ALFALFA LEAF CUTTER BEE IN NORTHWESTERN CANADA

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In Cooperation with Alberta Agriculture
Alberta Crop Research Program

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The alfalfa leaf cutter bee Megachile rotundata (Fabricius) [M. pacifica, Panzer] is a bee that can be managed and is a reliable pollinator of alfalfa. The area of adaptation has pushed from Southern Alberta in the early 1960's, when the bees were first introduced to Canada by Dr. G.A. Hobbs, to Northwestern Alberta (Latitude 55°-59°) by the early 1970's by Dr. P. Pankiw and B. Siemens. The northern strain of bees which have been under the stress of northern climatic conditions for over a decade will pollinate alfalfa at 17°C under sunny skies compared to 18°C for bees from Southern Alberta. Thus by using the northern strain of bees and polyethylene shelters, alfalfa can now be pollinated in areas with less than 250 daylight hours of temperatures above 20.6°C as compared to the 350 hours suggested by Dr. Hobbs.

LIFE HISTORY

Although the alfalfa leaf cutter bee is solitary, it is also gregarious, which makes it possible to raise large populations in man-made shelters. Several native bee species are also attracted to shelters with the alfalfa leaf cutter bees, but attempts to segregate these species and raise them in isolation from the alfalfa leaf cutter bees have not been successful to date.

The bees overwinter in cocoons or cells. They are incubated in June. At a temperature of 29.4°C (85°F) the males usually start emerging on the 18th day and the females on the 20th day. They mate and also feed on nectar and pollen. The female selects a nesting tunnel and may be cutting leaves and provisioning cells within an hour or two after emergence. She makes cuttings from leaves or petals. The walls are oblong leaf cuttings. The cells are filled with pollen and nectar. She lays an egg which floats on the nectar, and then caps the cell with circular cuttings of leaves or petals. Rose and buckwheat leaves are most attractive as are petals of birdsfoot trefoil. She builds cells end to end in the tunnel, beginning at the back and ending near the entrance which is packed with circular cuttings.

The egg hatches in the cell and the larva feeds on the pollen and nectar. The larva which sheds its skin several times as it develops is fully grown when the food is consumed. If food is scarce the adults may be smaller which often happens under adverse conditions during provisioning. Until it is fully grown the larva has a blind gut and cannot defecate and thus contaminate the cell. After eating all the food the larva places its dry faecal pellets beneath the cap at the end of the cell and separates itself from these pellets by spinning a tough silken cocoon. It usually takes a week after completion of spinning before the cocoon becomes tough enough to withstand stripping particularly with machines. The table gives an indication of the development of bees at different temperatures.

Influence of temperature on development of leaf cutter bees.*

Temperature °C	Days in Different Stages			
	Egg	Larva	Spinning Cocoon	Total
17	15	27	6	48
22	6	12	5	24
29	3	7	5	15

* According to Tasei and Masure (Apidologie 9(1) 273-290, 1978)

Bees that are placed in the field in late June usually have many of the tunnels filled by August 1. Usually the larva go into diapause. However, if temperatures are high after 2 or 3 weeks, they may break diapause and continue development into pupae and adults. These second generation adults are of little use as the weather here is too cool to provide any more cells and precautions have to be taken to prevent this occurring.

Accordingly, in our area, hives with 30-40% of the tunnel plugged may be brought in by ca August 5. In areas near Edmonton, Alta. and Prince Albert, Sask. where bees are placed earlier in the field, August 1 or even earlier, is the time to evaluate the amount of filled tunnels. To reduce mold in polystyrene hives, the covings should be removed and the boards loosened from the back of the hive to permit air circulation.

The hives should be stored in cool and dry rooms (18-22°C) for larvae to complete development and spin their cocoons. A check should be made periodically of the cells under the plugs to determine the progress of development. When all the cocoons are spun the temperature can be reduced to 18° C to prevent secondary hatching. When the cells are stripped, they are stored at 5°C till the following spring. Only the full grown larvae spend the winter in its cocoon, similar to the native species.

Next June the bees are taken out of cool storage and placed in an incubator and the larva changes to a pupae within the cocoon. At first the pupa is completely white, later the eyes turn pink, then black, the whole pupa turns grayish black. A week or so later the adult bee emerges by chewing its way out of the cocoon.

Emergence of adults from larvae that spend the winter in 4-5°C storage and are incubated at 29.4° C (85°F) varies with the latitude source of the bees.

Average days to emerge and days to reach 5% to 95% of 3 strains reared at 29.4°C and 60-70% R.H.

Origin	Latitude	Average Number of Days to Emerge		Range of Emergence (Days) 5%		95%	
		Male	Female	Male	Female	Male	Female
Brooks, Alta.	50 30 N	25	27	20	22	29	31
Melfort, Sask.	52 50 N	22	24	19	20	25	28
Beaverlodge, Alta.	55 10 N	20	22	18	20	23	26

Peace River (Lat. 55-56° N) bees begin emergence on the 17 day of incubation and complete emergence by the 26th day. Southern Alberta bees (Lat. 49-51°N) commence emergence at the 16th day of incubation and end about the 32nd day. Northern Saskatchewan bees (Lat. 52-55°N) are intermediate. Thus the higher the latitude the less heat units are required for emergence.

The females of Peace River bees start emerging about the 19th day at which time 50% of the males have emerged. By the 21st day 90% of the males have emerged and 50% of the females. Another 4 days are required for completion of emergence of the females.

As soon as the females emerge from their cocoons they mate. Females mate only once but males mate many times. The males spend their time chasing females and harrassing other insects especially other bees e.g. honey bees and bumble bees, keeping them away from the shelters up to distances of 20 m. Although very little seed set is attributable to males elsewhere, in northern areas, much of the seed up to 15 m from the shelter is set by the males. The senior author has observed 100% tripping of florets up to 10 m from shelter, before any females had emerged. The alfalfa fields ranged from 10 to 70% bloom.

The two sexes are easily distinguished. Males have thick yellow hair on their faces and green eyes. They also have square ended abdomens with yellow colored ends. There are no conspicuous rows of hairs underneath the abdomen. Females have gray hair on their faces, oval abdomens with pointed ends. The undersides of the abdomen are covered with parallel rows of conspicuous whitish hairs called scopas, which carry the pollen. Males do not sting. Females sting only if squeezed accidently and feels like the prick of a needle and less painful than a mosquito bite.

BEE REQUIREMENTS FOR ALFALFA POLLINATION

Bees are being reared primarily for alfalfa pollination. The sales of surplus bees is very lucrative at the present time after surpassing the sales of production of alfalfa seed. As there is an inverse relationship between forage area and bee population increase, shared crop arrangements would vary with different populations.

Reproduction of leaf cutter bees at various concentration on older stands of alfalfa.

BEES per hectare	BEES per acre	Reproduction ratio to bees incubated
15,000	6,000	2.3
20,000	8,000	2.3
40,000	16,000	1.8
50,000	20,000	1.6
70,000	28,000	1.5
80,000	35,000	1.3

Because our weather is not as favorable as Central Alberta or Northern Saskatchewan and far less favorable than Southern Alberta, more bees are needed here to do the same job.

We require up to 50,000 bees per hectare in the Peace River region, possibly 40,000 in Northern Saskatchewan and Central Alberta and 30,000 in Southern Alberta and Manitoba to pollinate alfalfa adequately in normal years.

For those contemplating making share agreements with seed growers, the contracts should be in written form, witnessed and should be of a longer duration (up to 5 years). Long range planning and good management of both bees and alfalfa is the key to successful production of both alfalfa seed and leaf cutter bees.

For Peace River area beekeepers it is best to obtain bees from your own area, because they are better adapted particularly if they have been reared in the area for several generations.

Reproduction of bees in 1977 at Beaverlodge, Alberta from different sources

Strain	Reproduction ratio to bees incubated Test 1	Test 2
Southern Alberta bees with 1 generation in north	1.5	
2 generations in north	1.7	1.6
Northern Saskatchewan bees	2.0	1.9
Peace River bees	2.4	2.4

Differences in reproduction are evident mainly in cool summers. When temperatures are normal or above normal, the differences are much less.

The reason for the higher reproduction of Peace River bees is that they work at lower temperatures and for longer hours.

Temperature °C at which southern and northern strains of leafcutter bees commenced tripping in 1976 and 1977 at Beaverlodge. Time (Sidereal)*

	Date	Northern Bees (Beaverlodge) Time	Temp.	Southern Bees (Smoky) Time	Temp.
1976	July 14	0930	15.2	0848	17.2
	July 16	0731	14.1	0811	17.2
	July 19	0859	15.2	0911	17.0
1977	July 27	0729	17.5	0749	19.5
	Aug.	0910	16.	0825	17.7
	Aug. 5	0930	17.5	0850	18.0
	Aug. 7	0910	17.5	0819	19.5

* 1200 Sidereal time is when the sun is due south or 180° by the compass.

PARASITES AND PREDATORS

Parasite problems are minimal in this area. Stenoma is a problem which is prevalent in other areas has not established here although it has been introduced by beekeepers who brought bees in from the southern areas. Parasites in this area include Coelioxys a parasite similar in size to the leaf cutter. It is a natural parasite of native species. As Coelioxys emerge just before new M. pugnata males they can be disposed of very easily in the incubation room.

A native bee parasite Sphecodes sp is also found on native species. This parasite will anaesthetize M. rotundata and lay eggs but they do not develop to maturity. It emerges at about 10-12 days at incubation at 29.4°C (85°F).

Another predator is a red larvae of a meloid beetle found particularly near wooded areas. Many of these can be removed during sorting and incubation.

OBTAINING BEES

Because of the ability of northern bees to work at lower temperatures the best choice of bees is the Peace River area. The next best choice would be Northern Saskatchewan, Northern Manitoba or Central Alberta. Least choice or at least is southern parts of the Prairie Provinces. However, it must be remembered that bees will adapt to local conditions. Thus bees from Southern Alberta will adapt to northern conditions in 4-7 years and bees from the Peace area later will digress to the more favorable conditions of the south in a few generations.

The cost of bees will vary and depend primarily on the price of certified alfalfa seed paid to the seed grower and on supply and demand. A price of 1 comb is 100 cells should equal the price of a half kilogram of certified seed.

Quality is an important aspect. With the leaf cutter bee being a new industry established at the Horticultural Centre at Brooks, a beekeeper can get the following particulars: cells per pound or kg, percent wastage, emergence percentage, male-female ratio, types of parasites. With this information he can estimate his total production. Taking a proper sample is extremely important. To have a representative sample mix the cells thoroughly and then take cells or cocoons from several parts of the pile and mix. Send the required amount for sampling.

Tests of over 1000 samples in the past 6 years showed that good quality bees will run to 9 emerging bees per gram of sample. Thus for 50,000 bees per shelter we load our incubation trays with 2.2 kg of cells.

INCUBATION

Incubation is an important aspect of leaf cutter bee management. Emergence of leaf cutter bees is dependent on 1) source of bees or latitude of origin and 2) temperature. The source aspect has been mentioned previously but summarizing the higher the latitude, the shorter the emergence period. Keep bees from different sources in separate trays when incubating.

Heat units have not been worked out for emergence but researchers have found the following: At 29.4°C it takes about 18 days for the males to emerge; at 24°C it takes 40 days and at 21°C ca 56 days. With lowering of temperature percentage emergence decreases considerably. Emerged bees can be held for 2 or 3 days at 18°C in a darkened room without any ill effects. This information is important when trying to adjust emergence of bees to bloom of alfalfa. An ideal situation is 40 to 50% emergence of male bees and 5 to 10% females when alfalfa is at 10% bloom.

The length of time for completion of emergence is dependent on temperature. Thus if bees are placed in the field when 40% are hatched and the day-time temperatures are in the 25°C range, the rest of the pupae will usually complete development and chew their way out of the cells in 7 to 10 days for northern bees. However, if the weather turns cool for a week or so, with less than 25°C, emergence could be severely affected. If after 5 to 6 days the temperatures are still low (below 25°C) the trays should be brought back in and reincubated for 1 - 2 days in a dark room. Emerged bees are better able to cope with low temperature than pupae that have not completed development.

Similarly high temperatures can also be detrimental. Temperatures above 38°C (100°F) are lethal to developing pupae. Such temperatures were recorded inside the shelters in 1979 when a high mortality of bees in unemerged cells was observed.

Incubation rooms need not be elaborate. Where a refrigerator-incubator room is not available, a room in a basement is ideal. The requirements are a window to allow parasites etc. to fly to an emergence, a baseboard heater (1500 watts) with a thermostat, a continuous fan, and a humidifier with a capacity of 2-4 gallons a day. A 12' x 12' room is sufficient for 2 million cells. Humidity may vary from 50-70% but the higher humidity is preferable, especially at emergence.

Start of incubation is usually 12 days before date of 10% bloom of alfalfa which normally occurs in the Peace River region on June 30 for older stands and July 4-6 for first year seed crops. In years with late springs these dates may be delayed by as much as a week or more. In some years it may be earlier. Also some varieties e.g. Grimm bloom earlier than other varieties e.g. Rambler. Normally we load our trays and commence incubating at 29.4°C (85°F) on June 12 for older and June 15 for new seeds.

Trays may vary in size. Do not spread the cells more than 5 cm (2 in.) deep. Our trays 22" x 24" and 3" deep are sufficient for 20,000 cells. The sides are 1/2" plywood and the bottom 5/16" plywood. Wire screen 20x22" is used for the top and a 5" lid.

Ten days after commencement of incubation another evaluation of the fields is made at which time control of insects in the field should also be initiated. If it appears that alfalfa bloom will be late, the incubation room temperature may be reduced to 25°C for 3-4 days to delay emergence but should be brought back to 29.4°C prior to bees emerging. If bees do emerge and weather is inclement, holding them at 18°C for 2 or 3 days may be necessary.

To get rid of parasites the incubation trays are peeled about 6-10 mm (1/4"-3/8"). Parasites and predators (beetle larvae and adults) are attracted to the window and should be vacuumed daily. A shop vacuum cleaner is ideal. Where natural light is not available, black light with long wave length may be used.

If you have bees from southern areas, Pteromalus venustus emerge at 9-11 days. At 10-12 days Dibrachys sp parasites of native bees emerge. All parasites should be vacuumed twice daily to prevent re-entry into the trays. If they are not drawn off to the light, they will reinfect the developing leaf cutter bee pupae and a second batch of Pteromalus will occur when the trays are taken to the field.

At 12-17 days Coelioxys parasites and native bees emerge. When Coelioxys have completed emerging, close the lids of the incubation trays. On the 17th day some M. rotundata males also will emerge and should be sacrificed to get rid of the Coelioxys.

On the 19th or 20th day when females commence emergence, take the trays to the alfalfa field. Dampen cells in trays to increase humidity. Many unemerged adults are found dead in the trays as the cells are too dry and tough for bees to chew their way out. For any distance travelling, a darkened van or truck cap with provision for ventilation is preferred. Where temperatures are high, ice may be required for cooling. The best transport temperature is 15-20°C with a dark interior

Many females will use the old cells in the trays for nesting. After emergence is completed, dump the cells from the tray onto a black garbage bag and let the females fly off before removing the cells from the field. A sunny warm afternoon is preferable.

Do not dump cells in front of or near the shelter as this attracts predators and parasites and there is a possibility of spread of disease. Cells should be collected and burnt.

Beekeepers who operate within a range of 20 miles could use the system of incubation originated by the Melfort Research Station (write Melfort Sask. for details). The basic principle is building special incubators with forced air for ventilation with a larger incubating room, which has the proper temperature and humidity. The emerging bees are collected in trays and taken once or twice daily to the field shelters. During inclement weather the adults may be fed and stored at ca 18°C in a darkened room for 2 or 3 days without any ill effects. This system not only insures maximum emergence of adults but is an excellent way to control the parasite Pteromalus. It also insures that cells are not left in the field with the accompanying danger of spread of disease, parasites and predators.

SHELTERS

Our shelters are based on the use of solar power and are constructed of four 4'x4' panels using ultraviolet resistant film of 4 or 6 mil. thickness. These types of shelters are 4-10°C warmer inside than outside the shelter during the day and provide better conditions for development of eggs and larvae. They also do not unduly restrict the bee's radiation which is important in activating the bees to go out and forage.

Fibreglass is being used successfully in Northern Saskatchewan and clear fibreglass may be satisfactory in our area in years with normal and above normal temperatures. Lexan and Coroplast are not recommended in our area. The motto of successful management of cool weather packages in our area is "Let there be light." Facing the shelter and hives south allows sunlight (partially diffused by the polyethylene) to shine on the face of the hives for 12 hours a day and female bees dispersed there use more evenly in the hives.

The shelter is constructed of four 4'x4' panels. Each panel is made of four pieces of 1"x3"x4' lumber, lap jointed and treated with sealer/preservative at the corners, and is covered with a 5'x5' sheet of polyethylene. The panels are predrilled and nailed with 2 1/2" double headed nails, with four nails in the back panel and 6 nails in the top panel. One film commercially used CIL 440 or 640 will last 3 seasons if stored at below freezing temperatures in the winter and 4 to 5 seasons if stored at above freezing temperatures. If the corners of the wooden panels are treated with pentachlorophenol, the panels will last 6 years or more.

The shelters can also be made 3' (90cm) in depth over 2' (60 cm) in depth. However, because of driving rainstorms, and the possibility of placing 2 rows of hives, the 4-foot model is preferred. Also, these panels 4'x4'x4' are interchangeable. Plastic is always faced to the outside.

The back end of the side panels are nailed with 1x6's or 1x8's to rest the hives. Also a 1x2 is nailed about 2 feet on the back to give the hives a back rest and to provide ventilation around the hives. A wood strip 2x2x46" tapered at each end to 3/8" is placed under the plastic on the top panel to shed rain.

The incubation tray is placed inside the bottom of the shelter on pieces of 2x4 and may be covered with plywood etc. to prevent rain entering the trays.

One of our problems is protecting the shelters. A metal rod of 3/8" to 3/4 rebar is satisfactory. They must be pounded and driven at least 20 cm (12") into the soil and be 20-30 cm from the front of the shelter on the inside. If polystyrene hives are used, another rod is needed to prevent the back panel. Where the ground is wet or if high winds are experienced, the front of the hive can be additionally anchored with 2 - 6' wooden stakes made of 1x2's driven at a 45° angle and nailed to the hive panels at ground level and 50 cm above ground level.

Three 3000 tunnel polystyrene hives (13"x14"x5") or four 2250 tunnel wooden hives (22"x18"x5") giving a total of 9000 tunnels are usually sufficient for 20,000 emerging cells with a 2:1 male-female ratio. Additional hives can be placed on a second row, using another 1"x6"x4" board nailed to the bottom of the side panel, to rest the hives. A 10 cm clearance from the top of the shelter should provide ventilation and avoid the higher temperatures occurring at this level.

Shelters 8x4x4 and 12x4x4 and larger can be constructed using a wooden framework of 2x4's and utilizing the plastic panels. These have not been tested but should be satisfactory.

The wooden framework of larger shelters may be anchored more permanently and remain in the field for the life of the alfalfa stand which is usually 5 seed producing years. The panels can be attached in mid-June and removed when hives are taken in and should be stored in a dry place.

Polyethylene shelters may also be used in central Alberta (north of Latitude 53), Northern Saskatchewan and Northern Manitoba. As July and August temperatures are higher, we advise using larger shelters and clear fibreglass instead of polyethylene. Shallow (3-4 feet deep) plywood shelters are suitable for the southern part of the western provinces.

Drift is a problem with our small shelters. Bees normally drift to the south and west and to end shelters in a row. They also drift to higher elevations and from lodged areas to nonlodged areas. They will drift from open fields to sheltered areas. They have been observed to overfly alfalfa for such crops as birdsfoot trefoil, alsike and sunflowers. When bees were put out at 2-5% bloom many bees drifted to other fields and were lost. When bees do drift to other shelters extra hives may be required and the pollination may not be uniform. If bees are placed in the shelters when 10% or greater bloom is available and lower rates are used e.g. 25,000 cells per hectare drift is minimal. Use of larger shelters with greater distances also minimizes drift.

NESTING MATERIAL AND HIVES

Molded polystyrene grooved boards are 3 3/4" wide, 11 3/8" long and 3/8" thick with 30 tunnels 15 of which are 8/32" in diameter and 15 are 9/32" in diameter. They are manufactured by a Canadian company, Beaver Plastic Ltd., 12806 - 63 Street, Edmonton, Alberta T5A 0W2. In new equipment the 8/32" diameter tunnels are preferred by the bees. More leaves are needed for construction of the cells in the 9/32" diameter tunnels. This preference is not as evident after the first year. Polystyrene grooved boards are very light; a 3000 tunnel hive only weighs 6-7 kg depending on material construction of the hive.

There is a slight problem with mold but the boards can be decontaminated with steam or household bleach (mixed 5% with water). Also the back of the hives may be bored with 1" holes, wire-screened and a layer of paper laid to absorb moisture from the leaf cuttings and reduce the mold problem. Light mold is not harmful to cells but is a problem when stripping or cleaning especially to workers with allergies. Decontamination should be preferably done before the hives are placed in the field.

End boards made of masonite 4 3/4" x 1[illegible] 3/4" with a 1/4"x1"x11" soft wood or plywood strip glued on one end, will prevent bees nesting in the half-tunnels at the end of the hive and will provide backing for the spring made up of two 5" three-quarter inch polyethylene tubing. At the other end of the hive, another strip is nailed to prevent bees nesting in the half-tunnels. The hives should also have strips nailed on the side to prevent the boards pulling away from the back as the bees will not use such tunnels.

Polystyrene grooved boards are placed in 100 tunnel hives 13"x5"x44". The face of the boards should be sprayed with black or other dark stain (with a linseed oil base), then when dry in about 3 days patterned with a contrasting stain (blue, biege, green, red). The pattern should not occupy more than 1/3 of the original area. Fine line patterns are preferred.

Wood grooved boards 5 1/4" wide and 11/32" thick with 13 tunnels are obtained in lengths of 1, 2 and 4 foot (31 cm, 62cm and 123 cm). They are usually cut in 4" lengths. On a tunnel basis they are at least twice the cost of molded polystyrene boards. They are more durable, with no mold problems. However, they are much heavier; a 200 tunnel hive weighs about 18 kg (45 lb). Also machining of some boards are not too exact and thus they are broken by power strippers. Wood also has the tendency to shrink, warp and crack. Most wooden grooved boards are imported.

A three tiered hive 17 1/2"x22"x9" will have about 165 boards for 2250 tunnels. To divide the tiers 2 divider boards made out of 1/8" masonite 5"x20 1/2" are required. Polyethylene spring made up of six 5" pieces of 3/4 polyethylene tubing complete the hive. The hives should be painted as for molded polystyrene boards.

In comparing old wood and polystyrene (mostly new) in the past 2 years for bee reproduction, wood is preferred. Further comparisons are being made with old wood and old polystyrene.

STRIPPING

When the cocoons are fully spun and the silk has changed color from white to light brown the cells are stripped. After stripping, the cells can be cleaned to remove the plugs and excess leaves. An oat screen or clipper cleaner with proper sieves are ideal. Also many meloid beetle larvae can also be screened. Do not over-clean the cells. If the outer leaves around the cocoon are removed, emergence of cells can be seriously reduced.

Care should be taken in proper adjustment of power strippers. Cells removed by hand strippers whether wood or polystyrene, though much slower are less subject to damage. Cells should be stored at about 5°C. Five-gallon stacking honey pails holding up to 50,000 cells are ideal. Drill two 1/8" holes just under the lid in the sides. Twenty-gallon paper containers with a capacity of 40 lb (18 kg) have also been used but are not as durable.

QUALITY AND PRODUCTION ESTIMATION

A simple method of evaluating production of cells is to take a representative sample and weigh about 50 grams on a diet scale. Count out the number of good cells or spun cocoons. Usually you should have 500 good cells or 10 cells per gram. Considering a 90% emergence you will have 450 bees or 9 bees per gram.

The leaf cutter bee testing centre at the Agricultural Research Centre, Brooks, Alberta will conduct a quality test for a reasonable sum. A quality test usually will give the following information: 1) number of good cells per amount weight; 2) percent emergence; 3) number of emerged bees per kg (or lb.) of cells; 4) male-female ratio; 5) parasites; and 6) predators. For those offering cocoons for sale a quality test is necessary. Buyers are most interested in number of emerged bees per pound, male-female ratio and the parasites or predators present.

As bees require a rest period for good emergence, it may not be advisable to test till the bees have been in cool storage for 2 or 3 months. For those wishing to conduct their own quality test, mix all your stripped cells in one large pile then take handfuls throughout the pile till you have about one pound or more. Weigh the sample carefully and separate the good cells. Weigh these again and count them. Take 10 samples of 100 cells and place in trays with 100 cell compartments and glass tops. Make your own mini-incubator using a cardboard box with a light bulb, a thermostat and a temperature-humidity indicator. A pan of water should provide enough humidity. Temperatures of 25-30^{o}C are sufficient. When bees start emerging, the glass top may be marked with a wax pencil indicating sex of the bee. Where parasites are present, the containers should have a tight fit, otherwise they will reparasitize the developing pupae in the rest of the cells and a low test emergence will result.

After emergence is completed and no more bees emerge for 3 or 4 days, inspect the intact cocoons by cutting the head ends of the cell off with a razor blade. This may include bees dying in the larval stage or several stages of the pupae. Some larvae may have broken dormancy the previous summer and developed into pupae. When they were placed in storage, these pupae will naturally die. Where a second generation occurs, management should be altered the following season to reduce this factor.

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