a constant diet of royal jelly to develop them into queens. The strongest of the royal candidates will take over as the new virgin queen and, after she's been on her mating flight, she will return to the hive and begin laying eggs.

Splitting does have its risks—the new queen might not be strong, she might not mate properly because the available drones are genetically weak or too few, or she might get injured or eaten by a bird during her mating flight. Some beekeepers like more control over the outcome of splitting so, instead of waiting for the bees to make a replacement queen, they install a mated queen instead. If the colony accepts her, she can begin laying right away, and the colony doesn't have to wait for a virgin queen to be born, her ovaries to develop, and for her to embark on her mating flight.

Whichever way a beekeeper manages swarming, it's important to provide plenty of sugar water to the newly divided colonies, because splitting is stressful on the bees, even at the height of the honey flow. They need easy access to food as they adjust to a new home, a smaller family, and a new queen.

Learning to read hive dynamics can bring beekeeping to the next level, pulling the beekeeper and the bees into a closer relationship, one that is not only mutually beneficial, but full of wonder and boundless discovery, too.

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

BEEKEEPING TASKS AND EQUIPMENT

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

For general queries, contact info@press.princeton.edu

© Copyright Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

Beekeeping Tasks and Equipement

A beekeeper's year

Beekeepers typically spend a minimum of 15–30 hours each year managing a single-colony apiary, to ensure they are meeting bees' needs and keeping them healthy. Count on another 12 hours for each additional colony. More experienced beekeepers, with over five to ten years of beekeeping, typically spend less time than a newbie beekeeper who is still learning the basics.

Beekeeping is strongly tied to the seasons and temperature, so it is helpful to follow a calendar of tasks to guide you as you seek to raise strong and healthy colonies. Even experienced beekeepers benefit from a checklist. Shifting the dates according to your local area and variable weather patterns, your beekeeping year varies widely depending on your location. The warmer your weather, the earlier in the calendar year you will start actively managing your colonies. In parts of the southern United States, bees can be active 12 months of the year because of the moderate temperatures. The calendar shown over the page, however, assumes that you and your bees experience four distinct seasons every year. It also assumes that you and your hives are in the northern hemisphere—in the southern hemisphere, simply swap January for July and so on.

The aim for this calendar is to provide a checklist of chores month to month, including feeding, hygiene, requeening, ventilation, protection, swarm reduction, and extraction. The beginning of the year sees the buildup of the bee population, and the later part the contraction of the population.

Previous page: An apiary in a city allotment.

Opposite: A beekeeper inspects the honeycomb in their hives.

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

JANUARY

Early inspections
(only in good weather—at least 40 °F / 4 °C)

1. Close and remove dead colonies.
2. Clean colony entrances, removing any drifted snow or ice.
3. Lift covers *briefly* to check three things:
   - amount of food stores;
   - cluster location;
   - presence of brood.
4. Feed weak colonies with fondant, loose sugar, and/or winter patties.
5. Clean/sterilize and refurbish old equipment.

FEBRUARY

Preparation for the coming season

1. Order new equipment and bee nucs or packages.
2. Undertake a *Varroa* count and plan treatment.
3. Cull frames, disposing of old damaged ones (over three years old) and ordering new ones.
4. Make swarm boxes.
5. Feed weak colonies with fondant, loose sugar, and/or winter patties.
6. Make any hive checks brief, picking a sunny day.
7. Paint beeswax on frame foundations.

MARCH

Often known as the "starvation month"—due to stress of brood rearing

1. Clean and scrape bottom boards, removing dead bees.
2. Remove mouse guards and entrance reducers.
3. Stimulate colonies by feeding with pollen patties and 1:1 sugar syrup.
4. Equalize colony strength by moving brood from strong to weak colonies.
5. Install packages mid-month.

APRIL

Buildup

1. Maintain active brood-rearing colonies by inspecting hives every seven to nine days:
   - Check on queen's status and brood pattern.
   - Check for presence of disease.
   - Practice good hive hygiene, cleaning tools after inspections.
   - Reverse brood boxes if necessary.
2. Practice swarm prevention by looking for queen cells.
3. Continue feeding as needed.
4. Start nucs or split strong colonies to increase colonies.
5. Set out baited swarm traps or boxes.
6. Begin testing and treating for *Varroa* mites.
7. Unite weak colonies.
8. Have extra hive bodies on hand for growing colonies.

MAY

Swarm season

1. Inspect colonies (*see* April).
2. Capture swarms, checking swarm boxes regularly.
3. Feed as necessary with 1:1 sugar syrup.
4. Add queen excluder, if using, and supers for honey flow.
5. Plant bee forage flowers.

JUNE

Queen rearing

1. Inspect colonies (*see* April).
2. Provide extra ventilation as weather warms.
3. Add more supers as needed.
4. Trap pollen for storage (if desired).
5. Rear queens, create nucs, and requeen.
6. Order honey containers and labels.

(continued...)

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

Index

Page references in *italics* indicate images.

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

For general queries, contact info@press.princeton.edu

© Copyright, Princeton University Press. No part of this book may be distributed, posted, or reproduced in any form by digital or mechanical means without prior written permission of the publisher.

For general queries, contact info@press.princeton.edu