INDOOR WINTERING OF HONEY BEE COLONIES IN MANITOBA

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John Michael Gruszka

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ABSTRACT

Gruszka, John Michael. M.Sc., The University of Manitoba, May, 1979. Indoor Wintering of Honey Bee Colonies in Manitoba. Major Professor; S. C. Jay.

An insulated indoor wintering facility was built to accommodate up to five hundred and twenty single brood chamber hives. The building contained four separate chambers, each individually heated and ventilated. Two hundred and twenty-five colonies were prepared and wintered indoors; seventy-five colonies in each of three chambers during the winter of 1976-77. A variety of treatments were used to test the effects of colony size, time of requeening, and food supplies on winter survival of honey bee colonies. Data were collected on colony weight loss and colony mortality during the winter.

Treatment did not have a significant effect on mortality. There was no significant difference in mortality among the six treatments performed.

There were significant differences in weight loss among the treatments and groups prepared. Differences were attributed to treatment and indoor conditions caused by the building construction and position of the hives within the building.

Comparisons were made between indoor wintered colonies, outdoor wintered colonies, and package bee colonies in the following spring and summer of 1977 on the basis of brood production, adult population and honey production. Similar measurements were made to compare indoor wintered colonies requeened in the fall, in the spring, and colonies not requeened at all.

Outdoor wintered colonies had the highest brood production, largest adult populations and produced the most honey. There was no significant difference between package and indoor wintered colonies in terms of total brood production and adult populations; however, the package colonies produced more honey. The results of the requeening trial were not conclusive.

Trials were performed to test the effectiveness of orientation cues in preventing losses of adult bees from indoor wintered colonies after they were removed from winter quarters in the spring. Observations were made on the rate of adult bee losses during the first six weeks of spring. Orientation cues did not prevent adult bee loss. Substantial losses of adult bees occurred during the first week of active flight.

Samples of adult bees were taken from indoor wintered colonies, outdoor wintered colonies and package bee colonies during the spring and summer and were analyzed for Nosema disease. Indoor wintered colonies were found to have substantially higher levels of Nosema disease than outdoor or package colonies during the early spring. The level of Nosema disease decreased dramatically as the season progressed.

INTRODUCTION

Before the development of the package bee industry in the USA, beekeepers successfully wintered honey bee colonies in most parts of Canada. The use of package bees, however, quickly became the most popular method of beekeeping - packages were inexpensive, easy to operate, produced enough honey to make them profitable, and required less work than wintered colonies which needed to be tended year round.

Since the early nineteen seventies, the beekeeping industry in Canada has seen a revival of interest in wintering colonies. Beekeepers have been prompted to winter their colonies by the increased costs of package bees. Also, as the demand for package bees increased, beekeepers found it increasingly difficult to obtain their supply early in the spring. According to beekeepers, the quality of the package bees, especially queens, has deteriorated as the demand for packages has increased. Canadian beekeepers have experienced losses in production due to late arriving package bees or supersedure of queens due either to disease or poor mating. These problems, coupled with reports of the movement of Africanized bees from South America towards North America have convinced many beekeepers to attempt to become self-sufficient by wintering their colonies of honey bees.

Present-day methods of outdoor wintering are basically similar to those used in the past. Advances and adjustments have been made to accomodate current materials and management methods. There has been, however, a radical change in indoor wintering techniques. In the past, colonies were wintered indoors in root cellars or basements. The current methods of indoor wintering utilize free standing, insulated structures and controlled environments with adjustable temperature, air flow and relative humidity. The only similarities between the old and new methods are that bees are kept undisturbed and in total darkness during the winter. Many commercial beekeepers in the three Prairie Provinces are now attempting to winter honey bee colonies both indoors and outdoors.

This study was the first part of a five year study of indoor wintering of honey bees to investigate the various aspects of the biology of a wintering colony which can be manipulated to achieve easy and successful wintering. The primary objective of this study was to determine which of several colony preparation techniques is most conducive to wintering colonies indoors. For various treatments, data were collected on colony mortality, food consumption, and colony development during the following summer. The timing of queen replacement was tested as a feasible management technique for wintered colonies. Tests were performed to determine the extent of the loss of adult bees from the colonies upon removal from wintering quarters.

The goal is to determine the optimal conditions necessary to winter bees indoors so that comparative economic and management studies can be performed with both indoor and outdoor wintering systems.

LITERATURE REVIEW

Much has been written concerning the wintering of honey bee colonies. The present literature review has been limited to research work conducted in Canada and to those geographical areas similar to that of Canada. Methods of wintering bees in milder climates were not considered to be relevant to this study.

It must be concluded that outdoor wintering is more popular than indoor (cellar) wintering since so much more information is available concerning outdoor wintering. Phillips and Demuth (1918) reported that outdoor wintering was practicable, seemed to give better results than cellar wintering, and that there was a decided change from cellar wintering to outdoor wintering by beekeepers at that time.

Indoor wintering was usually practised in areas where beekeepers believed that the winter climate was too severe, and where the winter was too long, for the colonies to survive outdoors. Indoor wintering was considered to be a more economic method since, by being kept at a more favourable temperature, honey consumption would be less than for outdoor wintered colonies. Beekeepers felt that the milder environment of cellar wintering reduced the high mortality sometimes experienced outdoors due to weather conditions (Johansson and Johansson,1971).

Successful wintering of honey bee colonies has resulted from an understanding of the biology and needs of the colony in winter. The early beekeeper's primary concern was to reduce the effects of the cold winter climate. Therefore, cellar wintering was popular, and at the beginning of this century, the protection of colonies outdoors with the use of insulation and some sort of packing or wrapping became common practise.

Sladen (1920) and Gooderham (1922) described wooden packing crates that were suitable for wintering under Canadian conditions. Merrill (1920, 1923) showed that packing was advantageous in the north central United States. Packing and insulation was advised for Kansas (Bayles and Parker, 1958), Indiana (Baldwin, 1919), Connecticut (Crandall, 1920, 1923), Colorado (Richmond, 1926), Iowa (Paddock, 1927), and Wisconsin (Wilson and Milum, 1927). Packing and insulation was recommended for wintering on the Canadian prairies (Braun, 1940; Le Maistre, 1942). Packing cases were used for individual colonies or groups of two or more colonies (Gooderham, 1926). Wilson and Milum (1927) tested a variety of materials (balsam-wool, wheat straw, celotex, planer shavings, clover chaff, leaves and ground cork) as to their insulating value and suitability for packing insulation.

Because of the cost and awkwardness of packing cases, other materials were tested as substitutes. Tar-paper wrapping, used with insulating material has been described by Paddock (1936), Burke and Adie (1952), Le Maistre (1942), Dyce and Morse (1960), and Edmunds (1961). A card-board packing case was described by Boch (1964). The use of tar-paper has become more economical than the use of wooden cases so that most beekeepers are now using tar-paper wraps for wintering outdoors. High costs of materials have also eliminated the use of double-walled bee hives described by Phillips (1922) for wintering.

The formation of a cluster of bees as temperature decreases was described by Phillips and Demuth (1915) and Milner and Demuth (1921). Knowing that the inner bees were insulated by the tightly packed outer shell of bees, some beekeepers questioned the need for insulation. However, the advantages of insulation have been demonstrated by Braun and Geiger (1955) and Haydak (1959, 1967) who showed that uninsulated hives suffered higher rates of mortality, consumed more honey during winter (Haydak, 1967) and had fewer bees in the spring than did insulated hives. Similar results were obtained by Villumstad (1959, 1960) in Norway.

The clustered bees generate heat through the metabolism of honey. Upper entrances to allow moisture, resulting from the metabolism of honey, to escape from the hive were advocated by Conner (1940), Farrar (1943, 1952), Dadant (1942), and Gooderham (1940). Baker (1942) demonstrated that colonies wintered more successfully with upper entrances than did those with no upper entrances. Provision of upper entrances has become standard practise for outdoor wintering.

Natural windbreaks are also an excellent form of protection and were recommended by Farrar (1952. 1963), Dadant (1942). Gooderham (1926), Paddock (1927) and Phillips and Demuth (1918). Johansson and Johansson (1969) suggested that windbreaks are more important than insulation for successful wintering.

The advocates of cellar wintering maintained that cellars were, in effect, sheltering the whole apiary in a protective environment, thereby achieving the same, or a better, degree of protection as packing and insulating outdoor wintered colonies. Designs for the construction of bee cellars were described by Pease (1937), Paddock (1936), Braun (1940) and Phillips and Demuth (1918).

Phillips and Demuth (1918) and Paddock (1936) elucidated the management requirements necessary for successful cellar wintering.

The colony's winter food supply is critical to successful wintering. The best food is good quality honey (Dadant, 1942; Phillips, 1922; Farrar, 1943, 1952; Johansson and Johansson, 1969). Certain honeys have been found to be unacceptable for winter stores, such as honeydew honey because it contains a high amount of particulate matter (Vorwhol, 1964; Phillips and Demuth, 1915), some late autumn-collected honeys (Phillips and Demuth, 1918; Gooderham, 1940), and honey that is prone to granulate (Richmond, 1926). Sugar syrup feeding is recommended for winter stores in areas where such honeys are a problem.

Phillips and Demuth (1918) recommended that at least forty-five pounds (20 kg) of honey be provided for winter feed. Johansson and Johansson (1966) suggested that at least seventy-five pounds (34 kg) are required under most North American conditions, while Farrar (1968) and Moeller (1977) suggested that at least ninety pounds (40 kg) are required. Braun and Geiger (1955) showed that the average weight loss of colonies during winter (thirteen year average) was between thirty-five and forty pounds (16-18 kg) per colony in Manitoba and that there was no significant difference in weight loss between outdoor wintered and cellar wintered colonies. Farrar (1952) showed that colonies, which consumed more honey during winter, also produced a higher net yield of honey during the following year.

The importance of pollen for wintering colonies has been stressed by Farrar (1934, 1952), Moeller (1977) and Johansson and Johansson (1969). All recommended the use of pollen supplements in the spring if natural pollen was inadequate.

The size of the wintered colony has been dictated by several factors. Outdoor wintered colonies, because they require substantial amounts of stored honey, have usually been wintered in two chambers. Indoor wintered colonies, because of the difficulties involved in manipulating the colonies, especially in bee cellars, were usually wintered in one brood chamber. Populous colonies (preferrably with young bees) were recommended for wintering; smaller and/or weaker colonies were united with stronger colonies because weak colonies were not likely to survive the winter (Gooderham, 1940; Farrar, 1952, 1963; Moeller, 1977). However, Gooderham (1945) described a successful method of keeping small colonies (nuclei) in a bee cellar. The method was intended as a means of procuring early spring queens by wintering queens in these small colonies, but comparative tests with package colonies showed that these nuclei produced as much honey as the package colonies. A similar method employed in Nebraska was described by Barker (1975) and by Diemer and Diemer (1937).

MATERIALS AND METHODS

A. Wintering Building

(1) General Features

A free-standing structure was built in the apiary of the Entomology Department on the campus of the University of Manitoba to be used for the indoor wintering of honey bee colonies. Construction began in July and was completed on 12 December, 1976. The erection of the building was accomplished with the assistance of volunteer labour by members of the Manitoba Beekeeper's Association and the Entomology Department.

The building was of stud-wall construction, the walls and roof trusses being pre-assembled by the materials supplier. Fifteen concrete pillars, each 76 cm X 76 cm X 24.5 cm, formed the foundation on which the building stood. The external dimensions of the building were 8.5 m X 9.75 m. The interior contained four controlled environment chambers for colony storage, each approximately 3.6 m X 3.6 m X 2.4 m, a central hallway, and an equipment room at one end to house the heating and refrigeration equipment (Fig. 1). Each chamber had a double door entrance to facilitate the moving of bees into and out of the chamber.

Each chamber was insulated with fibre glass batt insulation of an R7 value in the floor, of R12 value in the walls, and R20 in the ceiling. The roof was covered with white asphalt shingles and the exterior walls painted white in an attempt to keep the effect of solar radiation to a minimum, especially during the rising temperatures of the critical

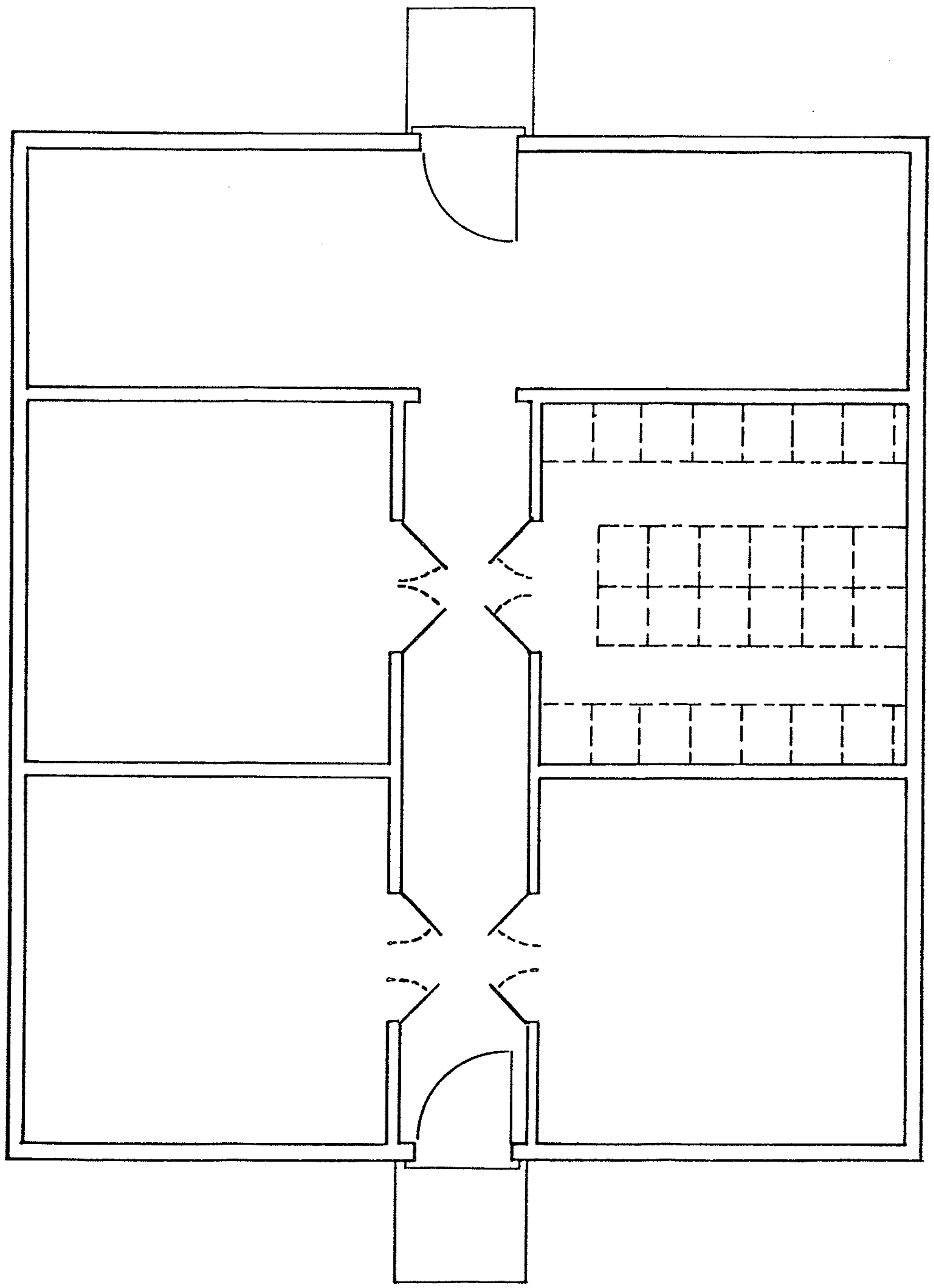

Figure 1. Diagram of wintering building to show the position of the chambers, equipment room, and position of hives.

spring period.

The entrances at both ends of the building had small platforms at the top of the stairs at approximately truck-bed level to facilitate the moving of hives into the building.

The floors of the chambers, hallway and equipment room were painted with a grey enamel paint. Hives were placed along each wall and down the center of each room, leaving aisles 76 cm wide. The center pallet supported two rows of hives, back to back. These pallets could accommodate twenty-six hives, so that each chamber had a maximum capacity of one hundred and thirty hives (five high) if only single storey hives were used, less if two storey hives were utilized.

(2) Heating System

Each chamber had its own heat supply, an electric forced-air furnace of a type common to domestic use, i.e., a model EL-10 (10 K.W., 630 c.f.m.) manufactured by Inter-City of Winnipeg, Manitoba. These were positioned in the equipment room (Fig. 2). The two furnaces servicing the chambers on one side of the hallway had a common air intake duct bringing in outside air through an external wall of the equipment room.

Ducts (45 cm X 30.5 cm) from each furnace carried the heated air into their respective chambers and opened into the center of the room at the ceiling. The opening was equipped with a baffle so that the incoming air was evenly dispersed throughout the room. The inflow air duct had a baffle control to adjust manually the rate of air changes per hour entering each chamber. A return air duct, opening half-way down one wall, provided recirculation of the chamber air; the amount recirculated could be adjusted manually by baffles inserted within the duct.

Thermostat controls were located within each chamber. Initially,

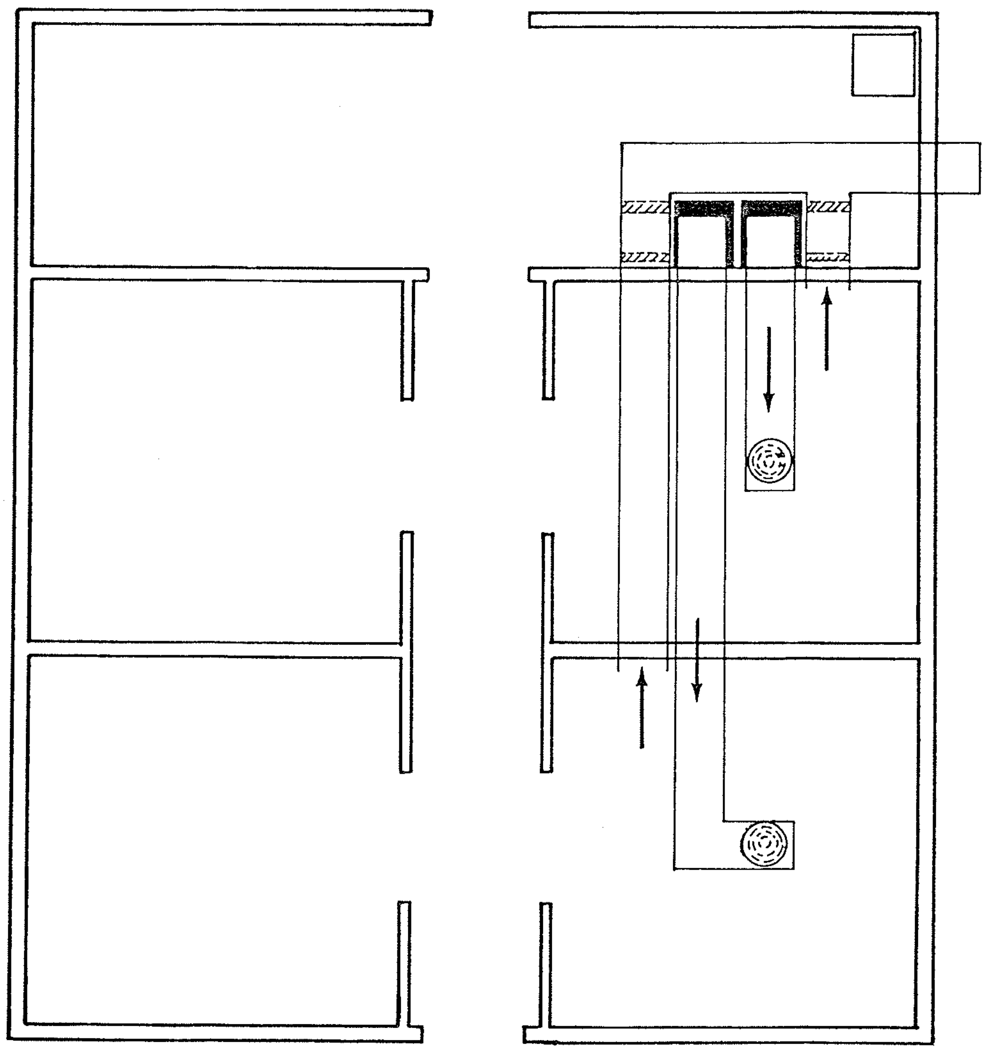

Figure 2. Diagram to show position of ventilation system and air flow into the chambers.

these controls had a range of $\pm$ 3^{o}F. This was found to be inadequate so that controls with a 1^{o}F range were installed. To have such a narrow range, the thermostat was connected to both heat and refrigeration systems simultaneously. This meant that the refrigeration equipment was turned off during most of the winter.

(3) Refrigeration System

Two refrigeration systems were installed, one for each pair of rooms. Each system consisted of a compressor unit and two cooling coils, one mounted on top of each furnace within the ducts leading into the chambers. The compressor units were mounted on the floor in the equipment room rather than exposed outdoors. This prevented cold damage to the compressors. Each compressor was three horsepower with a cooling capacity of 32,000 B.T.U. per hour. The systems were equipped with a hot gas by-pass.

The coolant temperature was set slightly above 0^{o}C to avoid ice build-up on the cooling coils from the humid re-cycled air. This resulted in a slight reduction of cooling capacity.

(4) Ventilation

Those ducts used for the heating/cooling system also provided the ventilation for the building. The furnace fans operated continuously, thereby forcing air constantly into the chambers. By manually adjusting dampers within the inflow ducts, the fresh air:recirculated air ratio could be adjusted. Dampers could also be adjusted to alter the amount of air entering each chamber. These were set for the greater part of the winter so that a volume of air equal to four air changes per hour entered each chamber.

The volume of air entering each chamber, i.e. air changes per hour, was calibrated and the appropriate settings of the baffles were marked so that the volume could be reset without recalibration. This volume was increased in the spring to help cool the chambers without the use of the cooling system and decreased again to obtain maximum efficiency of the cooling system once outdoor temperatures increased to a point where the cooling system was required.

Due to the constant inflow of air into each chamber, a positive pressure was created in the chambers. This forced air out of the rooms via the exhaust channels beneath the pallets on the floor. The exhaust ducts rose vertically 0.6 m from the pallets along the wall, through the wall and then down along the outside of the building (Fig. 3). This system was designed to prevent carbon dioxide build-up on the floor of the chambers. The doors to the chambers were fitted with weather stripping, to ensure that the rooms would be fairly airtight. The forced air system ensured that a certain amount of carbon dioxide-laden air was constantly exhausted. Return air ducts for recirculated air were 1.2 m from the floor to decrease the possibility of recirculating carbon dioxide.

At a capacity of seventy-five hives per chamber, the volume:hive ratio was 0.44 m^3/hive (15.56 cu. ft./hive); at the maximum hive capacity of one hundred and thirty hives, this would be reduced to 0.25 m^3/hive (8.86 cu. ft./hive).

The equipment room contained a fan, thermostatically controlled, to function when the temperature in this room increased beyond 16 to 18^{o}C. This fan removed the heat created in the room by the refrigeration systems. In the late spring, the removal of the heat was assisted by leaving the outside door open.