EFFECTS OF VARIOUS TYPES OF WINTER PROTECTION FOR COLONIES OF HONEY BEES UPON STORES CONSUMED DURING WINTER AND AMOUNT OF SEALED BROOD IN SPRING

Page numbers of An Abstract of A Thesis are lacking

by

VIRGIL RAYMOND BAYLES

B. S., Kansas State College
of Agriculture and Applied Science, 1953

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Entomology

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1954

TABLE OF CONTENTS

INTRODUCTION

There are many problems encountered in the wintering of honey bees. How the colony overcomes the rigors of the winter has a great effect on colony condition in the spring and every progressive beekeeper wants a strong colony at the right time in the spring, not too early nor too late. If it becomes too strong too early, it consumes stores in the hive; and if too late, it cannot fully assist the beekeeper in the gathering of the honey crop for the season. Whether or not the colony is strong will depend to a large extent on how successfully it survived the winter.

Phillips and Demuth (1918) stated that a bee may be compared to a storage battery in that it has a certain amount of energy to spend, after which it dies. They further stated that the bee resorts to muscular activity to maintain the proper cluster temperature. A system of wintering that would minimize this expenditure of energy would result in less loss of bees during the winter and aid in the increase in population of a strong colony in the spring.

These writers also stated that the essentials to success in caring for a normal colony of bees from the end of the last nectarflow in a season to the beginning of the next major nectarflow of the next season lies in providing three things in abundance; (1) stores of good quality; (2) protection from the wind and cold; and, (3) room for the rearing of brood at the appropriate time.

Stores of good quality are important in that they can be utilized more completely than those of poorer quality and thus in long periods of cold weather and confinement there is less chance for the occurrence of

Nosema because more of the food is utilized and less excreted.

Protection from the wind is the second essential and is also very important. With the hive facing south, the cold north wind is somewhat shut out and the wind from the south is usually warm and enters the hive and aids in aeriation or circulation of the air in the hive. By the use of windbreaks, or packing material of various sorts, the cold wintry blasts of air are deflected from the surface of the hive and the temperature of the hive is not reduced as readily.

Room for the rearing of brood at appropriate times is the third essential. In the early spring when the conditions are favorable, the queen will begin laying eggs and if the combs are full of honey or pollen, she is restricted to the amount of eggs she can lay until that space has been cleared of honey. There should be ample honey and pollen for the rearing of the brood but at the same time there must be vacant cells of appropriate number to allow the queen unrestricted egg laying in order to have an abundance of young bees in time for the first major nectarflow.

This study is an attempt to show the relationship between various types of winter protection in relation to loss of colony weight, i.e., the amount of stores consumed, and the loss of bees, and the condition of the colony in the spring. Somewhat similar studies were made in Manhattan, Kansas by Merrill (1920) but it did not cover all of these points and knowledge gained through the years have changed the concept of wintering problems considerably.

REVIEW OF LITERATURE

The function and the need for hive insulation has been tested and debated for more than 100 years. Hive and cluster temperatures have been investigated by numerous research workers in the United States and foreign countries. The conclusions drawn have been influenced by the instruments used, the condition of the colonies, and to a general extent, the concepts of bee management. Even today, beekeepers have their own ideas and methods of wintering bees. What works for one, another may say he has tried without success.

Farrar (1952) stated that for winter insulation to be protective, it would have to be around the cluster rather than around the hive, and in effect shut off all convection air currents between the warm air inside and the cold air outside. Even with the restricted hive entrance, the exchange of air through the packed hive is large in proportion to the space occupied by the bees.

Taylor (1949) stated that Langstroth did not believe in packing bees. According to his understandings, bees winter best in the north in unpacked, unpainted ordinary hives, open at the top and bottom, exposed to the south but protected from the wind. He also stated that an erroneous conclusion reached by many beekeeping authorities is that the colder it becomes, the more heat the bees produce in the cluster; that this heat is produced by muscular activity and that packing is necessary to conserve it.

Farrar (1952) stated that a theory of conservation of bee energy and honey stores prevailed for many years. Hive insulation or cellar wintering was supposed to conserve bee energy and therefore conserve honey stores.

It is sometimes possible to have a small colony survive the winter and use less than 10 pounds of honey. Spring feeding was, of course, a recognized necessity.

Newell (1944) stated that bees winter successfully in hollow trees and old buildings where the winter temperature is extremely cold. He has removed bees from hollow trees in the White Mountains where it is not uncommon in the winter to have the temperature register -45° F. and the bees are not able to fly out of their hives from October to early April. The bees are able to form a tight cluster during the winter and consume honey within this cluster to maintain a temperature not far from 57° F. within the cluster. During mild weather this cluster is broken even when the outside temperature is not high enough for flight. It is during such periods that the bees move to cover a new supply of honey.

Farrar (1943) stated that packing does not satisfy the conservation of energy theory because the winter cluster does not attempt to heat the inside of the hive. He studied the cluster and hive temperatures and made several thousand records by using two story colonies each equipped with 118 thermocouples. Colonies of single walls were contrasted with those of double walls and those of excessive packing. The use of many thermocouples distributed throughout the hive, established the fact that during a protracted cold period the temperature of the air surrounding the cluster approaches the outside temperature regardless of the degree of insulation of the hive. Even a greatly reduced hive entrance is large enough to permit air currents to dissipate the small amount of heat radiated from the cluster.

His experiment also showed that the winter cluster provides it's own insulation against heat loss. The insulating shell of closely packed bees filling the interspaces between the combs and any empty cells, ranges from one to three inches in depth, and the more loosely grouped bees in the center generate heat. The temperature within the winter cluster will vary above the minimum of 56° to 60° F. showing an increase or decrease which opposes within limits any external temperature change, whereas the cluster surface temperature remains normally somewhere between 43° to 46° F. As the air temperature surrounding the cluster declines, the cluster contracts and reduces the surface exposed to heat radiation, increasing the depth of the insulating shell, and concentrating more bees in the center to generate heat. Conversely, the cluster expands with a rise in air temperature. The cluster size and the internal temperature are so balanced that sufficient heat is conducted to the surrounding bees to maintain the normal cluster surface temperature.

Anderson (1943) stated that as the amount of packing decreases, the temperature variations within the hive increases. When he placed a quantity of honey in the hive the variations became even less. This was possibly the result of the fact that the frames of honey slowed the cooling off by the ability of the honey to hold the heat longer and more or less cause a gradual change in temperature. He stated that considerable time was required for heat from the outside to penetrate the packing and raise the temperature within the hive. It seemed to him that it took about seven hours or longer for the changes in the outside temperature to influence the inside of the hive.

Farrar (1943) stated that packing retards the rate of temperature change within the unoccupied hive space, but during a protracted cold period the air temperature within the packed hive but away from the cluster may approach that of the outside temperature. The packed hive, by cooling more slowly allows the bees sufficient time to contract their cluster to the most favorable position and density but it may not benefit from a rise in the external temperature which allows the cluster in the unpacked hive to shift its position or the bees to make a brief cleansing flight.

Taylor (1949) stated that bees partially regulate heat loss from the cluster by forming a thick rind or insulation layer and by increasing and decreasing the area of the cluster and that this has been known for a long time. What has been overlooked is that the overlapped wings of the bees in the cluster form a transparent surface which greatly reduces the heat loss by radiation from the surface of the cluster to the colder areas of the hive and also that by rapid vibration of their overlapped wings, the bees are taking in fresh air and allowing the stale air to rise from the cluster. He also stated that the air temperature in the hive is of minor consideration. The two most important conditions which affect the bees in the cluster being the degree of relative humidity and the temperature of the inside surface of the hive.

Rea (1948) stated that there is little or no difference in the air temperature surrounding the cluster in a packed hive and an unpacked hive. He also quotes Langstroth as stating that "damp" is the chief cause of winter loss.

Anderson (1948) stated that packing maintains a more constant temperature of the hive and conserves the amount of food required for winter use. This does not agree with what Farrar showed. He also stated that the even temperature of packed hives often retards broodrearing until later in the season when rearing progresses more rapidly than in unpacked hives. He believed that honey in the hive acts as a regulator to retard sudden temperature changes and gives the bees more time to form a winter cluster when the outside temperature is suddenly lowered. The honey does not cool as fast as the air and therefore slows the rate of cooling of the temperature within the hive.

Nielsen (1935) stated that strong well packed colonies exposed to all prevailing sharp winds may die or survive the winter so weakened they are practically worthless, while colonies of the same strength in single walled hives well protected from winds, winter well and consume far less stores.

Lynse (1950) stated that packing is not necessary but that black tarpaper wrapped around the hive does two things; it acts as a windbreak and absorbs the radiant heat of the sun, thereby reducing the heat loss of the cluster and at the same time lessens the condensation of moisture within the hive by the heating of the hive walls. He further stated that bees will winter well in a dry hive, the principle of wintering being the same everywhere. He also stated that the inside of a double walled hive is only slightly warmer than a single walled hive.

Brown (1943) stated that a beekeeper with a large number of colonies told him that when he started beekeeping many years ago, they packed their colonies in quadruple packing cases, then later in doubles, then singles, which was followed by tarpaper and no packing at all. In 1935 they had a continued period of unusually cold weather which lasted four to five weeks at temperatures ranging from zero to -20° F. with practically no snow. The bees that were packed wintered poorly while those without protection wintered well. As a result of this experience, very few beekeepers in Indiana pack their bees for winter.

Munro (1935) experimented with various types of homemade insulations for winter packing at the North Dakota Agricultural Experiment Station and he recommends the use of one thickness of celotex and believes it should be left on the colony the year around. In the winter, wrap the cases with tarpaper, but take it off in the spring.

Norton (1946) stated that the condition of the colony to be wrapped is of much importance and that colonies with a reasonable number of young bees in the fall are best. He further stated that he goes through winter after winter without a loss of a colony by following this policy.

Nicholson (1952) stated that in England they formerly used double walled hives altogether, but are now using the single walled hives. He also stated that the English beekeepers know that you don't have to keep the inside of the hive warm for colonies to winter well. He realized that excessive moisture is the likeliest cause of winter kill and not the lack of packing.

Rock (1948) stated that an old Scottish beekeeper told him he packed his bees with honey, meaning that he gave them more stores than they would normally need for the winter.

Langley (1945) stated that when he started beekeeping in the northern part of the United States, about 1915, the practice was to cellar winter the bees or heavy pack them in expensive cumbersome cases. They thought then that the more packing the better, i.e., with eight inches around the sides and eighteen inches of packing material on the top. Now scientific investigations have shown that the cluster does not heat the inside of the hive and that heavy packing has a refrigeration as well as an insulation effect, keeping the colony cold and not allowing the sunshine to warm up the hive to enable the bees to change position and move on to a new honey source within the hive. He now wraps the hives with one thickness of tarpaper and sometimes uses one thickness of corrugated paper under it. When the sun shines in the wintertime the tarpaper absorbs enough heat to warm the hive and allows the bees to take a cleansing flight that they would not be able to take if they were in a heavily packed hive.

Farrar (1952) stated that a colony with a strong winter cluster of young bees, with an abundance of honey and pollen within reach will winter well under almost all conditions. Since most winter losses are due to starvation, ample stores of pollen and honey are of prime importance.

In northern Minnesota, colonies were wintered with and without insulation but with a windbreak. In the spring very little difference was noted in the condition in which they survived the winter.

In the middle latitudes, Illinois, Iowa, Missouri, or Indiana, there is little evidence that packing of any sort is effective. The most common type of packing in this area is the use of tarpaper to wrap around the hives.

Lynse (1950) stated that in Illinois the beekeepers prefer a quiet sunny spot with a good windbreak and no packing to winter their bees. He also stated that the beekeepers in Illinois have not found that it pays for them to pack their hives.

Barnes (1952) stated that a good windbreak against the prevailing winter winds should be provided. The apiary should be located, if possible, where it has good air drainage, as free flowing air currents are desirable in winter as well as in summer in removing the stale damp air that may accumulate around the hive.

Farrar (1952) stated that a summary of management standards favorable to good wintering under all conditions may be enumerated as follows; (1) unrestricted brood rearing in the fall to provide a normal population of ten pounds of bees, (2) forty-five pounds of honey in dark combs in the top hive body plus twenty to thirty pounds in the lower hive body of a two story hive, (3) five-hundred square inches of pollen reserves or provisions made to supply supplement pollen cakes during March and April and such other periods when pollen collection is below colony requirements, (4) freedom from Nosema, (5) provision of an augar hole in the upper hive body and a reduced bottom board entrance, and (6) the location of the hives in full sunlight and where they are protected from the wind and provided with good drainage of the air away from the hive.

The overwintering of honeybee colonies has been considered one of the most difficult problems of management. Winter losses based on the number of colonies that do survive may average 15 percent. The reduced productivity of the colonies that do survive under poor wintering conditions may exceed by several times the apparent loss. Phillips and Demuth (1918) contend that there are four things to consider in the measurement of success in wintering; (1) when bees are packed and protected from the wind, they should be able to push out the dead bees in the hive as they die. There should never be an accumulation of dead bees on the bottom board. (2) A colony of full strength should have at least 12 combs of brood at the time they are unpacked. (3) A colony is not of proper strength for winter unless it has three to four combs of brood about two months before packing. (4) If a thermometer is inserted into the hive, at no time should it show a temperature below freezing. Farrar (1952) stated in contrast to the temperature factor that insulation around the hive slows the rate of temperature change, but in a cold climate it does not prevent subzero temperatures within the hive. The normal colony forms a cluster within the area of food stores and it produces and regulates its heat within a well defined temperature gradient independent of the air temperature surrounding the cluster.

There are many ideas and theories as to the essentials for good wintering. Phillips and Demuth (1918) stated that the essentials to success in caring for a normal colony of bees from the end of the nectarflow of one season the the beginning of the first major nectarflow of the next season depend on providing three things; (1) stores of good quality, (2) protection from wind and cold, and (3) room for the rearing of brood at appropriate times. The location of the apiary in the winter should be so that the cold winter wind is virtually eliminated artificially or otherwise. Rock (1948) stated that there are several factors involved in good wintering, such as the variability in strains and races of bees, late summer management in the size of the brood nests, regional honey flows, air drainage, and according to some, packing. He believed the most important point was the strain of bees, Carniolian first or second cross for excellent ability to survive the winter with a strong population on a minimum of stores. He indicated his belief that Italian bees are not too winter hardy.

Parker (1943) stated that the three banded Italian, Caucasian and the Carniolian bees winter well in Kansas and are not readily susceptible to the disease, European foulbrood, while the other varieties do not winter well and are not adapted to Kansas weather conditions.

Anderson (1944) stated that the factors that have a direct bearing upon the ability of a colony to survive the winter are not only many but are complicated by the fact that each winter presents a different combination of conditions. One can not anticipate which will be the most serious in any particular winter but must take steps to prevent loss from any or all of the difficulties that lie ahead. The problems that he thinks are most important are; quality and quantity of stores, protection from the wind, packing, vigor of the bees, and adult and brood diseases.

Latham (1934) stated that the site for locating an apiary for outdoor wintering must have a slope, preferably to the south or southwest. He stated that bees will not winter well on flat ground because the air stagnates about the hives and the inside of the hives is then unfavorable for the bees because of the collection of moisture there. On a slope the air is always drifting even when the wind is not blowing and this aids in the circulation of the air within the hive and reduces the moisture there. Newell (1949) stated that it is not the cold that kills the bees in the winter, but too much moisture within the hive. This moisture forms into ice within the hive in subzero weather and drips onto the bees when it thaws. He maintains that in a dry hive there is no danger of winter injury to a strong colony with sufficient honey and pollen to maintain moderate brood rearing. Deihnelt (1948) stated that he has shown by tests that water in the hive becomes laden with Nosema spores. The moisture on the roof of the hive will form into drops and fall onto the cluster of bees and seemingly spread the disease. By wrapping the hives with black tarpaper or building paper and or the use of upper entrances, the moisture in the hive can be greatly reduced. The black or dark surface color of the paper will absorb the heat from the sun and warm the walls of the hive, thus driving off the moisture and it will be circulated out of the hive either through the upper entrance, if there is one, or the lower entrance. Ventilated covers, on a small scale, are now coming into use for this purpose. Some beekeepers place a piece of burlap on top of the inner cover and let it hang out over the sides and flap in the wind and act as a wick to draw the moisture that has collected on it in the hive, to the outside. Satisfactory results have been claimed from this method.

Anderson (1948) stated that there is no relation between humidity and the prevalence of Nosema. A study on a larger scale might show different results he stated, but hives he kept in the unusually dry conditions of the laboratory developed Nosema as readily as those under normal conditions where the relative humidity was much higher. He did find that Nosema was one of the principal causes of winter losses and spring dwindling. He also stated that bees can withstand the high humidity of the hive with no immediate evidence of ill effects, but that high humidity does affect the food supplies causing indirect damage to the bees and combs by molding of combs and pollen.

Phillips and Demuth (1918) stated that a common practice has been to remove the hive cover at the time the bees are packed and to cover the frames with burlap to absorb and allow the escape of any moisture from the colony. Moisture is being generated constantly as the bees consume the honey stores, but if the bees are adequately packed the amount of moisture will be reduced to a minimum. The chief danger of course is from the moisture that condenses and in an adequately packed hive there is no condensation. The temperature never goes low enough for water vapor to condense, therefore it is obvious that upward ventilation for the escape of moisture is never needed in hives that are adequately packed.

Parker (1953) stated that there are five principle needs for the preparation of bees for winter. A colony should have a large population of bees, about 20,000 or three to five pounds of bees and a young vigorous queen, they should have at least 600 square inches of pollen and at least seventy pounds of honey, fifty pounds in the upper story and twenty pounds in the lower. Protection is needed to conserve the energy and heat produced by the clustering bees. These should be provided by October 15. Winter protection should be given the colonies during the later part of October and removed during the later part of April or the first week in May, depending upon weather conditions. The most common protection now is the windbreak (natural). If insulation is used it should be provided beneath the hive as well as on the sides and top. The size of the hive entrance in Kansas should be at least one and one-half inches to two inches long and three-eighths of an inch high. Mice are not able to enter this size opening and ruin the combs.

Grout (1949) stated that the requirements for bees to go into winter are eight in number; (1) a colony should have a productive queen, (2) there must be enough bees to cover twenty combs or eight to ten pounds, (3) at least five-hundred square inches of pollen, (4) at least seventy-five pounds of honey, forty-five pounds in the upper and thirty pounds in the lower, (5) reduced lower entrance and an upper entrance (auger hole), (6) protection from the wind, (7) maximum exposure to the sunlight, and (8) a well drained location. He stated further that packing will not make a strong colony out of a colony deficient in any of the above requirements.

Root (1950) stated that successful wintering is dependent on proper summer management.

Myers (1936) stated that the requirements for successful wintering are quite well known. They are good food and plenty of it, adequate insulation, strong colonies of young bees and protection from the cold winds. He also stated that the most common practice in outdoor wintering is that of providing a cheaply constructed outer case, large enough to hold several hives. Wooden cases are expensive to build or buy and present a storage problem so a great number of the beekeepers have now turned to the tar paper pack. It is inexpensive, presents no storage problem as it can be rolled up, and doesn't take much room and can be used for a number of years before having to be replaced. It takes only a little time to install the tar paper as compared to the wooden cases. He also stated that he had two experienced men and one helper put tar paper packs on thirty-two colonies and it took them only one hour. It would have taken much longer to have put wooden cases on the same number of colonies.

Root (1950) stated that except for extremely cold localities, moderate packing or a simple wrapping of building paper around the hive is probably safer and better than excessive packing or what has been appropriately called ice house packing that puts the colony in cold storage where the heat from the rays of the sun cannot reach the cluster. Bees seldom die of cold, it is their inability to move to stores near them due to the low temperature of the hive.

Cale (1934) stated that most beekeepers have given up the idea of a heavy packing case and have adopted some simpler method like the Iowa tar paper case. This is used all through Iowa, Nebraska, Kansas, and northern Missouri and is being adopted elsewhere as a cheap way of winter packing where winter packing is needed. In using it, the colonies may be grouped into twos, threes, fours or packed singly. Where bees are kept in a permanent grouping through the summer, it is easy to use.

Cale (1935) stated that some beekeepers in the north use the tar paper wrap with a top entrance, closing the usual summer entrance. This method is gaining favor over the cellar wintering in the northern bee yards. In addition to the tar paper, straw and other material may be used beneath the tar paper. It costs about fifteen to twenty cents per colony per year including labor to wrap the bees in tar paper.

Nielsen (1934) stated that it is generally agreed that it is the long periods of even cold temperatures during which times bees do not survive. Bees do withstand below zero temperatures if not continued too long. It is in this connection that the black tar paper packing can be used to a very good advantage. The black color gathers or absorbs the rays of the sun and warms up the hive quickly which enables the cluster to break and reform in a new location.

Gates (1949) stated that the winter of 1948 was the worst in history in the state of Washington. The bees were confined to the hives from the middle of November until the last of February and for over two months the temperature was below freezing, some times twenty degrees below and once -30° F. There was a snow in February that covered the colonies and he lost only one colony and that was due to late broodrearing and the bees didn't move up to the honey. He had the hives in pairs and they were in the open and exposed to the cold winds. There was no windbreak but the colonies were protected with tar paper covering. The tar paper had absorbed enough of the sunshine to enable the cluster to move to new food sources during this long cold period. The colonies all came through the winter in good condition and were strong in the spring except for the one that died. He gives this as one example of good results from the use of the tar paper wrap.

Norton (1946) stated that hives wrapped with tar paper can be lifted from time to time in the spring to detect those needing stores while those in wooden packing cases must be unpacked. Wrapped colonies start broodrearing earlier than unprotected colonies as it is easy to maintain the ninety-four degree Fahrenheit broodrearing temperature with the tar paper absorbing the heat from the rays of the sun.

Sadler (1951) stated that he used packing cases in Canada but they cost about thirty dollars each and were too expensive. He obtained tar paper and used two layers for protection and his wintering results were about the same as when he used the expensive wooden cases. He was able to use the paper for two years before replacing it.

Rowland (1949) stated that loose snow is an excellent protection for bees. Colonies may be buried in a snow bank without injury, though just enough snow to nicely cover the hive probably affords the best protection. The formation of ice or crust on the snow at or a little above the hive entrance preventing the penetration of air will do more harm than a great depth of loose snow.

Sturdevant (1934) stated that during the winter of 1933 he wintered about thirty hives under a snowdrift which entirely covered the hives and they remained in that condition for about ten weeks. The bees consumed but little honey and all colonies increased in strength in the spring.

Phillips and Demuth (1918) stated that frequently a great loss of colony strength is due to a delay in applying the packing. Perhaps this is the most common source of loss in outdoor wintering aside from that due to the failure to pack.

Reese (1945) stated that when the bees are packed, pack them in honey. Be sure to have full combs of honey on each side of the upper and lower brood nest and within reach of a good big cluster of bees.

Newell (1944) stated that a good windbreak is of considerable advantage as bees are able to make short flights during bright sunny days in winter where otherwise they might be confined to the hive.

The purpose of a windbreak is not to stop the wind but to divert or break its course. Low dense shrubbery, young timber or thick woods, a high bluff, a series of buildings or an orchard will break the force of the wintery blasts.

Stephenson (1951) stated that he sets his hives in groups side by side in early November and in long rows facing south. He chooses a level well drained location and packs for a thickness of about two feet across and on top of the hives and also between them with straw but leaves the front of the hives uncovered. By leaving a double super of honey and drilling a hole for an upper entrance in the upper food chamber, the colony is well protected and has plenty of food for the winter.

Rea (1948) stated that the air temperature in the hive is a minor consideration, the two most important conditions which affect bees in the cluster being, (1) the percentage of relative humidity in the hive and (2) the temperature, not of the air, but of the inside surface of the hive. If the hive is open at the top, it lowers the relative humidity by allowing the moisture to pass out of the hive through the top. Condensation of moisture can be reduced by ventilation and by allowing the heat of the sun to raise the inside surface temperature of the hive. Why waste a lot of time and money packing bees to make it harder for them to produce a honey crop?

Rea (1948) also stated that bees in unpacked hives have more frequent flights and the periods during which condensation occur are shorter. During winter, frequent flights are of an advantage because the bees can void water in the feces which otherwise would have been maintained in the hive and would have had to have been taken care of by condensation. This water is a natural thing in the hive as it is produced from the utilization of the honey by the bees. When they consume the honey it produces water and carbon dioxide and for every gallon of honey consumed, approximately one gallon of water is produced. Unless the bees have frequent flights to carry the water out of the hive, it will condense in in the hive as bees in a cluster will not ventilate the hive by fanning and therefore as the cold air and the warm vapor come in contact, condensation occurs. He further states that maintaining a dry relative humidity in the hive during winter and early spring will do more than any other thing to prevent dysentery, spring dwindling and Nosema.

Moisture in the hive is caused by the bees generating heat to keep their bodies warm by the utilization of the honey which is a carbohydrate. The warm air rises until it reaches the cold inner cover and there it condenses into water which finally drops back onto the bees in the cluster. If the bees do not create enough heat to offset the condensation of moisture, some of them will become cold and die. This often happens to the queen and the colony is then queenless. In the side combs, the moisture may cause mold to form and also the combs to sag. The moisture outlet should be at the top to afford a good circulation within the hive and elimination of the moisture.

Stricker (1951) noticed that moisture entered the hive by capillary action when the hive was set directly on the ground. To eliminate this, he set his colonies on concrete hive stands with a heavy sheet of rubberiod between the ground and the hive which broke the capillary action. In his experiments he showed that the moisture of the hive is expelled upward and outward by bees using an upper flight entrance near the top of the hive.

Norgren (1934) stated that the top entrance appeared to enable the bees to control ventilation to their liking and thus reduce the humidity of the hive.

Wolford (1949) stated that in the northern beekeeping regions the climate justifies insulation in the winter and that there are some advantages of the auxillary top entrance especially when wintered colonies are not examined. The main purpose in using the upper entrance in this region is not only for ventilation to reduce the humidity but also to provide an air vent to the outside which is storm and ice proof.

Whitman (1948) stated that he places a piece of corrugated cardboard over the hive just above the bees and fastens it on with tacks. He then cuts holes in it the size of his thumbnail with the holes matching the openings between the combs. He then wraps his hives with moisture proof felt paper and ties it in place with twine, then cuts the paper off two or three inches above the top of the hive and folds it in and creases it at the corners. He then sets one or more supers of honey on top of it to make an air chamber above the wrapped portion of the hive so that the moisture will pass through the holes in the cardboard and up into the unwrapped super. The moisture will then condense on the sides of the super and run out the top lip of the paper which extends over the hive top. He has examined his bees wrapped in this manner when the temperature was 28° F. and found bees in all corners of the hive. In the unwrapped hives, they were in a tight cluster.

Farrar (1943) stated that the winter cluster will form in the upper hive body provided the stores are contained in dark combs and there is a small center free of honey. Under these conditions the cluster will cover the combs of sealed honey or if they have not been used in brood-rearing, the bees will cluster in the lower hive body.

Bees of all ages will be found distributed throughout the cluster and the daily mortality during the broodless period will be proportionally represented by bees of all ages. This mortality seldom exceeds fifteen percent in a healthy population. Most of this loss appears to be caused by the few bees that fail to keep up with the contracting cluster during a temperature decline. The loss is not from starvation for they usually have honey in their honey sacs.

Farrar (1952) stated that starvation is the major cause of winter loss. It may result from inadequate or from improper position of stores and also from populations too small to maintain contact with their stores. Management practices prior to the winter period may influence all three situations. Maximum food requirements, rather than the average must be satisfied.

Grout (1949) stated that winter losses are usually reported as the percentage of colonies that die. Beekeepers seldom realize that a much greater loss results from colonies that survive in a weakened condition and consequently with greatly reduced productive capacity. No other branch of agriculture could survive if it continued to suffer the winter losses experienced by most beekeepers. Winter losses result from starvation, weak colonies, inadequate supplies of pollen, Nosema disease, and queenlessness. These causes may be separate or collective to cause the weakening or death of a colony. The type of climate will influence the standards that have to be met to insure successful wintering, but he doubts that there is any commercial honey production region that has so severe winters that normal healthy colonies can't survive in good condition if properly provisioned with honey and pollen.

Milum (1952) stated that there was plenty of evidence that unpacked colonies use more stores than protected colonies over a long period of time when broodrearing is not in progress. The answer he gives for this fact is that the bees of a cluster can not consume stores when they are chilled or the temperature is not high enough for them to break cluster to move to honey. In the unpacked hive the rays of the sun on the side of the hive body will raise the temperature enough on the inside to enable the bees in the unpacked hive to move about and feed. In the packed hive, the packing on the outside prevents the rays of the sun from raising the temperature inside the hive.

Farrar (1952) stated that colonies that consume more than the average amount of stores produce the greatest yields. He also stated the reason for this is that broodrearing is a heavy drain on stores and more honey is used for feeding the brood.

Deyell (1945) performed an experiment on the comparison of protection to the amount of stores used and the condition of the colonies in the spring. The following are his results; in an examination on April 12, the packed colonies has lost 23¼ pounds in weight in five months while the unpacked colonies had lost an average of 28½ pounds in the same length of time. On April 24 he examined the colonies for brood and found that the packed colonies had an average of 8½ combs containing brood while those of the unpacked colonies had an average of 9¼ combs containing brood. He stated that the above seems obvious that packing does save stores and it may conserve on bee energy but the experiment shows that the larger consumption of honey in the unpacked hives resulted in more brood and larger colonies.

Lindsay (1935) stated that it is thought by most of the commercial beekeepers in the West that winter packing does not pay since the bees will shift the honey to the desired location within the hive to a considerable extent, especially, if the weather is warm through October and November.

Cale (1942) stated that Farrar claims that the condition of the bees in the colony has more to do with the successful wintering than packing, protection, or shelter. Cale stated that he thinks that is certainly correct.

Coggshall (1952) stated that a number of factors should be considered in determining wintering practices. He lists the following as the important factors; (1) colony condition, (2) food supplies, (3) apiary site, (4) entrance and insulation, (5) location and season, (6) humidity and (7) the cost of labor that will be involved.

METHODS

For the comparison of different types of winter protection of colonies of honey bees, the most likely types used in this part of the United States were selected. These include no protection, windbreak of low trees, tar paper wrap (black 15 lbs. building paper) one thickness of celotex and two thicknesses of celotex overcoat type of packing cases. The colonies with the celotex cases and the tar paper wrap were packed in pairs and the ones with no protection and windbreak were arranged in paired units.

Weights

The colonies in hives were weighed on platform scales at the beginning of the experiment and again at the end. Total weight of colony in the fall minus the total weight of the colony in the spring equals the stores consumed and loss of bees. The weight of bees was estimated by assuming that the number of bees closely covering the entire surface of one comb was equal to one pound of bees. The weight of the bees of each colony was adjusted to as near the same weight as possible by shaking bees from one colony into another until the weights were about equal. Dilute artificial wintergreen in water was shaken into the colonies before the bees were transferred to create a neutral odor and allow the bees of other colonies to be united with one colony.

Brood Measurements

This was accomplished by actual square inch measurements of the sealed brood in the comb by the use of a rule.

Temperatures

The range and comparative air temperatures were obtained from the daily temperature records taken by the Department of Physics at Kansas State College, Manhattan, Kansas.

Arrangement of Colonies and Source of Queens

This experiment was arranged to indicate the need for winter protection of colonies of honeybees in this region, and if winter protection is needed, what type and what thickness of packing would be necessary for best results.

Ten two-story colonies of bees were used and paired so that each pair had queens of the same source and of about the same age. Colonies and the source of queens heading the colonies were; colonies A and B, Kansas State College queens; colonies C and D, Kansas State College queens; colonies E and F, J. G. Miller Starline Hybrid queens; colonies G and H, Kansas State College queens; colonies I and J, Kansas State College queens. The Kansas State College queens were field matings while the J. G. Miller queens were American foulbrood resistant hybrids from Corpus Christi, Texas. The queens matched against each other were of approximately the same age. Each colony was given an adequate supply of stores and was examined once during the cold months and in the early spring to determine need for additional stores by lifting the hives and determining its weight. On February 4, 1954 the colonies were opened and a mixture of one-half pound of honey and one-half pound of dried pollen was introduced to each colony and placed on waxed paper on the top of the frames of the upper food chamber to insure the colony an adequate supply of pollen and this was examined later on days of favorable weather conditions to determine if the bees had worked the pollen and moved it to the cells of the combs. After a period of about one week all of the pollen had been moved in most colonies to the cells and the wax paper had been taken out of the hive by the bees.

Explanation of the Exposure of the Colonies

The two colonies that had no protection were set in an exposed location that was open to the North and subject to the cold North wind,

(Plate V, Fig. 2). They were set on concrete hive stands with no insulation underneath the hive and no windbreaks. During the winter these colonies were partially shaded by trees to the South of them.

The two colonies that had only a windbreak for protection were set on concrete hive stands and had a natural barrier from the wind ond the North, East and West (Plate V, Fig. 1). The windbreak consisted of low branching trees and shrubs and evergreen trees. On top of the inner cover of these colonies a piece of burlap was placed with the ends hanging over the sides and the metal telescope cover was placed over it. The ends of the burlap were allowed to flap in the wind and aided in the elimination of the moisture from the hive by acting as a wick drawing the moisture out to evaporate as the burlap flapped in the wind.

The two colonies that had the two layers of celotex for protection had the two layers bolted on from the sides and a double thickness of this material placed on the top (Plates II and III). Four or five layers of newspapers were placed on top of the inner cover to fill the recessed space there between the inner cover and the protective layers of celotex. The bee escape hole in the inner cover was closed by the newspapers.

The two colonies with the single layer of celotex case were arranged in the same manner as the double layer case except the protective covering was only of one thickness (Plate I).

The two colonies with the tar paper wrap were protected by wrapping a single layer of tar paper around the colonies and tieing it with twine at two different levels. The top part of the tar paper extended above the top of the hive so it was cut at the corners of the hive and folded over the top envelope style, and the outer cover was placed on top of it (Plate IV). The tar paper at the entrance was cut out to enable free flight for the bees. Four or five layers of newspapers were placed on top of the inner cover as in the other colonies.

All of the colonies that had a protective covering were placed on a wooden hive stand (2 x 4 inch studding) that was large enough to hold two colonies and the inner area of the stand was packed with straw to protect the colonies from the cold air coming up from underneath the bottom board (Plate VI).

All of the colonies in the experiment had reduced entrances during the experiment. The size of the entrance was 3/8 inch by 2 inches.

RESULTS

A comparison of hive weights in the fall and spring was made to show the loss in weight of the various colonies and the amount of stores consumed during the winter. The comparison of the loss of weight of the test colonies during the winter showed that the colonies protected by the tar paper wrap had the least loss of weight and the colonies with one layer of celotex had the most loss in weight, while those with two layers of celotex protection were next in greatest loss of weight (Table 1). This follows the theory that too much packing or insulation keeps the inside of the colony cold due to the insulation and with the tar paper wrap, the insulation is thin and absorbs heat from the sun since it is

EXPLANATION OF PLATE I

Fig. 1. Colonies "C" and "D" in a one layer celotex packing case of the overcoat type.

Fig. 2. Colonies "C" and "D" with the packing case partially dismantled.

PLATE I

Fig. 1

Fig. 2

EXPLANATION OF PLATE II

Fig. 1. Colonies "E" and "F" in a two layer celotex packing case of the overcoat type.

Fig. 2. Colonies "E" and "F" with the packing case partially dismantled.

PLATE II

Fig. 1

Fig. 2

EXPLANATION OF PLATE III

Fig. 1. The protective material that is placed on top of the two layer celotex protective covering type of protection of colonies "E" and "F".

Fig. 2. The protective material that is placed on top of the one layer celotex protective covering type of protection of colonies "E" and "F".

PLATE III

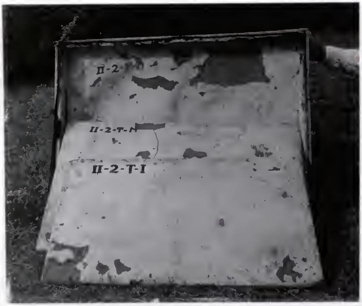


Fig. 1

Fig. 2

PLATE IV

Fig. 1

Fig. 2

EXPLANATION OF PLATE V

Fig. 1. Colonies "G" and "H" with the telescoping cover removed to show the placement of the burlap on top of the inner cover.

Fig. 2. Colonies "I" and "J" showing exposure to the cold winds during the winter.

PLATE V

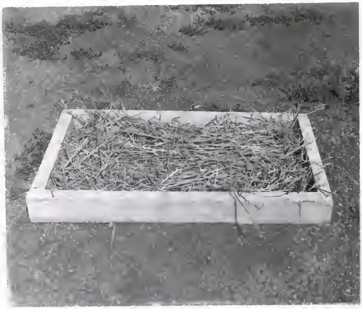
Fig. 1

Fig. 2

EXPLANATION OF PLATE VI

The wooden hive stand with the straw insulation upon which all the colonies that were packed were placed.

PLATE VI



dark in color and therefore the bees are more active, collect more pollen and increase colony population more rapidly in the spring than the others.

Colony "D", with one layer of celotex for protection died of chemical poisoning during the winter.

The colonies with no protection and those with a windbreak for protection showed about the same amount of loss in weight during the winter, those with no protection showing the least loss in weight in these two groups. The loss in weight during the winter was from the amount of stores consumed and dead bees during the winter.

Table 1. Comparison of two-story colony weights in pounds before and after wintering.

Colony	Type of Protection	Weight Oct. 28, 1953	Weight Apr. 19, 1954	Reduction in Weight	Average Reduction in Weight (lbs.)
A	Tar paper	137.00	130.25	6.75	
B	"	130.00	125.25	4.75	5.75
C	1 layer Celotex	123.50	89.00	34.50	
D	"	120.00	*	*	34.50
E	2 layers Celotex	152.00	122.50	29.50	
F	"	153.50	123.75	29.75	29.62
G	Windbreak	136.00	112.00	24.00	
H	"	135.75	115.75	20.00	22.00
I	No Protection	138.25	113.25	25.00	
J	"	119.25	103.00	16.25	20.62

* This colony died of chemical poisoning during the winter.

Colony "D" died during the winter and the cause of death was determined as that of chemical poisoning. The stores fed to this colony had been in contact with the fumes of naphthalene for a number of months and the honey had absorbed enough of the naphthalene to be lethal to the bees. At first when it was noticed that a large number of bees were dying and being pushed off the bottom board, it was thought the cause to be Nosema disease, but after careful microscopic examinations of a large number of bees, it was determined that this was not the case. Some of the bees examined showed evidence of spore cysts of Nosema but others did not show any. All of the bees that were dead had honey in their honey sacs so the possibility of starvation was ruled out. On examination of the hive, dead bees were found in most all parts of the hive and the great number of them that died at about the same time indicated poisoning by chemicals. It was learned from reliable sources of authorities on honeybees that this type of poisoning had happened before and since this honey had been in contact with the fumes of naphthalene for a great number of months, the cause of death was determined to be chemical poisoning. The practice of using naphthalene as a repellent and control for the greater wax moth and the Indian meal moth at the Kansas State College apiary has now been discontinued.

A comparison of the weight of bees in the fall and spring was made along with a comparison of square inches of sealed brood in the spring to show the loss of adult bees during the winter and to indicate which type of packing would be best for a colony to stimulate early spring broodrearing. This comparison of the test colonies showed that the colonies with no protection, or with only a windbreak had the greatest amount of sealed brood in the spring and that those with two layers of celotex had the least amount (Table 2). This indicated that too much protection is detrimental to early broodrearing.

Colony "A" showed that the colony protected with a tar paper wrap started broodrearing earlier than those with other types of protection, and this was shown by the increase in the estimated weight of adult bees in the spring.

Colony "B" showed a loss of bees during the winter and the explanation for this could be that the queen was not a good early season egg layer or had a low hatchability of eggs, since there is a great variation in queens of the same source. It is believed that Colony "A" was more typical of results to have been expected under tar paper protection conditions.

A comparison of the average monthly temperatures during the experiment was arranged to show how this period compared to the average monthly temperatures over a long period of time (Table 3). The table shows that the temperatures during the test period were higher in most respects than those of an average year. Because the temperatures during the fall and spring were higher and because there was a higher than average temperature in February and April, broodrearing was started early. The temperature during March was about average and therefore was not detrimental to broodrearing.

Table 2. Comparison of weight of bees in pounds in the fall and spring and the number of square inches of scaled brood in the spring following wintering.

Colony	Type of Protection	Estimated Weight of Bees in pounds **					Square inches of sealed Brood *	
		Fall	Average	Spring	Average	Average Gain or Loss	Spring	Average
A	Tar paper	6.00		10.75			534	
B	"	6.75	6.37	3.50	7.12	+ 0.75	336	435
C	1 layer of Celotex	4.50		4.00			429	
D	"	8.00	6.25	***	4.00	- 2.25	***	429
E	2 layers of Celotex	8.00		4.75			402	
F	"	8.75	8.37	1.75	3.25	- 5.12	155	279
G	Windbreak	5.75		6.50			512	
H	"	5.00	5.37	8.75	7.62	+ 2.25	619	565
I	No protection	4.25		7.75			599	
J	"	3.25	3.75	7.00	7.37	+ 3.62	526	562

* Sealed brood estimated April 19, 1954; sealed brood was not a factor in the fall because the bees had already ceased brooding at the time the experiment was established.

** The greater the increase, the earlier the brood reared was started.

*** This colony died of chemical poisoning during the winter.

Table 3. Average monthly temperatures in degrees Fahrenheit, Manhattan, Kansas.

Years	October	November	December	January	February	March	April
1953-54	61.5	45.1	34.4	27.8	43.9	40.6	60.7
1909-54	58.1	44.0	32.2	29.2	32.4	44.0	55.2

DISCUSSION

Table 1 shows that there was less average loss in weight of the colonies protected by tar paper than the others tested (5.75 as compared to 34.50, 29.62. 22.00, and 20.62 lbs.) and Table 2 shows broodrearing was started earlier in the spring than in the case of any other type of protection tested; this is indicated by the increase of estimated weight of bees in the spring over the estimated weight of bees in the fall which was + 0.75 as compared with - 2.25, and - 5.12 in the case of the other two types of protection. This is also indicated to some extent by a comparison of the square inches of sealed brood, which was 435 in the case of the tar paper wrapping, and 429 and 279 in the case of the other two types of protection.

Where no wrapping or packing is to be given colonies of bees in the winter, the natural or artificial windbreak or even no protection is shown to be preferable to the celotex type of protection (Tables 1 and 2). The main object of wintering honeybees is to bring the colony through the winter in good condition with an adequate number of bees and have one that will increase colony population rapidly in the spring.

It was shown in this experiment that too much packing or protection can be detrimental to the colony. Too much insulation keeps the bees in the colony cold, delaying broodrearing in the spring which results in a weak colony not able to take advantage of the first major nectarflow or the collection of pollen in the spring.

The dark color of the tar paper absorbs the heat of the sun more rapidly than the other types of protective materials and raises the temperature of the hive, enabling the bees at suitable times during the winter to take cleansing flights. The bees in other colonies protected by heavier insulation materials, resulting from the lower hive temperature factor, do not have as many cleansing flights nor the stimulation in broodrearing as in the colonies protected by tar paper. As the temperature within the hive approaches or goes above 69° F. the activity of the colony increases and cleansing flights may be taken. The tarpaper is cheap, is easily stored and can be used several times. Other packing materials are expensive, are bulky and require considerable space for storage during the summer.

The colonies when in units of two, protected by the tar paper wrap have an added advantage, in that they can be lifted at the corners to determine the weight of the colony for the need of stores during the cold weather without removing the packing material while those with celotex and other types of packing material must have the protective cover removed before being able to inspect them for the need of stores.

This study did not determine whether a better overall benefit to the colony could be obtained by providing or omitting a tar paper covering. Further studies will be necessary to determine whether early brood rearing (in which colonies with no tar paper excelled) or less loss in weight through winter (in which colonies with tar paper excelled) is of greater benefit to the colony.

SUMMARY

Five pairs of colonies of honeybees were compared during the fall of 1953 and the spring of 1954 to determine the type of winter protection which would give the best results in wintering colonies of honeybees in the vicinity of Manhattan, Kansas.

Colonies with the tar paper wrap type of protection underwent the least loss in weight, i.e., least stores consumed and least bees lost, during the winter and colonies with one layer of celotex lost the most weight. Colonies with no protection and with the windbreak lost about the same amount of weight, and ranked intermediate between the celotex- and tar paper-covered hives, indicating, on the basis of relative weight loss, the use of the tar paper wrap for winter protection in this area if winter protection is to be given. The celotex cases keep the colonies too cold in the spring and during warmer periods in winter because of the insulation which slows the temperature change within the hive. In the case of the tar paper wrap, the insulating material is thin and permits a more rapid change of temperature in the hive and since it is black in color it absorbs the heat from the sun and thus raises the temperature within the hive, resulting in opportunities for cleansing flights during winter and initiation of broodrearing earlier in spring.

Gain in the weight of bees in the spring over that in the fall shows that early broodrearing has taken place and this is one objective in the successful wintering of bees. A slight gain was attained in the case of the tar paper coverings. The colonies with the celotex overcoat type of protection showed significant decreases in weight indicating that broodrearing had not been under way very long before the final data of the experiment were recorded. This was an indication that this type of protection is too heavy for this locality to have early broodrearing and an early spring increase in the population of the colony. There was a significant increase in the weight of bees in the colonies with no protection and windbreak.

The average number of square inches of sealed brood was greatest in the colonies with no protection and windbreak and least in the colonies with the celotex protection. The tar paper wrap colonies were intermediate.

The average monthly temperatures during this study were about the same as the average over the past 45 years except in February and April. This increase in temperature at that time of year is favorable for early spring broodrearing.

It is concluded that for winter protection of honeybees in the area of Manhattan, Kansas, the use of the tar paper wrap for colonies is the best of the protective materials used, that overwintering without any protective covering is better than the single and double celotex coverings as used in these studies, on the basis of loss of weight during winter; and that no protective covering is better than tar paper, and distinctly superior to celotex, on the basis of relative increase in weight of bees and sealed brood during early spring.

ACKNOWLEDGMENTS

Grateful acknowledgment is extended to Dr. R. L. Parker of the Department of Entomology, under whose direction this work was completed, and for his helpful suggestions and corrections during the compilation of the information in this thesis, and to Dr. Herbert Knutson for suggestions in writing the manuscript. Acknowledgment is given to the Department of Entomology, Kansas Agricultural Experiment Station in providing the colonies, beekeeping equipment and other facilities for the experiment. Acknowledgment is also extended to Mr. Salah El Din Rashad, for his help in recording data of this experiment.

LITERATURE CITED

Anderson, Edwin J.
Some research on wintering bees. Glean. Bee Cult. 71: 681-683. 1943.

________ Our winter problem. Glean. Bee Cult. 72: 433-435, 467. 1944.

________ Hive humidity and it's effect upon wintering bees. Jour. Econ. Ent. 41: 608-615. 1948.

Barnes, Ralph W.
Wintering bees. Amer. Bee Jour. 92: 419-420. 1952.

Brown, Allan T.
New ideas about wintering. Glean. Bee Cult. 71: 595. 1943.

Cale, Gladstone H.
Just how shall we winter. Amer. Bee Jour. 74: 444. 1934.

________ Tar paper wrap catches winter sunshine. Amer. Bee Jour. 75: 528. 1935.

________ Shall we winter the bees. Amer. Bee Jour. 82: 436. 1942.

Coggshall, William L.
The wintering problem. Amer. Bee Jour. 92: 414-415. 1952.

Deyell, M. J.
Packing bees for winter. Glean. Bee Cult. 73: 458-460. 1945.

Diehnelt, Walter
Wintering bees. Amer. Bee Jour. 88: 502. 1948.

Farrar, Clayton L.
Interpretation of the problem of wintering the honeybee colony. Glean. Bee Cult. 71: 513-518. 1943.

________ Ecological studies on overwintered honeybee colonies. Jour. Econ. Ent. 45: 445-449. 1952.

Gates, A. H.
Wintering out of doors. Amer. Bee Jour. 89: 470. 1949.

Grout, Roy A. et al.
The hive and the honeybee. Hamilton, Illinois: Dadant and Sons. 652 p. 1949.

Gilbert, C. H.
Wintering bees. Glean. Bee Cult. 63: 598-602. 1935.

Kruse, Chas.
Diseases and wintering. Amer. Bee Jour. 74: 408-409. 1934.

Langley, C. G.
To pack or not to pack. Amer. Bee Jour. 85: 392. 1945.

Latham, Allan.
Cellar vs. outdoor wintering. Glean. Bee Cult. 62: 665-667. 1934.

Lindsay, W. E.
Arranging the colony for winter. Amer. Bee Jour. 75: 516. 1935.

Lyase, Julius
Simplest and most efficient way to winter bees. Amer. Bee Jour. 90: 408 and 540. 1950.

Merrill, J.H.
Preliminary notes on the value of winter protection for bees. Jour. Econ. Ent. 13: 99-111. 1920.

Mills, J.
Wintering bees; advantages of having a double brood chamber well filled with honey. Glean. Bee Cult. 70: 726. 1942.

Milum, V. G.
The behavior of wintering. Amer. Bee Jour. 92: 411-412, 437. 1952.

Munro, J. A.
Celotex protection for bees. Glean. Bee Cult. 63: 585-588. 1935.

Myers, H. M.
Methods of wintering bees. Glean. Bee Cult. 64: 649-651. 1936.

Newell, R. E.
The wintering problem in Massachusetts. Glean. Bee Cult. 72: 436. 1944.

____
This is how I winter. Amer. Bee Jour. 89: 526. 1949.

Nicholson, L. B.
Wintering in England. Glean. Bee Cult. 80: 84. 1952.

Nielsen, Benjamin
Preparing bees for winter. Glean. Bee Cult. 62: 605-607. 1934.

________ Preparing bees for winter. Glean. Bee Cult. 63: 671-672. 1935.

Norgren, J. F.
Winter packing and top entrance hive. Glean. Bee Cult. 62: 588-589. 1934.

Norton, J.
Moisture control in wrapped hives. Amer. Bee Jour. 86: 468. 1946.

Parker, Ralph L.
Beekeeping in Kansas. In Insects in Kansas. Smith, Roger C. et. al. Kansas St. Bd. Agr. Rept. 440 p. June, 1943.

________ Bee Culture in Kansas. Kans. Ag. Exp. Sta. Bul. 357. 81 p. 1953.

Phillips, E. F. and G. S. Demuth.
The preparation of bees for outdoor wintering. U. S. D. A., Farmers Bul. 1012. 20 p. 1918.

Rahmlow, H. J.
The subject of wintering bees. Amer. Bee Jour. 88: 540. 1948.

Rea, G. H.
Method of wintering. Glean. Bee Cult. 76: 545-547. 1948.

Reese, Charles A.
Pointers on wintering bees. Better Fruit. 28: 14. 1933.

________ Two important factors for successful wintering. Glean. Bee Cult. 73: 429. 1945.

Rock, H.
Factors in wintering. Amer. Bee Jour. 88: 400. 1948.

Root, A. I. et. al.
A B C and X Y Z of Bee Culture. Medina, Ohio: A. I. Root Co., 703 p. 29th Ed. 1950.

Rowland, M. J.
Natural protection for bees. Glean. Bee Cult. 77: 746-747. 1949.

Sadler, W.
Wintering in quadruple cases. Glean. Bee Cult. 79: 649-651, 703. 1951.

Stephenson, A. E.
Wintering bees. Mod. Beekeeping, 35: 381-382. 1951.

Stricker, M. H.
A system of wintering. Glean. Bee Cult. 79: 587-589. 1951.

Sturdevant, J. H.
Wintering under snow. Glean. Bee Cult. 62: 691. 1934.

Taylor, Merritt, I.
Langstroth was one hundred years ahead of his time. Amer. Bee Jour. 89: 127. 1949.

Whitman, Oscar H.
A different idea in wintering. Amer. Bee Jour. 88: 596. 1948.

Wolford, William H.
Insulation and an auxillary air vent. Amer. Bee Jour. 89: 570-571. 1949.

EFFECTS OF VARIOUS TYPES OF WINTER PROTECTION FOR COLONIES OF HONEY BEES UPON STORES CONSUMED DURING WINTER AND AMOUNT OF SEALED BROOD IN SPRING

Lacks page numbers.

by

VIRGIL RAYMOND BAYLES

B. S., Kansas State College
of Agriculture and Applied Science, 1953

AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Entomology

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1954

The purpose of this study was to test various types of winter protection given colonies of honey bees in the vicinity of Manhattan, Kansas, and to determine which type is best.

Five pairs of colonies used to test five different types of wintering methods typical of this region, viz., tar paper wrap, one layer of celotex, two layers of celotex, windbreak, and no protection at all. Each paired colony was supplied with a queen of the same source and of the approximate same age. The colonies were adjusted to the same approximate weight by shaking bees from one colony into another. Dilute artificial wintergreen in water was shaken into the colonies before the bees were transferred to create a neutral odor and allow the bees of other colonies to be united with one colony.

The sealed brood was measured in square inches in the spring to determine which colonies started broodrearing early in the spring and to what degree. This measurement was accomplished by actual measurement of the sealed brood with a rule.

At the completion of the experiment the colonies were again weighed to determine the relative loss in weight, i.e., the amount of stores consumed and the loss of bees.

Average monthly temperatures over a period of forty-five years compared with those during this study showed February and April to have been warmer than usual.

Colonies with the tar paper wrap type of protection underwent the least loss in weight, i.e., least stores consumed and least bees lost, during the winter and colonies with one layer of celotex lost the most weight. Colonies with no protection and with the windbreak lost about the same amount of weight, and ranked intermediate between the celotex- and the tar paper- covered hives, indicating, on the basis of relative weight loss, the use of the tar paper wrap for winter protection in this area if winter protection is to be given. The celotex cases keep the colonies too cold in the spring and during warmer periods in winter because of the insulation which slows the temperature change within the hive. In the case of the tar paper wrap, the insulating material is thin and permits a more rapid change of temperature in the hive and since it is black in color it absorbs the heat from the sun and thus raises the temperature within the hive, resulting in opportunities for cleansing flights during winter and initiation of brood rearing earlier in spring.

Gain in the weight of bees in the spring over that in the fall shows that early broodrearing has taken place and this is one objective in the successful wintering of bees. A slight gain was attained in the case of the tar paper coverings. The colonies with celotex overcoat type of protection showed significant decreases in weight which indicated that broodrearing had not been under way very long before the final data of the experiment were recorded. This was an indication that this type of protection is too heavy for this locality to have early broodrearing and an early spring increase in the population of the colony. There was a significant increase in the weight of bees in the colonies with no protection and windbreak.

The average number of square inches of sealed brood was greatest in the colonies with no protection and windbreak and least in the colonies with the celotex protection. The tar paper wrap colonies were intermediate.

The average monthly temperatures during this study were about the same as the average over the past 45 years except in February and April. This increase in temperature at that time of the year is favorable for early spring broodrearing.

It is concluded that for winter protection of honeybees in the area of Manhattan, Kansas, the use of the tar paper wrap for colonies is the best of the protective materials used; that overwintering without any protective covering is better than the single and double celotex coverings as used in these studies, on the basis of loss of weight during winter; and that no protective covering is better than tar paper, and distinctly superior to celotex, on the basis of relative increase in weight of bees and sealed brood during early spring.