Insect Pollinators of Alfalfa Grown for Seed

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Insect Pollinators

IV

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G. E. Bohart and W. P. Nye

Alfalfa must be cross-pollinated to set high yields of first-quality seed (Plates 11 and 12). Attempts to develop satisfactory self-fertile varieties or to substitute chemical applications or mechanical tripping machines for bees have been unsuccessful. For rapid and thorough pollination, the field must be supplied with enough bees to do the job.

When alfalfa pollination is adequate, the field never develops the appearance of full bloom. Flowers wilt and begin to set pods before the racemes are fully open (Figure IV-1). This gives the field a characteristic dull, brownish cast. If a field develops a "flower-garden look," the following steps should be taken to improve pollination: (Plates 13 and 14)

1) Keep the alfalfa in a condition attractive to bees.
2) Eliminate competing sources of pollen and nectar.
3) Have a sufficient supply of bees in the area.

(Maintaining an attractive field is especially important for pollination by honey bees (Apis mellifera L.). This should be planned in advance and will be dealt with in the section on honey bees.)

More than 60 species of bees pollinate alfalfa in the intermountain states, but only about 20 are commonly encountered. In a single field, it is unusual to find more than five species abundant enough to be of practical importance. The more important pollinators of alfalfa in the Intermountain Region are: the honey bee, one species of alkali bee, 6 species of bumble bees, 5 species of leafcutting bees (1 species primarily), and 8 other bee species.

Honey Bees Most Abundant

The honey bee is the most abundant alfalfa pollinator in all western seed areas, much of the Southwest and also in limited areas in Utah. Two working forces occur on alfalfa: nectar collectors (Figure IV-2) and pollen collectors (Plate 15). Their relative efficiencies in northern Utah are indicated below.

<table>
<thead>
<tr>
<th>Nectar collectors</th>
<th>Pollen collectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of flower visits causing tripping</td>
<td>1±</td>
</tr>
<tr>
<td>Flowers visited per minute</td>
<td>14</td>
</tr>
<tr>
<td>Flowers pollinated per hour</td>
<td>8.4</td>
</tr>
<tr>
<td>Relative efficiency rating</td>
<td>1</td>
</tr>
</tbody>
</table>

In spite of their low efficiency rating, large numbers of nectar collectors can set a fair crop of seed. In a field with a good potential for seed yield, an exceptionally dense population of nectar collecting honey bees (5 per square yard) tripping about 1 percent of the flowers they visit can set a crop of about 400 lbs. per acre. These high populations are seldom reached. Bees tend to leave alfalfa fields and go to competing bloom when the nectar production does not keep pace with the foraging by the nectar collectors.

One flower tripped per 100 visited is close to the average for most areas and most seasons in Utah. Sometimes, especially in northern Utah, the figure is much lower. In states to the north and in Canada, nectar collectors are usually so inefficient as alfalfa trippers that they cannot be relied upon to set commercial yields of seed. In the Delta area of Utah, especially late in the season, the tripping rate by nectar collectors often reaches 2 per 100 flowers visited. At this level only half as many bees are needed.

Although there is some evidence that flowers become easier to trip as the air becomes warmer and drier, it has not been possible to correlate atmospheric conditions with tripping rates by nectar collecting honey bees. It has been claimed that tripping rates by nectar collectors can be increased significantly by regularly moving bees into alfalfa from other sources of bloom to take advantage of the period during which the bees are learning to avoid the tripping mechanism. Unfortunately, the learning process is so rapid that any resultant increase in tripping cannot be measured in the field.

Pollen Collectors Trip Alfalfa Flowers Much More Efficiently

Obviously, bees tripping 45 times as efficiently as nectar collectors do not have to be as numerous to set a good crop of seed. Unfortunately, pollen collectors are usually much less abundant on alfalfa than are nectar collectors (the percentage ranges from 0 to as high as 75 but rarely exceeds 20), and measures taken to increase this percentage are unreliable; in some cases they reduce the agronomic potential of the crop.

Theoretically, 0.1 pollen collectors per square yard should be able to trip nearly as many flowers
IV-1. Progressive stages of raceme development in alfalfa: A to C following pollination by bees; D to F unpollinated flowers.
as 5 nectar collectors per square yard. However, in
actuality, pollen collectors usually spend from 25 to
50 percent of each foraging period collecting nectar
and tripping relatively few flowers. Populations of
pollen collectors fluctuate much more than popula-
tions of nectar collectors from hour to hour and
from day to day, so more leeway must be allowed
in evaluating their work. In general, if each pollen
collector is considered equivalent to 20 nectar col-
lectors, a fair judgment can be made of the efficien-
cy of the whole honey bee population. On this
basis, five bees per square yard, 5 percent of which
are pollen collectors, could be expected to set a 700-
lb. seed crop under good conditions.

During the course of our study of the pollination
of alfalfa, it was observed that some colonies of
honey bees collected more alfalfa pollen than others
placed beside them in an alfalfa field. These ob-
servations led to the development of a strain that
collects alfalfa pollen more readily than “ordinary”
honey bees in Utah. In Utah and Idaho, this strain
collected alfalfa pollen while surrounding colonies
collected almost none. Most of the pollen collection
took place on rather dry, sparse patches of alfalfa
in an otherwise more luxuriant stand, indicating
that the value of the strain may be somewhat limi-
ted by the growing conditions of the alfalfa. The
high alfalfa pollen-collecting strains tested were
highly inbred and had poor overwintering qualities
and excessive queen supercedure during the early
part of the season. Although the use of first-
generation hybrids resulting from crosses with
ordinary bees overcame these problems, the prog-
eny had lost part of the alfalfa pollen-collecting
tendency. Back-crossing the hybrids to drones of
the alfalfa pollen-collecting line increased alfalfa
pollen collection and improved wintering qualities.
The line finally developed is being maintained by
the US Department of Agriculture bee stock center
at Baton Rouge, Louisiana and is available there.
Any attempt by a grower to use this strain should
be made in cooperation with a competent bee
breeder familiar with techniques of artificial
insemination.

**Improve Pollination by Honey Bees**

1. **Make the field attractive.**

An open, upright, strongly flowering type of
alfalfa growth tends to attract both nectar and
pollen collectors. Pollen collectors avoid a rank
type of growth even more than do nectar collectors.
However, large plants are necessary for high seed
production, so moisture should not be so low as to
cause stunting.

2. **Eliminate competing sources of pollen and nectar.**

Since colonies per acre must be considered on
the basis of total acres of alfalfa bloom within a
radius of at least 1½ miles from the colonies, limit
the acreage of bloom that is not going to produce
alfalfa seed. Alfalfa hay grown in the same area
should not be allowed to flower extensively. Crops
that produce attractive bloom at the same time as
alfalfa should not be produced within a mile or
more of alfalfa seed, and pastures containing sweet-
clovers and true clovers should be closely cut or
pastured to prevent bloom. Weeds and plants that
produce attractive bloom simultaneously with
alfalfa should be eliminated within at least 1½
miles from the colonies. Sweetclovers, true clovers,
mustards, gumplant, and thistles are among the
principal weed competitors for nectar and pollen in
the Intermountain Region. Several other plants
such as salt grass, Russian thistle, poverty weed,
and greasewood produce little or no nectar but are
important pollen sources for honey bees. However,
the number of honey bees that collect pollen from
alfalfa depends more on the condition of the alfalfa
than on the abundance of other pollen sources.
Consequently, competing pollen sources would
have to be virtually eliminated for a mile or more
around the seed field before an increase in pollen
collectors could be anticipated.

Control of competing plants is easiest on new
land where weeds are not yet a serious problem and
where farming is not diversified. The use of under-
ground drains and irrigation lines and the elimi-
nation of permanent fences facilitates weed control.
Control of pollen and nectar sources, as with several
other factors in alfalfa seed production, can be
handled best by community effort.

3. **Provide the necessary bees.**

Growers of alfalfa seed must have sufficient
numbers and proper distribution of pollinators.
The following must be determined:

**A. How Many?** The density of bees in the field
and the percentage of pollen collectors (either
honey bees or wild bees) are the best indications of
the number of colonies needed. If competing plants
are scarce and the field is attractive, three to four
colonies per acre should result in field populations
of up to 6 bees per square yard. If as many as 10
percent of these are pollen collectors, fewer bees
will be necessary. When less than 1 percent of the
bees are pollen collectors, 5 or 6 colonies per acre
can be used to advantage. However, if the field is
surrounded by acres of attractive bloom, all such
acreage within 1½ miles should be considered in
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deciding upon the number of colonies to be brought into the area. In most areas, elimination of competing sources is more practical than trying to provide enough bees to cover everything.

B. How Strong? Strong colonies with plenty of brood are recommended. In a heavily stocked range, the stronger the colonies, the better they maintain themselves. Also, the larger the amount of brood, the more stimulus there is for pollen gathering.

C. Where to Place? For fields with fewer than 10 acres, the colonies can be placed adjacent to the field. If the field is ½ mile or more across, the colonies should be distributed in groups that are no more than ¼ mile apart. This within-field distribution is recommended because bees from colonies in the center of a large acreage of alfalfa must fly considerable distances to reach competing plants. Also, although honey bees can distribute themselves uniformly over great distances from the colonies, they waste valuable working time and energy in just flying to and from the flowers.

D. When to Place in Field? When bees are brought to the field before bloom is well-established, many may become oriented to other sources of food and will never, or only belatedly, visit the field in which they are placed. To avoid this possibility, it is better to bring in about one-fourth of the required number at about 10 percent of full bloom and the remainder when there is 50 percent bloom.

E. When to Remove? For best seed production, the alfalfa should come into bloom evenly. The pollination should then be completed within 4 weeks and the bees removed. After the first-crop seed is pollinated, the bees should be moved a distance of at least 3 miles to a second-crop seed field. Any flowers tripped after August 20 will usually freeze before seed matures. Bees should be removed after pollination to avoid poisoning from late insecticide applications or interference with harvesting operations.

F. How to Obtain? Honey bees are best obtained from beekeepers. Few seed growers have the time or skill to maintain the number of colonies needed for alfalfa pollination.

G. Why is Community Effort Important? With a little encouragement, beekeepers will place as many colonies in an alfalfa seed area as they think will make them a good honey crop. No more than one colony per acre is usually provided, although some beekeepers are willing to place as many as two per acre if the bloom is heavy. Beekeepers may be encouraged to place their bees in or next to a seed field regularly if (1) suitable locations are provided and (2) assurances are given that bees will not be killed by improper use of insecticides (see section on control recommendations). Many times, cooperation of neighboring growers must be obtained to prevent bee poisoning.

To obtain more than one to two colonies of bees per acre of bloom, seed growers will generally have to pay the beekeeper. Payment for pollination has rarely been practiced in seed areas of the Intermountain Region. Several attempts have been made, but most agreements have turned out to be unsatisfactory to one or both parties. Failures have usually been attributable to one or more of the following conditions:

1) Inadequate insect control or poor or unattractive bloom caused by too dense alfalfa (frequently a hay-type stand).
2) Too much acreage (neighboring growers do not contribute to the arrangement).
3) Low seed potential on dry-land fields with inadequate moisture.
4) Insecticide damage to the bee colonies.
5) Excessive amounts of sweetclover, gumplant, and other competing weeds in the area.

Successful honey bee pollination does not come easily, but growers should consider the increased seed yields obtained where intensive cultural practices are augmented by honey bees for pollination. In California, contracts between seed growers and beekeepers are usually handled on an area basis through associations to assure equitable cost and distribution of bees.

Wild Bees Are Efficient Pollinators

The term “wild bee” refers to the various species not used by man for honey production and does not include honey bees, whether they come from apiaries or wild colonies. Several species of wild bees have been recognized for many years as efficient pollinators of alfalfa (Figure IV-3).

With few exceptions, wild bees visit alfalfa for both pollen and nectar. Many species seem to have a special knack for tripping the blossoms to get at the pollen; others have more difficulty. In general, bees more than ⅜ inch long are more efficient tripplers than smaller species, and bees less than ¼ inch long do not trip at all. Among the more efficient and abundant pollinators are bumble bees (Bombus) of several species, alkali bees (Nomia melanderi Cockerell), leafcutting bees (Megachile) of various species, a “flower-loving” bee (Anthophora urbana Cresson), and a carpenter bee (Xylocopa californica Cresson) in southern Utah. All of these species trip from 10 to 20 flowers per minute. It is easy to see how honey bees, most of which collect nectar and trip few alfalfa flowers, came to be lightly regarded in comparison.
IV-2. Honey bee collecting alfalfa nectar. Note side approach to floret (length 1 cm).

Number of bees needed.

By relating tripping rates and working hours of bees to the number of flowers in a stand and the percentage of tripped flowers forming pods, a rough estimate can be made of the numbers of various kinds of bees required to set a particular seed crop. On this basis, the most efficient pollen collectors (bumble bees and large leafcutter bees) need not be quite so abundant as the somewhat less efficient ones such as alkali bees and alfalfa leafcutting bees.

Number of bees available

Unfortunately, wild bees are not present in most alfalfa seed fields in sufficient numbers and their distribution is uneven. We are now learning how to increase wild bees and move them to places where they are needed. Not only are wild pollinators scarce in most alfalfa fields, but many species are in a stage of progressive decline. Areas newly opened for alfalfa seed production often have excellent yields which begin to decline within a few years. An increase of injurious insects plus the insecticide applications needed to control them may be responsible in part. Other causes include: destruction of nesting sites, increase of acreage to be pollinated, and destruction of alternate food plants that bloom earlier or later than alfalfa.

Only two species of wild bees in Utah are known to be manageable

The native alkali bee (Nomia melanderi Cockerell) and the accidentally introduced alfalfa leafcutting bee (Megachile pacifica (Panzer) (=rotundata) (F.)) are the only species of wild bees in Utah that have been successfully managed. Plans are being made to introduce new, potentially manageable species from other parts of the world. Other species now present seem to offer little hope for large scale use.

The Alkali Bee

Until the 1960s, the alkali bee was the only manageable wild pollinator in the Intermountain Area. In Utah, many of the high seed yields and reported from some areas near Delta, Millard County, and from the Uintah Basin have been from fields near large alkali bee nesting sites. In Washington, Oregon, Idaho, and Nevada, many seed growers have successfully established and maintained nesting sites for several years.

Alkali bees are about two-thirds as large as honey bees and can be readily recognized by the pale-green or greenish-bronze bands across their abdomens (Plate 16 and Figure IV-4). They are found principally in the larger valleys where poorly drained alkaline areas are prevalent. They are abundant in some areas and totally absent in others. It is common for them to appear in large numbers one season and to disappear almost as quickly several years later.

The flowers attractive to alkali bees are rather limited. In the Delta area of Utah, only sweetclover and Russian thistle offer serious competition to alfalfa, although a few other less abundant plants such as saltcedar, bindweed, true clovers, and purple bee plant are attractive. The common competitors for honey bees, such as greasewood, povertyweed, gumplant, sunflower, and rabbitbrush are generally not attractive to alkali bees.

Alkali bees prefer to nest in fine sandy loam soils with a low percentage of clay. The percentages of sand and silt can vary widely, but the sand should be very fine. Soils that aggregate readily (develop a crumb structure) are unfavorable. A prime essential is a constant underground supply of moisture extending to the ground surface. “Soggy” soil is too wet, however, and the surface should be well drained. The bees select bare or only sparsely vegetated ground. Typical growth on nesting sites includes saltgrass, smotherweed, summer cypress, iodine bush, and samphire or pickleweed. These plants should be short and sparse enough to allow sunlight to reach most of the ground surface. Salty soils often provide the best soil and vegetation conditions. A salty crust, if present, should not be thick or hard, and there should not be a dry, fluffy layer under the crust.

Alkali bees construct their nests close together to form nesting aggregations (sometimes loosely spoken of as colonies) (Figure IV-5). However, each female is solitary. She functions as both queen and worker and constructs and provisions an individual nest burrow. A nesting aggregation may cover an acre or more with burrows, many of which are not more than an inch or two apart. The population of such a nesting site compares favorably with that of honey bees in an apiary of 50 colonies.

An individual nest consists of an entrance mound at the ground surface and a vertical underground burrow branching into one or two clusters of cells. Each cluster is comprised of 5 to 10 oval cells placed side by side rather close together (Plate 17). After constructing a small group of cells, the mother bee provides each cell with a ball of pollen, places an egg on the ball, and seals the cell. The young larva, after hatching from the egg, must complete its development without further assistance.

In Utah, Idaho, and Wyoming, adult male alkali bees usually appear in the fields near the first of July. Females often do not appear in any numbers until the middle or latter half of July. Males in the field are restless and stop only occasionally to feed
IV-4. Female alkali bee with load of pollen at nest entrance (length 1 cm).

IV-5. Alkali bee nest mounds (tumuli).
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on nectar from flowers. However, they do trip a high percentage of the flowers visited, and sometimes they become the most important pollinators. Females work much more efficiently than males. The grower, in order to take full advantage of alkali bees, must usually time the alfalfa bloom for late July or early August. This means that these bees can be used for second-crop seed only. There is often a partial second generation, and some adults may be found in September. During early September, the adults perish, but their offspring remain in the soil as mature larvae until the following summer.

Since alkali bees are gregarious and are also rather exacting in their nesting requirements, it is important that their nesting sites be protected from disturbance. During the active season, any disturbance such as harrowing, flooding, and trampling can be disastrous. During the fall, winter, and spring months, pasturing, light watering, and shallow harrowing should not be harmful unless the surface is left in a loose condition that insulates the soil and delays emergence of the bees. Fencing a site to exclude cattle may do more harm than good if dense vegetation results. In such cases, weed killers should also be employed. Nesting areas should not be drained or leached. Application of insecticides during bloom is hazardous to alkali bees and should be done only according to recommendations (see section on insect control recommendations). Skunks often damage or destroy nesting sites and should be controlled with poisoning or trapping programs.

The greatest number of nesting sites are found in areas where seepage occurs near irrigation ditches. The establishment of new irrigation districts, or the expansion of old ones, is often followed by a rapid increase in the number and size of the nesting sites. Whole aggregations often migrate into a new site in a single season. Consequently, the seed grower in a favorable area may prepare and maintain favorable sites near his alfalfa and expect natural occupancy. Growers should retain seeped areas and be aware of the danger of "killing the goose that lays the golden egg" by overzealous programs of drainage and water conservation.

Building and maintaining alkali bee nesting sites.

Considerable success has been achieved in creating alkali bee nesting sites. It is often possible to take advantage of existing hardpan layers. The layer should be a foot or more below the soil surface. Gently mound or slope the surface so that rainwater and excess irrigation water can drain off the nesting site. Build either parallel blind ditches or install drain tiles with joints covered by gravel to bring in water for subirrigation.

Where a natural hardpan is not present or is too porous, plastic film can be substituted. A 3½ foot deep excavation should be prepared with a level bottom and 1-to-1 or 2-to-1 slope on the walls. The entire excavation should be lined with sheets of 0.008-inch polyethylene or 0.006-inch vinyl film overlaid with 4 to 6 inches of soil for protection. If the excavation is larger than the sheets of film, adjacent pieces can be overlapped on ridges about 1 foot high. This procedure creates water-holding compartments. A 6 to 8-inch layer of clean gravel should be spread over the protecting soil. Some site builders lay a grid of drain tile in the gravel layer to ensure rapid and uniform distribution of water. At 3- to 4-foot intervals, foot-wide holes should be dug into the gravel and filled with soil to serve as wicks. The gravel layer should be covered with an inch or two of straw or with burlap to keep dirt from plugging the gravel. The excavation should then be filled with fine sandy loam until the surface is gently crowned. At each end of the site, or compartment, a large diameter pipe or tile should extend from above the soil surface to several inches deep in the gravel layer. The gravel should be mounded around the base of the tile. If a grid of drain tile has been laid in the gravel, the standpipe should connect with it (Figure IV-6). Moisture should appear uniformly across the surface of the site. Water, approximately to the top of the gravel, should be run into the pipes.

Where the soil is low in salt, it is necessary to add stock salt at the rate of a pound per square foot to help draw moisture to the surface. The salt can be raked in as crystals or dissolved in water and sprinkled on the surface. More salt may be required, but it is easier to add salt than to remove an excess. Subbing of the site takes place most readily if the soil is moist when dumped into the site. Be sure to keep the site moist during the entire nesting season. Sometimes only one watering is required before the bees are active. Soil in the top 15-18 inches should feel moist to the touch. However, if the soil forms a ball when squeezed in the hand, that ball should fall apart when gently tapped.

The site size depends upon the acreage of alfalfa to be pollinated and the resources of the grower. It is unlikely that a surplus of wild pollinators will ever develop in artificial sites, so the best recommendation is to continue building and expanding. Groups of farmers should pool equipment and labor to build sites on an area-wide basis.

Newly created alkali bee nesting sites are usually colonized slowly, in which case it becomes necessary to introduce bees. Two techniques have been
successful:

1) In the spring, install blocks of undisturbed soil containing overwintering bee larvae. Soil that holds together adequately can be sawed into blocks with a disk saw (or a pair of saws) mounted behind a tractor. The blocks can be pried loose with a pitchfork and placed on pallets on a truck bed. More fragile soil can be moved as plugs by driving 12-18 inch wide steel cylinders (sharpened sections of well casing) into the ground with the drawbar of a tractor. The cylinders should be cut down one side so the plugs can be removed and wrapped with bottle-wrap cardboard to prevent breakage. When the cores are installed, they should be covered with enough soil to prevent water from standing on them during rainstorms. One good core for every 20 to 30 feet of nesting site should allow for good initial colonization.

2) An easier way to colonize new sites is to transfer adult bees from established sites and release them on the new ones. To be successful, such transfers must be made when the female bees are just beginning their nesting activities. They can be swept from the site with an insect net composed of a light material such as nylon organdy. After about 200 bees are accumulated in the net, carbon dioxide supplied from a cylinder should be used to quiet the bees. Empty the bees into paper bags and place them in a picnic cooler over a bed of ice in plastic bags. The bags containing bees should be separated from the ice by several layers of towel. Keep the bees cool until they are released late at night on the new site. Holes several inches deep should be punched in the soil with a pitchfork or other device before releasing the bees. They will crawl into the holes, and many of them should eventually use these holes to start nests.

The Alfalfa Leafcutting Bee

The alfalfa leafcutting bee was accidentally introduced into the eastern states in the 1930s and was first noticed in Utah in 1955. Since that time many growers throughout the western states have managed large populations by using procedures developed at various experiment stations. Since this bee nests above ground, it is not limited by soil conditions and thus can be managed under a wider variety of conditions than the alkali bee.

The charcoal gray alfalfa leafcutting bee is a little larger than a house fly (¼ to ½ inches long). The female carries her pollen on the underside of the abdomen, which has inconspicuous white hair bands on top and is usually pointed upward at the tip (Plate 18). The variety of flowers visited is moderately limited and includes, primarily, the small-flowered forage legumes and a few of the mints. In seed producing areas of Utah, sweetclover is usually the only host plant common enough to offer serious competition with alfalfa.

The female bees build their nests in such places as nail holes, spaces between overlapping boards, beetle holes, and tubing in shop equipment. Near Flowell, Utah, they nest in lava blocks and are known as "cinder bees." Knowledge of such habits has led to the creation of nesting sites made of wood or plastic foam blocks with drilled or preformed holes, sheets of grooved wood or foam plastic blocks fitted together to form nesting holes, bundles of soda straws, and stacked or rolled sheets of corrugated paper.

Under natural conditions, alfalfa leafcutting bees like to nest in east- or southwest-facing walls. They also nest readily in door and window frames and in rafters and interior places as long as they have light, ventilation, and ready access to the area. Although they enter buildings to nest, they tend to avoid tree shade.

They nest gregariously, but each female makes her own individual nest in a hole. Each nest is composed of a series of cells made of leaf pieces, then each cell is provisioned with a nectar moistened mass of pollen, provided with an egg, then sealed (Figures IV-7 and 8). The nest is protected from the elements and potential enemies by a plug of circular leaf pieces. One bee can lay as many as 30 to 40 eggs and make as many nests as necessary to provide space for her young. Near alfalfa fields, most of the leaf pieces are cut from alfalfa. Other leafcutting bees commonly select leaves from various shrubs and trees, but the alfalfa leafcutting bee prefers flower petals and leaves from tender-leaved plants (Figure IV-9).

In most of Utah, the adult bees appear in mid- to late June, the males preceding the females by a few days. The adult lifespan is about 6 weeks. A partial second generation appears in the latter part of July and maintains the population through August at about the same level. Consequently, the bees are about equally effective as pollinators of first- and second-crop seed. A slightly delayed first crop has the best timed bloom to take advantage of these bees.

The alfalfa leafcutting bee trips about as many flowers per minute as the alkali bee, but it usually starts foraging later in the morning. Another limitation to its effectiveness as an alfalfa pollinator is its tendency to visit only the flowers near the top of the stand. Its flight range in the alfalfa field is less than that of the alkali bee, but this is actually an advantage since bees flying from shelters placed in the field are not likely to work on a neighbor's property or to be killed by insecticides he may employ. It is estimated that 10 shelters, each with about 10,000 nesting females, should provide excellent pollination of a square 50-acre field. With a field this size, six shelters around the edge of the field and four at about 600-foot intervals within it should ensure fairly even distribution of foragers.
IV-6. An experimental artificial alkali bee nesting site using different soil types and salt concentrations.

IV-7. Alfalfa leafcutting bee cells in a grooved board. (A matching grooved board has been removed to expose the cells.)
Natural enemies of the alfalfa leafcutting bee

About 30 species of insect enemies of the alfalfa leafcutting bee have been discovered. They can be divided into scavenger-predators (nest destroyers) and parasites. The former group includes various ant species, the European earwig (*Forficula auricularia* L.), several species of dermestid beetles, grain beetles (principally *Tribolium audax* Halstead), the dried-fruit moth (*Vitula serratineela* Ragonot), and the Indian meal moth (*Plodia interpunctella* Hubner). The important parasites in Utah include a chalcid wasp (*Monodontomerus obscurus* Westwood), a sapygid wasp (*Sapyga pumila* Cresson), and a checkered beetle (*Trichodes ornatus* Say). The checkered beetle is a parasite in some respects and a nest destroyer in others. Sometimes vertebrates create problems. Several species of birds capture adult bees near the nesting holes or pull soda straws out of the nesting units. Live-stock in the field sometimes eat foam plastic units, and rodents may destroy bees in plastic and paper nesting units in storage and in the field.

Other population problems

Although 10-fold annual increases in leafcutting bee populations have been reported, a 5-fold increase can be considered excellent. Actually, percentage increases tend to level off as concentrations per acre reach optimum levels. Growers with adequate numbers should be satisfied with bee populations doubling in good years and merely holding the line in poor years. Although some of the factors that hold down population increases can be partially controlled by suitable management techniques, extremes in weather conditions can take a severe toll. During 1970, in Millard County, a high-wind that rose suddenly when the bees were foraging appeared to reduce nesting populations by over 50 percent. Extremely high temperatures in the nesting materials can destroy most of the eggs and young larvae present. Insecticides sometimes account for high mortalities of adults and appear to reduce successful nesting by some of the survivors. Also, some experimental evidence suggests that larvae are damaged by insecticide residues on alfalfa foliage, though this has not been verified in the field. Finally, high egg and larval mortality may occur in the apparent absence of natural enemies, unfavorable weather, or insecticides. Since such mortalities are often associated with high densities, crowding on the field or in the nesting shelters has been suspected, but the precise reasons remain obscure. Some workers believe that 100 percent dependence on alfalfa pollen is detrimental.

Alfalfa leafcutting bees can be obtained by placing “trap lines” of nesting materials in places found to harbor good nesting populations. Old buildings in rural or semirural situations near alfalfa or sweetclover are often suitable. As soon as a trapping station shows good nesting activity, more materials should be provided to fully exploit its potentialities.

Bees can also be obtained by purchasing the overwintering larvae in their nesting materials or as cells taken from the nesting materials. In the latter condition, they are much easier to assess as to number and condition and will fit more easily into the management program to be recommended. When purchasing bees, examine the contents of a good sample of the cells. Many poor quality consignments of leafcutting bees are being sold.

Levels of management

The management of the alfalfa leafcutting bee is based primarily on providing it with nesting holes and shelters in or adjacent to alfalfa seed fields. The various systems of management are mostly associated with the degree of care given to the bees at different life stages and seasons. At the most primitive level of management, holes are merely drilled in wooden structures for nesting by the bees. The second level involves fastening boxes of soda straws or wood blocks containing drilled holes inside open doorways or windows of outbuildings. The third level, still commonly employed, is to place the nesting materials in shelters of various kinds positioned in and around the fields. Many farmers who use this system also bring the nests into unheated buildings or basements for protection during the winter. However, better care is provided by placing the nesting materials in cold storage until late spring and then in incubation until males begin to emerge.

More careful managers remove the cells from the nesting holes in the fall, bulk them in large containers for cold storage, and place them in trays for incubation and eventual placement in the field. Handling the bees in loose cells during the off season allows more efficient use to be made of cold storage and incubation facilities and provides for better nest destroyer control in the fall and better parasite control in the spring. Furthermore, it allows for a true assessment of the percentage of live cells and for a more careful timing of emergence. Finally, it furnishes clean, empty units for use in the early summer. On the other side of the coin, loose cells are especially vulnerable to improper temperatures and low humidity, and failure to control parasites (especially parasitic wasps) is more serious than with the bees in holes.

Basic specifications and a schedule for management where the “loose cell” technique is employed are as follows: Use nesting materials made of wood, particle board, or foam plastic with drilled or preformed holes of 7/32 or 8/32 inch in diameter or sheets of such materials with chiseled or preformed grooves that, when fastened together, form round or half-round holes of the same diameter. The holes should extend completely through the materials but should be blocked at the back by tightly glued...
Insect Pollinators

IV-8. Alfalfa leafcutting bee cell opened to show the egg resting on the mass of pollen.

metal foil or well-fitted but removable wood or plastic backing. Grooved sheets can alternately be fitted into boxes and held tightly together and in place with lips and spring devices.

About 3 weeks after nesting is finished in the fall, cells should be removed from the field. The cells can be “punched” from the blocks (after the backing is removed) or scooped from the grooved sheets (after the sheets are separated). Punching units can be made up as a “peg-board” fitting the pattern of holes. Before being punched out, the materials should be well dried to prevent the crushing damage that occurs when the leaf cells are moist.

After removal, the cells should be separated and “winned” in front of a fan or screened to remove excess leaf material and many of the scavenger-predators. They can then be bulked in secure containers and placed in cold storage at 35-40°F. In the late spring, they should be incubated 1 to 2 layers deep in shallow trays at 85-90°F and about 70 percent RH. Protect the cells from reinestation by parasitic wasps by covering with 2 to 3 inches of sawdust from which the coarsest and very finest (dusty) particles have been screened. Since most of the chalcidoid wasps emerge several days before the bees, most of the wasps can be eliminated by attracting them to fluorescent tube UV lights placed near the floor of the incubation room an inch above pans of slightly soapy water.

Within 3 to 4 weeks after the bees are placed in incubation (depending upon temperature), males can be expected to start emerging. About 2 days later when many of the males (but no females) have emerged, the bees are ready to be taken to the field. If parasitic wasps are still present, the cells and sawdust should be shaken over hardware cloth above water. Fresh sawdust (1 to 2 inches) should then be added. The trays can be used as drawers and placed in the upper part of a field shelter that should also be provided with nesting material containing about the same number of nest holes as the cells in the tray. More nesting materials should be added if and when about 50 percent of the first group become filled with nests.

Although scavenger-predators and minute parasitic wasps can be held to rather low levels by the cited procedures, *Sapyga pumila* emerges at about the same time as the host and, if abundant, must be controlled by an emergence trap. This is also a useful device for further reducing scavenger beetle populations (See: Utah Experimental Station Research Report #16 by P. F. Torchio).
Shelters

A good shelter is designed partly on the basis of the habits of the bees and partly on the basis of the need to protect them from environmental influences. The following features should be incorporated, insofar as possible:

1) **Conspicuousness.** The shelter should be large enough to accommodate 100,000 nesting holes and be high enough above the alfalfa to aid homing bees. There is some evidence that yellow increases conspicuousness.

2) **Northeasterly exposure.** If the open side of the shelter faces to the northeast, the bees are induced to early activity. However, only the early morning sun, if any, should shine directly on the nesting surfaces.

3) **Protection from high angle rays of the sun.** A flat, double roof should be extended beyond the walls of the shelter and painted white or covered with crinkled metal foil.

4) **Ventilation.** Screened openings in the wall of the shelter near the roof assist air circulation. Nesting material should be mounted at least 1 inch from the walls.

5) **Protection from the wind.** The shelter should be deep enough to prevent incoming bees from being blown away by high winds.

6) **Protection from birds.** Where birds are a problem, chicken wire or some sort of grill should be fastened across the face of the shelter.

7) **Protection from pesticides.** Means should be provided to close the shelter while insecticides are being applied.

8) **Movability.** The shelter should be designed so it can be lifted with a winch or fork lift or mounted on a trailer.

9) **Self-cleaning.** Nesting materials should be mounted at an angle to allow nest debris to fall away from holes.

10) **Provisions for poisoning beetles.** A screen can be placed a few inches above the floor of the shelters. Leaf debris rubbed through the screen and mixed with pollen and a nonfuming residual insecticide will both attract and kill scavenger beetles.

11) If the debris is not used as a poison trap, it should be disposed of regularly. Otherwise, scavengers will have an opportunity to build up.

Most shelters are built in the form of a box. However, an A-frame construction can incorporate most of the features recommended. Because of their obvious advantages, trailers (designed to provide bees for about 25 acres) are gaining popularity (Figure IV-10).

**The Economics of Alfalfa Pollination**

Most varieties of alfalfa have enough self-fertility to set a few pounds of seed per acre. External agents such as tripping machines, hot, drying winds, or a sudden downpour can trip many flowers but this will seldom result in more than 100 lbs of seed per acre because of the limited self-fertility of alfalfa. On the other hand, adequate pollination by bees in a seed field that is properly watered, protected from harmful insects, and well harvested should result in a yield of from 1000 to 2000 lbs per acre.

As a minimum measure, the seed grower should encourage a good population of honey bees by having attractive alfalfa, using care with insecticide applications, and providing beekeepers with good locations. The cost will then be no more than any recommended seed growing procedure. If bee colonies are rented, the cost may be as much as $10 per colony for as many as 5 colonies per acre and should be a major investment.

The cost of pollination by alkali bees can vary from essentially nothing to several thousand dollars each year for several years; thereafter, it will be considerably less. However, the cost is less and the benefits are greater if the entire seed growing area is involved.

Pollination by alfalfa leafcutting bees is more of an individual matter, and costs can be better determined than in the case of alkali bees. Loose cells can be purchased for 1 to 2 cents apiece, and wooden boards with drilled holes (presumably filled with good cells) for 50 to 100 dollars apiece.

The cost of such items as nesting materials, shelters, cold storage facilities, and incubators can be calculated as with any other farming operation.