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Cooperative Extension

Cooperative Extension: Maine Wild Blueberries

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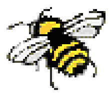
Replaces Honey Bees and Blueberry Pollination Cooperative Extension Bulletin 629. Frank Drummond Professor, University of Maine Cooperative Extension and Department of Biological Sciences. April 2002

The Honey Bee 

Introduction

Many species of insects visit flowers in search of nectar and pollen. In return for these foods, the insects inadvertently pollinate the flowers. The major groups of insect pollinators are the bees, moths, butterflies, flies, and beetles. Some of the common minor groups of insect pollinators are ants, wasps, thrips, and true bugs. Many native insect species are important pollinators of commercial food crops, especially the bees. About 25,000 species of bees are known throughout the world, and 2,000 species are native to the U.S.

In Maine, there are more than 50 species of native bees that are associated with lowbush blueberry. However, because of the alarming decline in native bee numbers over the past several decades (due to bee habitat loss, fragmentation, and pesticide use, farmers have relied more and more on managed bees (see the blueberry fact sheets on *Management of the Alfalfa Leafcutting Bee*, # 300; and *Commercial Bumble Bees*, # 302) for pollination of lowbush blueberry. Honey bees are the “work horses” of managed bees and some estimates suggest that honey bees account for 80% of the insect pollination in agricultural crops. The use of the honey bee in lowbush blueberry has increased tremendously over the past 40 years. In 1965, almost 500 honey bee colonies were brought into Maine for lowbush blueberry pollination. By 1985 about 25,000 honey bee colonies were brought into Maine for lowbush blueberry pollination, but by the year 2000, more than 60,000 colonies were brought into Maine for pollination of this crop.

The honey bee is the common name of the bee species, Apis mellifera L. This species, native to Mediterranean Europe, Asia, and Africa, was introduced into North America about 400 years ago for honey and wax production and crop pollination. This bee is different from many of our native bees in that it is social and lives in large colonies consisting of tens of thousands of sterile female worker bees, hundreds of male reproductives (drones), and usually a single female reproductive or queen. Most native bees are solitary (where individual female adult bees nest alone in the soil or in twigs), or primitively social (where female bees of the same species may share nests or even defense of the nest). There are some native bees that are social associated with lowbush blueberry in Maine. These species are represented by the bumble bees that live in small colonies, usually less than 100 individuals with a single reproductive queen.

While some native bees are specialists that have evolved as highly efficient pollinators of only one or two species of flowering plants, most are generalists that are capable of pollinating a number of native and introduced plant species. One of the strengths of the honey bee as a pollinator is that it is a very broad generalist and so it can be used for pollination of many different food crops. Other positive attributes of this bee for pollination are that: 1) it can be easily managed in artificial hives; 2) it can be moved into and out of crop fields during and after bloom; 3) it has excellent spatial memory capabilities and this in combination with its ability to communicate the location of nectar rich floral resources among worker bees, means that large numbers of honey bees can quickly take advantage of floral resources and pollinate crops that only flower for a short period; and 4) it can learn how to manipulate and thereby pollinate complex flowers that are not accessible to many species of generalists bees (although, see discussion of honey bees and blueberry flowers below). Some of the drawbacks of honey bees are that: 1) they are defensive around their colony and may sting; 2) having evolved in warmer climates, they usually do not fly on days where the air temperature is below 50º F; and 3) being broad generalists capable of learning and communicating, they can switch from foraging on the intended crop to other more rewarding resource-rich wild flowers.

What do honey bees look like? You are most likely to see an adult sterile female worker bee as it comes and goes from a hive or forages for nectar or pollen on a flower. **Figure 1** shows a honey bee worker and a queen (larger bee).

Figure 1

The worker is about 1/2 inch in length and its color ranges from light brown to dark brown to almost black (there are various races and/or subspecies of honey bees in the U.S. such as Italians, Caucasians, Carniolans, and Africans with differing pigmentation). The large eyes are usually shiny black and the thorax (where the six legs and two pairs of wings are attached) is covered with a dense mat of brown hairs. The abdomen is long and quite often characterized by alternating light and dark bands or rings. There are very few species of large brown bees in lowbush blueberry fields in Maine and so there is little chance for confusion. However, there is a syrphid fly (flower or hover fly) that is a bee mimic and is a similar size and color to the honey bee. Close inspection reveals that this fly has only one pair of wings and that the wings at rest are held in a delta pattern, unlike honey bees that hold their two pairs of wings parallel to their body.

Aggressiveness is a variable trait in the honey bee that we normally use in Maine for pollination of lowbush blueberry. The arrival of Africanized honey bees in the U.S. in 1990 means that growers and beekeepers should realize that these more aggressive bees could make their way into Maine during the pollination season. It is not considered likely that Africanized bees can survive the winters in Maine. The African subspecies was introduced into Brazil in 1956, hybridized with the gentler European races and spread rapidly throughout northern South America, Central America, and into the U.S. The Africanized bees are now established in some southern regions of the U.S. including: Texas, California, New Mexico, Arizona, Puerto Rico and St. Croix. These bees can be extremely defensive, stinging farm workers, passers-by, and livestock, especially after hives have been disturbed or managed. Growers are being warned of the potential for Africanized bees to end up in their fields and should inspect the defensive nature of all rented hives by walking around the hives (once settled in the location) and observe the bees during pollination. Any questions regarding the possibility of Africanized bees on Maine blueberry land should be forwarded to the state apiary inspector, Maine Department of Agriculture, Augusta, ME.

The Honey Bee Colony

The honey bee colony is usually composed of one queen, several thousand (5,000-75,000) workers, and several hundred drones. The wax that comprises the combs over which the bees cluster is secreted by the worker bees and comprised of adjacent six-sided cells for storing food and brood rearing. Brood refers to the immature stages of the honey bee.

The queen deposits a single, small, white egg in the bottom of a cell in a wax comb. She can be very fertile laying about 1,500 eggs per day. After three days, the egg hatches into a larva which is fed a mixture of pollen, nectar, and a rich protein secretion called royal jelly by worker bees for five to six days. **Figure 2** shows both uncapped and capped (sealed) brood on a comb.

The cell is then sealed by the workers and the larva develops into a pupa (a non-feeding resting stage), and then develops into an adult bee. The adult sterile worker bee emerges from the cell as an adult bee 21 days after the egg is laid. Queen bees require about 16 days and drone bees about 24 days to develop to adult maturity.

Figure 2

Colony population buildup occurs through the reproductive efforts of a single queen and the nursing, feeding, foraging, and defensive efforts of the sterile workers. During lowbush blueberry bloom most honey bee colonies are in a phase of rapid population growth and so pollen and nectar foraging should be at a maximum (given that the colony has a strong and healthy foraging force of workers).

Swarming is a process of colony reproduction in which the colony splits. When a colony is crowded or if an old queen is failing, the workers will begin to raise a new queen. Just prior to emergence of the new adult queen, the majority of workers will issue from the hive with the old queen in search of a new location for the colony. First, this part of the colony will usually cluster in a large mass surrounding the old queen, typically, on a branch in a tree. Scout bees will leave the swarming colony and search for a protected nesting site (usually dark and dry, often a tree cavity). When scouts find a nest site they return to the swarm and direct the mass of bees and the queen to the new nest site. The part of the colony that remains in the hive will support the new queen that emerges. If one queen emerges before any other queens she will sting and kill the others so that only one queen usually heads the colony.

Workers visit flowers to collect both pollen and nectar (about 5-30% of flying honey bees are collecting pollen). Pollen is collected when it becomes entangled with the dense branched hair on the bee body. The bee combs the pollen from the body hair and packs it into pellets on specialized curved spines on the hind legs (pollen baskets) for transport to the hive. About 50-350 flowers are visited per pollen load brought back to the hive and a given bee will make between 1 and 50 pollen collecting trips per day. Pollen is necessary food (protein and lipid source) as is the honey made from nectar (carbohydrate source), for rearing brood. Pollen and honey are stored in the wax comb for the colony's use. The amount of food material collected and stored depends upon many factors, including: the available flora, colony strength, bee race or subspecies, weather, and available comb space.

Water is also essential for the welfare of the colony and is collected to dilute honey consumed by the bees and to regulate the colony temperature and humidity. On hot days colonies may be stressed and suffer if deprived of water even for only a few hours. Much energy is expended by honey bee workers when transporting food and water to the hive. A grower, using honey bees for pollination, will profit by placing the hives inside the field, but close to a water source. Colonies should be placed in a sunny location, near water (or supplied with artificial pools of water), and also placed in a location that is protected, as much as possible, from the wind since high winds reduce the frequency with which bees will leave the hive to forage.

Pollination of Lowbush Blueberry

The Blueberry Flower and Fruit

Lowbush blueberry flowers grow in clusters on the last several inches of the stem. The white, greenish, or pink petals of the flower are united to form a tubular or bell shaped corolla, which hangs open-end downward. Ten stamens (stalks bearing the anthers containing the male germ cells or pollen) are inserted at the base of the corolla, around the style (female organ containing the female germ cells or ovules). The style extends beyond the stamens, out of the corolla and is receptive only on its tip, the stigma. **Figure 3** shows a picture of a lowbush blueberry flower with petals removed to show the style and stigma (in green) and stamens surrounding style (in brown). The ovary is at the base of the style.

Figure 3

During the period of stigma receptivity, pollen is released through pores on the end of the anther (these unusual anthers are called poricidal and can be envisioned as a salt shaker; when the anthers are shaken or agitated by a bee they release pollen). Nectar is produced in nectaries at the base of the corolla. The amount and concentration of nectar increases from 0 to 48 hours after anthesis (onset of pollen release). Because the anthers are protected by the bell-shaped corolla and the pollen is relatively heavy and sticky, wind does not aid in the pollination process. Stigma receptivity may last five to eight days depending on the weather and clone genetics, among other factors (for instance, the plant micro-nutrient is believed to extend the period of stigma receptivity in blueberries). However, if pollination does not occur within two to three days after the flower opens, fruit set is less likely and by 7-8 days becomes improbable. As soon as fertilization occurs (fusion of pollen and ovule germ cells), the flower begins to lose its attractiveness and development of the ovary (fruit) begins.

The ovary matures into the many seeded (fertilized ovules) berry that ripens two to three months after flowering. The berry may contain as many as 65 small seeds which do not interfere with fruit palatability. The number of developing seeds per berry influences the size and rate of ripening of the fruit. More seeds result in larger and earlier maturing berries.

There is considerable variation between genetic clones, geographic regions, and between years (i.e.. weather) in the pollination of lowbush blueberry in the field. Many lowbush blueberry clones growing under favorable conditions are, typically, capable of setting up to 80-90 percent of their blossoms. Some may even reach 100 percent. However, in June there is often a drop of fruit by the plants. This “June drop” may range from slightly greater than 0% to 60% of the set fruit, depending upon weather and probably clone genotype. There is, however, considerable self-sterility (3-90% self-sterility reported in some studies) and some cross-sterility in lowbush blueberries (some of this might be due to clones that are completely male sterile, but some of this is due to inter-specific incompatibility). This sterility results in failure of fertilization or early abortion of fruits. There can be multiple species of Vaccinium, generally referred to as lowbush blueberry, as many as five species in some fields. In addition, in some fields, 45% of the lowbush blueberry clones produce scarce amounts of pollen. With so much self-sterility and pollen scarcity, free transfer of pollen between clones is essential to maximize fruit production. Therefore, it is critical that bees be locally abundant or be brought into fields to insure cross-pollination between clones. Since insect pollination is essential for maximum blueberry production, failure to produce good crops is frequently the result of poor pollination. The lowbush blueberry plant species diversity will be a major consideration in determining whether the additional expense of bringing in honey bees to maximize pollination is cost effective. This is discussed next.

Incompatibility Among Lowbush Blueberry Species

As briefly mentioned above, some fields have many species that are commonly referred to as wild lowbush blueberries. These include, but are not limited to, the common lowbush blueberry (Vaccinium angustifolium), sour top blueberry (V. myrtilloides), dryland blueberry (V. pallidium) and huckleberry (Gaylussacia buccata). It is suspected that many of these species overlap in some of their flowering times and that in general, crosses between some species do not result in fruit. For instance, it has been found that pollen from sour top can pollinate and fertilize flowers of common lowbush blueberry, but several days after fertilization the ovary aborts and the berries drop off the plant. Because sour top pollen can fertilize V. angustifolium ovules causing them to abort, these ovules are prevented from being fertilized by compatible pollen, thus lowering fruit set in a field containing these incompatible species. This fact is believed to be the root of the controversy regarding the advantages of using honey bees for pollination. Some fields show a tremendous increase in yields when honey bees are placed in blueberry fields (sometimes as great as 1,000 lbs / acre increase in yield for every hive, up to five hives per acre, added in a field), whereas other fields show little, if any, increase in yield with an increase in honey bee stocking rate. It has been shown that fields with a large proportion of sour top (about 50% of the lowbush blueberry plants) have an expected fruit set, at best, of 50% no matter how many honey bees are placed in the field. Therefore, the decision to place honey bees in a lowbush blueberry field is a complex one that starts with knowledge of the composition of lowbush blueberry species that make up a given field. Ideally, it seems that it would be most desirable to manage fields that have few blueberry species, preferably only V. angustifolium, with a high diversity of cross-fertile clones. Another important criteria in determining whether one should use honey bees for pollination is the extent of the native bee pollinator force in a field. This is discussed next.

Insect Pollination of Lowbush Blueberry
Growers may fertilize, prune, control insects, diseases and weeds, irrigate, and follow other cultural practices, yet without the insect pollinators, first among which are native bees, their crops may fail. No other cultural practice will cause blueberry fruit to set if its pollination is neglected. If native bees are not in adequate abundance then management practices should be implemented to conserve and increase native bee populations (see fact sheet # 301). Until native bee populations increase in size, commercial pollinators such as honey bees (see fact sheet #224), alfalfa leaf cutting bees (see fact sheet # 300), or commercially available bumble bees (see fact sheet # 302) MUST be used.

Blueberry pollination is performed naturally by native bumble bees and solitary bees. Fifty-nine species of native bees have been observed in native lowbush blueberry fields. Bumble bees, when present, play a major role in blueberry pollination. The bumble bee works a few blossoms in one spot, then flies and works another spot, thus facilitating cross-pollination between clones. Bumble bee queens forage up to 400 yards from their nest site. Because of their size, they can shake out and distribute a large quantity of pollen from blueberry flowers. What makes bumble bees especially efficient pollinators is that they work the bloom at a very high speed (10-20 flowers / minute vs. 5-9 flowers / minute for honey bees), in addition, bumble bees are buzz pollinators (i.e.. they vibrate the flower shaking the pollen from the poricidal anthers) unlike honey bees. Bumble bees can place more than 50 pollen grains upon a lowbush blueberry stigma in a single floral visit (0-10 for a honey bee). Another characteristic of bumble bees that make them an efficient pollinator of lowbush blueberry is that they possess long tongues. This allows them to extract nectar from flowers with long corollas such as some clones of lowbush blueberry. It has been observed that honey bees will not visit all clones of lowbush blueberry. Some of the clones with long corollas and narrow corollar openings do not allow honey bees access to the nectar rewards of the flower. However, one disadvantage of the bumble bee is that only over-wintered bumble bee queens are present during the majority of the lowbush blueberry bloom period in Maine. Usually queens are not numerous, although some small blueberry fields that are not managed intensively in Maine have more than adequate populations of queen bumble bees to ensure maximum pollination

Many other native bee species are also natural pollinators of lowbush blueberries. Many of these species are solitary, but some are primitively social living in loose multi-female aggregations. Native bees nest mostly in uncultivated, sparsely vegetated, sandy soils, or they are twig nesters in a variety of shrubs that exhibit soft pith within their branches. Their flight activity is usually confined to their nests (200-800 yards of their nest). These bees are from many families and are quite diverse in size and habits, digger bees (Family: Andrenidae), sweat bees (Family: Halictidae), cellophane bees (Family: Coletidae), and mason and leafcutting bees (Family: Megachilidae). Some of the species such as Osmia atriventris, commonly called the Maine blueberry bee, is very adept at pollinating blueberry. It drums the anthers with its forelegs in order to extract pollen from the lowbush blueberry plant. Many of these species are excellent pollinators of lowbush blueberry, but may be negatively impacted by weather from year to year, parasites and diseases, and many of the common lowbush blueberry production practices (especially insecticide applications). Because of the year to year fluctuations in native bee populations, many blueberry growers use honey bee colonies for pollination in order to reduce the risk of having a year of poor pollination due to low native bee densities. In other areas, native bee numbers are never high enough for adequate levels of pollination. This is often the case in the blueberry barrens in downeast Maine.

So how does one know whether honey bees are a good management option? It is important to not only know the lowbush blueberry plant species structure in your field (discussed above), but also the native bee population strengths in your field.

Determining The Need for Honey Bees – native bee densities
One “rule of thumb” for lowbush blueberry states that independent of bee species (native bee or honey bee), at least 1.0 bee per square yard is necessary for adequate pollination (“good looking fruit set”). A more refined estimate of

fruit set suggests that in a period of one minute, 1.0 bee per square yard of blooming lowbush blueberry when it is sunny and calm, and the air temperature is above 65º F. A slightly different estimate (percent berry set) can be derived from a predictive model that Dr. Frank Drummond developed. A knowledge of the number of bees per square yard of lowbush blueberries in bloom will provide an estimate of the average expected percent berries at harvest. This predictor is derived from typical lowbush blueberry fields in Maine. This predictor is based upon the number of honey bees and native bees (recorded separately) counted per square yard of bloom in a one minute period. In all three of the estimates of adequate pollination mentioned above, counts on at least 10 different one square yard, marked quadrants of bloom should be made throughout the field to provide a representative average (for more detail see Fact Sheet # 204). The predictor model is based upon the premise that, on average, a single native bee is 2.3 times more efficient as a pollinator than an individual honey bee (derived from field measurements). The percent berries resulting from the percent of fruits (from pollinated flowers) remaining after June Drop (PB) is a function of the number of native bees (NB) and honey bees (HB) per square yard in a minute of observation:

$$PB = 14.5 + (7.8 * HB) + (17.7 * NB)$$

Using the above predictive model, if on average 3 native bees are observed per minute in a square yard of bloom, then the expected percent berries (PB) will be 67.5% or ((17.7 * 3) + 14.5). Now, if no native bees are present, and honey bees are used so that an average of 5 honey bees are observed per minute in a square yard of bloom, then the expected percent berries is 53.5% or ((7.8 * 5) + 14.5). It is important to remember that percent berries is less than percent fruit set…it is the proportion of berries remaining after June drop, or those fruit that will most likely mature into a harvestable crop. Forty to sixty percent berries (PB) is an average expectancy for a non-irrigated field in a year with adequate soil moisture. If one uses the above predictor, it must be realized that this is a linear model, and so it is possible to have bee densities which will yield greater than 100% PB. If this happens, just assume the prediction to be 100%.

All of the above estimates can be used to determine whether the bee foraging force (native bee or honey bee) is adequate for pollination, given that there are no serious problems with blueberry plant species incompatibility. However, the decision to invest in commercial pollination is more complicated than it appears. First of all, evaluating the native bee densities in a particular field in one year may not be a good index of the bee densities two years from that instance when the field is in bloom again. Native bee populations can fluctuate in lowbush blueberry fields considerably from one year to the next (from 2-10 times). At this point there is no means of accurately predicting the density of native bee populations into the future. Unfortunately, honey bee contracts usually have to be made during the fall or winter before bloom and so there isn't very much lead time for instantaneous decision making. There are two possible benefits to measuring your native bee densities. The first is to assess fields in the early bloom stage immediately before honey bee hives arrive. In this case, judgments can be made regarding the relative strength of native bee populations in each field and then honey bee hives can be apportioned to each field relative to the native bee strength, putting more hives in the fields that have the lowest native bee populations. This practice is only practical if hives are not placed in fields until 20-25% bloom (the recommendation). The second use of estimating native bee populations in a particular field is to gather long-term data on the bee populations for a given field (5-10 years) to establish the risk (1 year in 10 years or 3 years out of 10 years) that poor pollination will result in the absence of honey bees. This would be a good practice in small fields that may have high native bee densities most years.

However, the final analysis of any decision regarding capital expenditures to improve pollination should be based upon what the actual percent of berries on a stem are that have resulted from pollination. This is addressed below.

How to Assess Success of Pollination

There are a few ways a blueberry grower can measure the actual effectiveness of crop pollination. Inadequately pollinated blueberry fields have a "flower garden" appearance, but if the flowers are being pollinated and fertilized about as rapidly as they are receptive, the flowers lose their corolla soon afterward, giving the field a "greenish" appearance. Other signs of adequate pollination include ease of separation (popping) of the corolla when flowers are brushed by a hand, or stems laden with symmetrical fruit. The best way to go about measuring pollination success is to measure it quantitatively. Measuring yields at harvest is not always indicative of pollination success since other factors such as disease, weed, and insect pressure, and weather conditions such as temperature and rainfall may have significant effects on yield. A good method involves marking stems with embroidery thread or ribbon at loose cluster, just before bloom starts. At this stage flowers can be counted above the thread tie before they open. The stems can then be revisited a week after bloom has ended to assess fruit set (the percent of set fruit relative to the initial number of flowers). Later, by the middle of June (2-3 weeks after bloom) after June drop, the percent of remaining berries held on the plant that should mature can be estimated by counting the fruit and determining the proportion of fruit relative to the initial number of flowers. At least 30 stems, representatively taken from clones throughout a field, should be used in these estimates. In addition, knowledge of any frost damage, and insect or disease damage should be taken into account in determining whether these estimates reflect pollination or whether they might also include other factors.

If honey bees are decided upon for pollination, the grower must decide whether to raise honeybees or to rent hives from a commercial beekeeper.

What a Grower Should Expect from Colonies

The advantage of honey bees as pollinators over other commercial pollinator species is that supplies are usually adequate and affordable. While honey bees may not be the most efficient bee for lowbush blueberry pollination on an individual bee basis, the reason that they are good pollinators is that hundreds of thousands or millions of foraging workers can be brought to a field with a scarcity of bees. The economic benefits of bringing honey bees to a field can be considerable. Although hive rentals can be one of the single most expensive management practices in blueberries, it might also result in a high return. Definitive data on the cost/benefit relationship for renting hives are not available for lowbush blueberry in Maine. Grower survey data suggests that, on average, a correlation exists between honey bee hive stocking density and yield such that for every one hive per acre placed in a field, one thousand pounds of increased yield results (the data only cover the range of 1-5 hives per acre). However, we must be cautious in drawing a definitive conclusion from this data, because it may be that other influences are involved. For example, perhaps those growers that place more hives on their fields also practice more intensive pest management, fertilization, and irrigation, etc. Until we have better data available, the best practice for a grower using honey bee hives is to measure pollination success as the number of hives are increased over time. In this way each grower can find their own cost/benefit ceiling.

Raising Your Own
Having your own apiary is certainly a consideration that should be contemplated. The risks are not small (bee diseases, pests, overwintering losses), however, and it takes time to become a competent beekeeper. A grower considering this option is best advised to speak to the Maine State Apiculturist and to join a local chapter of the Maine State Beekeepers Association for expert advise.

Renting Hives
Renting hives during the bloom period is the most direct option for securing additional pollination, but it is also maybe the most expensive. Usually, the beekeeper provides transportation, and unloading and loading of the hives. It may or may not be your responsibility to provide bear protection (electric fencing), protection from insecticide exposure, and access to water for the bees. Having a clear written agreement is very important before entering into a commercial pollination arrangement. More information on renting honey bee hives (list of commercial pollinators) can be found in the University of Maine Cooperative Extension Fact Sheet #224. Whenever the renting of honey bee colonies is referred to in this fact sheet, overwintered permanent hives either from Maine or from the southern U.S. are the focus. However, in some localities, disposable pollination units (DPUs) are commercially rented for pollination. These are temporary inexpensive hive units (generally made of polystyrene) with a free or caged queen and 3-6 lbs of bees. The sole purpose of these hives is for pollination of the crop. The hives are destroyed or left to

die after bloom. Flight activity has usually been found to be higher in traditional hives, thus researchers recommend that growers use two to three times as many DPUs as traditional hives per acre. In general, DPUs are not a recommended for pollination if traditional hives are available.

Colony Strength – Considerations


Figure 4

To ensure that a good pollination service is being received, the grower needs to know about differences in colony strength. Colony strength refers to the number of bees in the hive and the population structure of the colony (does the colony have a queen and is the colony rearing brood, necessitating workers foraging for pollen. A strong colony has a minimum of 15,000 bees in each deep section (hive body or story). When the hive is opened, bees should immediately appear to "boil over" and cover the tops of the frames **Figure 4**. Beekeepers utilize different types of equipment in migratory operations. The width of the hives generally varies from 8 to 10 frame supers or boxes. Also, some beekeepers transport colonies in one deep and one shallow super. A colony for pollinating blueberry should be housed in at least a two-story hive (preferably two deep hive bodies), containing at least 30,000 bees, and have 6 to 10 full frames of brood in all stages of development. Remember that the physical size of the hive (number of boxes) is not a good indicator of the strength of the colony. It should be stressed that an accurate assessment of the pollinating strength of the colonies cannot be made merely by counting boxes. A hive might consist of several hive bodies, but the bee cluster size inside may fill only a single hive body.Some quick indications of colony strength can be obtained by watching the flight activity of the bees at the entrance. On a bright, warm day (greater than 55º F and winds less than 15 mph), dozens of bees should be constantly coming and going at each entrance as shown in **Figure 5**.

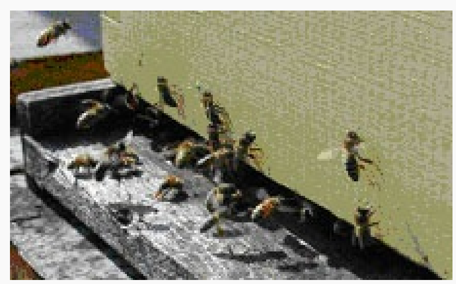


Figure 5

Fewer flying bees in front of some colonies may indicate that the colonies are not strong. Keep in mind that an examination of the colony inside the hive gives the best indication of its strength. To obtain a very crude "ball park" estimate of the foraging bee strength, count the number of bees RETURNING to the hive in 15 seconds. Then multiply this number by 0.06 (a factor that represents the proportion of an individual foraging bee's makeup on a well covered comb in one minute). This product (number of returning bees in 15 seconds x 0.06) will provide a crude estimate of the number of full frames in the hive well covered with bees. So, for example, if you count 125 bees returning to the hive in 15 seconds then 125 x 0.06 = 7.5 or the estimated number of full frames well covered with bees is 7.5, a good strong colony. If the number of bees returning to the hive in 15 seconds is too high to count, then count the bees returning in 10 seconds but multiply the number of bees by 0.09 instead of 0.06.

Determining Colony Strength – based upon bees on the comb

The best way to determine colony strength is to look inside the hive. Use a veil and gloves when opening the hive. Better yet, have the beekeeper open the hives for your inspection. The beekeeper will be skilled and knowledgeable in handling bees with minimum disturbance.

- Have the beekeeper smoke the entrance of the hive to calm the bees and then raise the cover. Dozens of bees should "boil over" the top. Hundreds of bees should also be seen on every frame.
- Next, the beekeeper should pry the supers or stories apart. More bees should be seen on every frame in both stories.
- Check all supers if the hive is more that 2 stories high. A colony with a cluster of bees on only a few frames near the center of the hive is generally too weak to be of much value for pollinating blueberries.

An additional and important way to estimate colony strength is by estimating the number of square inches of brood. This is because the presence of uncapped brood in a hive stimulates pollen collection – the prerequisite to pollination. To get an estimate of the square inches of uncapped brood, count the number of full brood frames and roughly determine the proportion of the brood that is uncapped, then multiply the total number of full brood frames first by the average proportion of uncapped brood and then multiply this product by 100. A strong colony should have 600 to 1,200 square inches of uncapped brood. A blanket of bees should be seen covering the brood. Another measure is: seven frames that are at least 60% covered with brood in all stages and 25% in the egg or younger uncapped brood stage as shown in **Figure 6.**

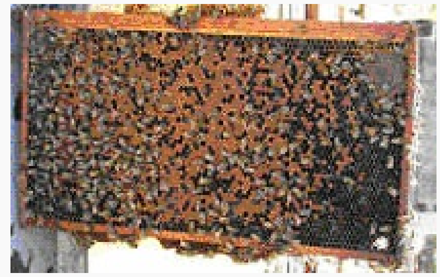


Figure 6

Pollination Recommendations and Practices

Evidence indicates that the grower will profit most, in terms of quantity and quality of berries produced, earliness of harvest and concentrated ripening, if the highest possible honey bee populations are maintained during flowering time. Most growers make some attempt at having honey bees near their fields. However, this supply is seldom adequate. There should be sufficient strong colonies to provide at least one foraging honey bee per square yard of field area during good bee weather (at a bare minimum). When the bee population is high, the more attractive blossoms become pollinated and the corollas fall rapidly, forcing the bees to work the less attractive blossoms. Thus, the higher the bee density, the more effective they are in pollinating blueberries.

Number of Colonies to Use

The greatest benefit in blueberry pollination is obtained when there are sufficient pollinators to distribute the pollen freely, not only from anthers to stigma of self-fertile flowers, but also between self-sterile clones.

Because of the wide variety of conditions that exist in an area, the exact number of bees that a blueberry grower will need cannot be given. The number of honey bees needed depends on: 1) the number of native pollinators already in the area; 2) the number of other flowering plants that bloom at the same time as lowbush blueberry and thereby compete for the pollinating insects; 3) weather conditions during bloom period; 4) the amount of available blueberry blossoms; 5) the lowbush blueberry plant species composition within a field; and 6) the grower's expectation of yield.

The following are "rule of thumb" recommendations for the amount of honey bees needed:

1. In small isolated fields, surrounded by woods, use two hives per acre, as most of the bees' activities will be limited to the blueberry field.
2. In small blueberry fields surrounded with fields containing competing flowering species, use two to three hives per acre.
3. In large fields as on the blueberry barrens, use three to five hives per acre.

Scheduling Delivery of Colonies

Try to schedule the delivery of honey bee colonies to coincide with 10-25% bloom. Early contact with the beekeeper is helpful for both parties. If the bees arrive too early they may fix upon other flowering plants outside of the field and may not switch back to blueberry once the field comes into bloom. Of course, if the bees come in to a field too late (50% bloom or later), the earlier blooming clones will not be pollinated resulting in potential yield loss.

Distribution of Colonies in the Field

Honey bees usually pollinate flowers more thoroughly within 100 yards of their colonies than they do flowers at greater distances. To get the best coverage, therefore, hives should be distributed in groups throughout the field.

Distribute the bees in the center of the fields as conveniently as existing field roads allow. Or, place the colonies in the field in groups 0.1 mile (approximately 500 feet) apart in all directions. If it is not desirable to place hives evenly throughout the field (hives are often clustered on pallets and so this constrains distribution of hives), then grouping hives in clusters increases the competition for blueberry bloom in areas close to the hives and forces the foraging force of bees to fly farther out into fields to collect nectar and pollen.

The following table gives the number of colonies a grower could use in each cluster to obtain uniform distribution of bees in fields that are at least 7-10 acres in size.

[redacted]	[redacted]
1	7
2	13
3	20
4	26

The natural tendency of a colony is to spread its foraging activity over the full flight range (in excess of one mile) and to forage on flowers that give up plentiful nectar and pollen rewards The grower, however, would prefer honey bees from rented colonies to forage within the confines of a specific field and on blueberry flowers exclusively. A controversial strategy often suggested for improving pollination efficiency is to rotate colonies to restrict the flight range and disrupt any established foraging pattern on flowers other than blueberry.

The premise involved in the periodic moving of colonies from field to field is that the first day or so after a colony is moved, the bees forage only near the hive and on flowers in this localized area (most likely blueberry flowers). Whenever bees are moved to a new location, they go through a period of orientation during which they get used to their new surroundings. Throughout this time, they are most effective as pollinators of the flowers nearest the hive. Once fully oriented, their foraging extends further. According to this strategy, bees should be present for three or four days during the peak of blueberry bloom then moved to later blooming fields for more efficient use of their pollinating service. The moves must be to a new field at least 3-4 miles from the old field to avoid disorientation and loss of foragers. This strategy has been tested in New Jersey on highbush blueberry and resulted in increased numbers of honey bees foraging close to the hive on blueberry immediately after the move. Whether hive rotation is practical for most growers in Maine and whether yield increases result in lowbush blueberry is not known.

Requirements for Colonies
The placement of honey bee hives in blueberry fields is important to increase the success of honey bees in pollinating the crop. The following points should be adhered to when possible:

- hives should be placed in fields to be pollinated or as close to the fields as possible.
- orientation of hive entrance should be toward the early morning sun so that bees will star foraging earlier in the morning before the wind increases.
- placed on knolls and high ground, NOT low spots that accumulate damp cool air.
- protected from wind (windbreaks or hay bales around hives).
- avoid placing hives near buildings, irrigation valves, farm workers, or road traffic.
- access to water by honey bees (very important to survival and performance of honey bees).

Increasing the Impact of Honey Bee Hives
Various management practices directed at honey bees or at the blueberry crop may have either positive or negative effects on the ability of honey bees to efficiently pollinate the blueberry crop. A few are discussed below.

The idea of removing competing bloom is controversial and has not always been shown to improve crop yields.

Recent thinking by pollination research biologists is in favor of enhancing, NOT eliminating alternate bee forage since it often results in attracting bees to an area. Alternate forage also may encourage native bees to nest near the crop. This forage may also result in the increase of native pollinator populations. This is especially true for flowering plants that flower before and after blueberry bloom. Of course this has to be balanced with crop loss due to weedy plant species.

The use of attractant sprays has been evaluated for honey bees in a variety of crops. Attractants are designed to increase bee visitation to treated crops with the goal of increasing pollination. Several attractants have been developed and marketed, but most have had a doubtful performance record. One of these attractants, Fruit Boost®, is based upon a specific formulation of a synthetic form of the honey bee queen mandibular pheromone. This product has been tested in Maine lowbush blueberry and it did result in the sprayed bloom attracting more foraging honey bees than the non-sprayed bloom. However, there were no significant increases in yield or berry weights due to the Fruit Boost® spray. One possible use for this attractant that has not been evaluated is to treat fields in bloom when the associated honey bees are visiting non-crop flowering plants. This tactic would be in an attempt to get the bees to switch back to foraging in blueberry bloom, but it must be evaluated by growers.

Pollen traps attach to the entrances of hives and harvest pollen from bees returning to the hive. It has been thought that pollen traps induce a pollen deficit in the colony and thus increase the proportion of bees that forage for pollen. The results of this management strategy have been inconsistent and have not been evaluated in lowbush blueberry. The use of a pollen trap for the entire bloom period may also be detrimental to brood rearing.

Increased pollen collection is also believed to occur when colonies are fed sugar syrup. This results from a rapid change in the behavior of individual foragers from collecting nectar to collecting pollen. The experiments aimed at documenting this phenomenon are also not consistent and need to be performed in lowbush blueberry fields.

Blueberry production practices with negative impacts on bee foraging and pollination are: 1) exposure of bees to irrigation and 2) exposure of bees to pesticides. Irrigation during the day may prohibit bees from foraging on flowers, irrigation water can knock bees out of the air while flying and wet flowers are not usually visited by honey bees. Irrigation during bloom should be restricted to night applications. Of the pesticides used in lowbush blueberry, the insecticides have the potential for major impacts. Insecticides act as repellents, they can disorient the bee so that it can not find its way back to the hive, and insecticides can lead to outright bee mortality or a more insidious weakening of the colony. The University of Maine Cooperative Extension Wild Blueberry Fact Sheet # 209 lists the relative honey bee toxicity of insecticides that are recommended by the University of Maine Cooperative Extension for lowbush blueberry production.

Honey bees should be removed from fields when flowering has ceased so as to avoid over-exploitation of the wild flora to the detriment of native bees.

Knowing and Understanding the Beekeeper

If growers plan to use honey bees, they should have some basic knowledge about honey bees and beekeeping. A better knowledge by the grower of the beekeeper's viewpoint and some of the problems associated with the rental of bees for pollination improves communication between the grower and the beekeeper leading to better pollination service. The grower usually considers only the fee and the potential value of the bees to the crop, along with associated problems of having the beekeeper, extra vehicles, crew, and the bees in the field.

Renting Honey Bee Colonies – the beekeeper's view

The beekeeper usually sees the deal from an entirely different viewpoint. The advantages of renting hives to the beekeeper include:

- The fee, which may be more certain than a honey crop.

- The possibility of arranging the blueberry pollination job between other honey crops.
- The possibilities of the bees finding better forage than had they been kept in their permanent location.
- The possibility of securing a blueberry honey crop in addition to the fee for pollination.

However, the beekeeper also must consider such disadvantages as:

- Conflict between the time the pollination service is needed and the major honey flow in the permanent location.
- The adverse effects of overstocking an area on a colony. Overstocking may be necessary to provide the maximum pollination service that the grower desires.
- Increased chances that colonies may become infected with diseases carried by other colonies in the new area.
- The predisposing of hives to European foulbrood disease (there is some evidence that colonies restricted to highbush blueberry may have an increased likelihood of contracting this disease).
- Damage to the colonies by pesticides or bears.
- Wear and tear on colonies and equipment during moving.
- Problems that arise when moving bees at night to a new location.
- Collection of the pollination fee.

Some beekeepers operate their colonies in the same location year after year. Others move their colonies between states. Most beekeepers begin their move after nightfall when all the bees are in the hive. The entrance of the colonies may be closed for the period of the move or left open. The entire load is usually covered with a net to prevent the escape of bees. Most beekeepers attempt to deliver colonies at night so that the bees remain inside the hive while it is being positioned in the field.

Unfamiliarity with the area combined with poor night visibility can prove hazardous for the beekeeper. A simple, safe and fast method of distributing colonies within the field will greatly reduce the problem of delivering bees. Growers are advised to contribute in this regard by clearly marking where they want to place the colonies in the field. Providing a guide for the bee truck or a tractor and a trailer with driver to aid in distributing the colonies is usually appreciated by the beekeeper.

Renting Honey Bee Colonies – the contract

Whenever you rent bee colonies for pollination service, obtain a written contract or agreement that covers at least the following points:

- Number and strength of colonies to be used.
    - number of grade A colonies and rental fee
    - number of grade B colonies and rental fee
- Plan of distribution of colonies in the field.
- The beekeeper’s right to enter the field to service colonies.
- The degree of protection from pesticides that will be given the bees.
- Time of bringing in and removing the colonies.
- Plan of payment of the rental fees.

An example of a written contract can be found in the book, “ *The Hive and the Honey Bee”*.

Bee Stings

Some growers hesitate to use honey bees for blueberry pollination because they fear being stung. Some knowledge of the bee and its venom may reduce this fear. The sting is the mechanism of defense for the colony.

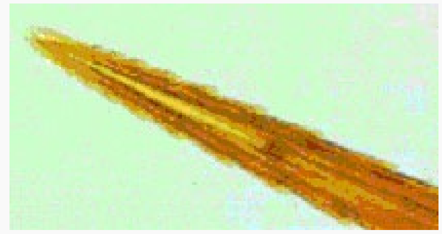


Figure 7

The stinger is torn from the body of the bee after it is imbedded in the victim because the stinger has barbs on it similar to a fishing hook Figure 7. The worker bee usually dies within an hour after the stinger is lost. The queen does not lose her stinger (but she is not likely to sting), which is used only to destroy other queens and lay eggs. The drone, the male bee, has no stinger.

Bee venom is a protein that acts as an antigen in your body resulting in your body’s manufacture of specific immunoglobulin E antibodies. If you have been stung before, the bee venom reacts with the antibodies which are attached to tissue cells called mast cells. These mast cells contain numerous vesicles filled with histamine and other substances that promote inflammation, swelling, burning and itching. If you are not allergic to bee stings your body’s reaction is confined to the area of the sting. If you are hypersensitive to bee venom (allergic) or you receive a lethal dose of bee stings (about 10 bee stings per pound of body weight) a systemic reaction can occur in which large amounts of histamine are released from the mast cells and dilation of blood vessels and the constriction of your respiratory passages can result in death unless the victim receives treatment at a hospital (administration of an antihistamine or adrenaline). Hypersensitive people can be desensitized by seeing an allergist.

Preventing Honey Bee Stings

There is no practical way to completely avoid bee stings while conducting normal activities on a farm, particularly where numerous colonies are involved. Some steps can be taken to reduce the possibility of being stung.

- Do not bump, jar or otherwise disrupt a hive.
- Do not stand or move within 30 feet directly in front of a hive entrance.
- Do not get close (within 300 feet) to an open hive or a hive that was opened and worked previously that day.
- Do not move fast near bees, swat or slap at a bee.
- If approached by a defensive bee (usually buzzing loudly and flying around your head), stand still and cup the hands loosely over the eyes, nose and mouth and walk slowly away from the hive.
- Do not go near a hive unless your head, especially your hair, is covered with a beekeepers veil.
- Do not go near a hive while wearing wool or leather clothing or dark colored clothing. Also, do not wear perfumes or sweet smelling aftershave lotions when working near bees.
- Use a bee veil to protect the head and neck while working near bee hives and long pants, a long sleeve shirt, socks, and work shoes (no bathing suits and sandals).
- Do not try to open or move honey bee hives without the help of an experienced beekeeper.

Removing the Stinger

Because venom is forced into the blood stream for some minutes after the sting is received by the involuntary muscles associated with the bee’s poison gland which is attached to the end of the stinger. The stinger should be removed as quickly as possible. Attempting to pick the stinger out with the fingers is slow, and may press more venom out of the poison sac. Instead, scrape the stinger up and away very quickly with the edge of your thumb nail. Topical applications of the following substances, immediately after being stung, can relieve the pain and itching: raw onions, meat tenderizer (made into a paste), baking soda, ammonia, ice, vinegar, and honey. If you are allergic to bee stings carry an emergency kit, and if you are stung, seek medical attention at once.

Acknowledgements

I would like to thank a friend, Vivian Butz Huryn, an experienced commercial beekeeper and queen breeder, for reviewing this fact sheet and making suggestions for its improvement.

Additional Reading

Some additional references that you might be interested in are:

"Crop Pollination by Bees", by Keith S. Delaplane and Daniel F. Mayer. 2000, CABI Publishing.

"Insect Pollination of Crops", by John B. Free. 1993. Academic Press.

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