normally high spanworm populations, the methidathion spray could prove to be more useful than the currently recommended pink spray as it will also control some leafroller species (H. Madsen, personal communication). Work is currently in progress to measure the relationship between males captured in pheromone traps in the fall and larval populations in the spring. This information could also be used to determine the need for spring control measures.

3. Our experiments suggest that methidathion applied at the recommended rate of 5.6 l/ha does not cause significant predaceous mite mortality. This observation will require further investigation in other locations and subsequent years.

4. There is some evidence that methidathion applied at tight cluster can have detrimental effects on insect pollinators if dandelions on the orchard floor or adjacent deciduous stone fruit trees are in bloom. Cultural practices may need modification to overcome this problem.

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COMPARISON OF HONEY BEE QUEENS OVERWINTERED INDIVIDUALLY AND IN GROUPS

STEPHEN R. MITCHELL[1], DANIELLA BATES[2], MARK L. WINSTON[1], AND DOUGLAS M. MCCUTCHEON[2]

SUMMARY

Productivity of honey bee queens, as measured by area of sealed worker brood and net weight of colonies, was generally higher with queens overwintered in 2-frame nuclei, than with queens overwintered in a group. Poor acceptance and supercedure of group overwintered queens suggest that this method of storage is not yet acceptable for commercial use. Survival of the nucleus queens was low in outdoor 2-frame units during the winter, but improved with an indoor system. Overwintering queens indoors in 2-frame nuclei and outdoors in 3-5 frame nuclei with supplemental feeding of carbohydrate in late winter should provide a source of queens which could partially fulfill market demands in spring.

INTRODUCTION

Two systems of bee management are commonly employed in the cold beekeeping regions of Canada. Traditionally, beekeepers destroy all bees in the fall after removing honey, and renew their apiaries in the spring with imported packages containing 0.9-1.8 kg of worker bees and a queen. Increasingly however, beekeepers are overwintering a portion of their colonies and reducing the need to import packages. Nevertheless, large numbers of packages are still imported annually from the United States; in 1982, 350,000 packages valued at $10 million were imported (Winston 1983).

Recognition of impending threats to North American apiculture from two parasitic mites of the honey bee and from Africanized bees moving northward from Latin America, has resulted in the establishment of research programs on queen breeding (Corner 1977) and package bees (Winston 1983) in British Columbia. The presence of one of these mite parasites, *Acarapis woodi* (Rennie), was discovered in some of the package and queen producing regions of the southern United States in 1984, and has resulted in quarantines and import restrictions being imposed on the affected areas. A ban on importations of packages from the United States would create considerable hardship for Canadian beekeepers, since New Zealand is the only other country from which bees may be imported, and it is only a minor source of packages and queens (Canadian Honey Council 1982).

The feasibility of producing package bees at competitive volumes in western Canada was first demonstrated by Pankiw and Corner (1970), and is now the subject of extensive research in British Columbia (Winston 1983; McCutcheon 1984). Development of a package bee industry would be facilitated by successful overwintering of large numbers of queens, since spring-reared queens may not be available early enough to meet the April deadlines necessary for commercial Canadian beekeeping. This study was started to investigate various methods of overwintering queens.

In the study, queens were overwintered either in a 2-frame nucleus (small populations of worker bees on 2 frames) or in a mass holding facility, as described by Harp (1969). In the nuclei, single queens are free to move over the combs; in the Harp system, many queens are confined in special compartments on a modified frame. In both systems, the queens may lay eggs. An evaluation of queens overwintered by these two methods was undertaken in April 1983.

[1]Department of Biological Sciences, Simon Fraser University, Burnaby, B.C. V5A 1S6.

[2]B.C. Ministry of Agriculture and Food, 32916 Marshall Road, Abbotsford, B.C. V2S 1K2.

METHODS

Mated Italian honey bee queens, *Apis mellifera ligustica* Spin., which had been reared by the Ministry of Agriculture and Food in 1982, were established in colonies at Abbotsford, B.C. in late October. Eighteen queens were installed in a strong 20-frame colony outdoors according to the method described by Harp (1969). In brief, queens were placed singly in adjoining 4 cm x 4 cm wooden compartments on a comb (9 on each side of the frame). Hive bees had access to the queens through queen excluder material covering the compartments. The colony was gorged with approximately one liter of honey one-half hour before the queens were introduced. An empty comb was placed on either side of the compartment frame, serving as storage space for sugar syrup, medicated with Fumidil B and sulphathiazole. Nine liters of this syrup (2 parts sugar; 1 part water) were fed in October, 1982. In January and February 1983, baker's fondant icing sugar and pollen supplement patties were fed to the hive. One frame of brood from the support colony was placed next to the queens every 10-14 days. During March and April, two frames of brood were taken out of the support colony and placed next to the queens at 2-week intervals. Frames of pollen or pollen supplement patties were added every week. In addition, 9 L of sugar syrup were fed to the colony.

On 3 November 1982, 68 queens were placed singly in 2-frame nuclei which were kept either in a 10°C building (32 nuclei) or outdoors in a long row (36 nuclei). The nuclei were derived from the partition of a standard Langstroth hive body, resulting in 4 nuclei per box. Indoor nuclei had 2.54 cm of styrofoam insulation on top, while those outdoors were insultated with styrofoam on the top and sides and then wrapped with roofing paper.

Queens from the Harp overwinterig system were caged and transferred to a queenright colony on 12 April 1983. To evaluate the Harp and nucleus queens, 26 packages of 0.9 kg (2 lb.) each were produced at an apiary in Fort Langley, B.C., on 14 April. Six Harp queens, 10 nucleus queens, and 10 spring-produced queens imported from California were introduced to the packages in mailing cages, one queen per package. Syrup (1 part sugar: 1 part water) containing Fumidil B was supplied in standard feed cans. In order to simulate the usual interval between package production and hiving, all packages were held in a cool basement for 48 hours. The packages were then hived at an apiary near Aldergrove, B.C., in standard Langstroth hive bodies containing 10 frames of foundation. Colonies were arranged randomly and each received 4.5 L of syrup (2 parts sugar: 1 part water). Between the time of installation and early June, each colony received an additional 12 L of syrup. A second hive body containing 10 frames of foundation was added to each colony when there were enough bees to cover 8 frames in the original box.

The surface areas of comb occupied by sealed worker brood, honey and syrup, and pollen were determined on 10 May, 30 May, 20 June, 15 July, and 5 August, 1983. An 800 cm^2 plexiglass plate scored in 25 cm^2 units was used to measure the areas to the nearest 10 cm^2. Colonies were also weighed on the measuring dates; net colony weight was calculated as the total colony weight minus weight of empty equipment. By 4 August, only one Harp queen was still alive and data for this single colony were not included in the analysis. Data were analyzed using a one-way ANOVA (SPSS-X).

Further overwintering trials were undertaken in 1983. Forty-eight Italian queens imported from Texas were put in a populous 20-frame colony on 25 October, using the Harp system as previously described. Bees in the top super were gorged with honey poured on the top bars, the frame holding 48 queens was inserted in the center of that super, and more honey was poured on the top bars. The hive was wrapped with roofing paper for insulation in January 1984. On 5 and 25 February, 2 frames of brood from a support colony were added. On the first date, the colony also received syrup medicated with Fumidil B. On 25 February, syrup containing Fumidil B and Terramycin, and a pollen supplement patty were added to the colony. Medicated syrup was again given to the colony on 11 March.

RESULTS

Queen overwintering 1982-1983

From October 1982 until mid-April 1983, the Harp bank system suffered a 28% queen loss. Sealed brood was present in each compartment containing a live queen. However, when 10 Harp queens were placed in individual cages and introduced to a new queen bank in April, six died within 48 hours.

The total overwintering loss of nucleus queens was 53%; of the 68 queens introduced on 3 November, 36 were alive on 22 March. Only 33% of the nucleus queens survived outdoors; but 75% of indoor-wintered nucleus queens survived until April.

Queen overwintering 1983-1984

There was an initial loss of 9 queens between 18 October and 21 November 1983. The remaining 39 queens had sealed brood at 5 February when two frames of brood were added. Twenty-seven queens were alive on 25 February when brood was again added to the colony, but there was a subsequent decrease to 10 queens by 11 March.

Queen evaluation 1983

During the course of the evaluation, queen supercedure occurred with 2 of the 10 California queens, 2 of the 10 nucleus queens, and 5 of the 6 Harp queens.

At all observation dates, colonies with California queens or nucleus queens had more sealed brood than those with Harp queens; the differences were significant on 30 May and 15 July (fig. 1, $p < 0.05$). In addition, nucleus queens produced slightly more brood than California queens, although the results were not significant at any dates ($p > 0.05$).

Surface areas of honey (syrup) were not significantly different at each observation date. Through July, the amount of pollen stored in all colonies increased from an average of 808 cm^2 on 20 June to 2800 cm^2 on 5 August (Fig. 1), but there were no significant differences at any measuring date between the treatments ($p > 0.05$).

The pattern of net colony weights (Fig. 1) was similar to that of sealed brood, with the Harp queens being lowest all season, but the differences were statistically significant only on 30 May ($p < 0.05$).

DISCUSSION

The results of this and other studies suggest that queen survival using the Harp overwintering system may be too variable for commercial use. Storage of viable mated queens for 5-6 months during the winter with low mortality would be necessary for spring package production, but in our studies, mortality from October - April ranged from 28% in 1983 to 79% in 1984. Similarly, Szabo (1977) found 77-98% mortality during 5 months of winter storage. In contrast, Harp, (1969) found only 5% mortality during the winter in Wisconsin. Levinsohn and Lensky (1981), using a system of confining queens singly and adding sealed brood every 10-14 days, reported a 5-year average of 20% mortality after 5 months storage in queenless colonies in Israel. The highest mortalities were reported by Szabo, which may have resulted from failing to add carbohydrate during the winter. Carbohydrate was fed to colonies in the other studies, by shifting frames of honey closer to stored queens every 2-4 weeks (Harp 1969), or by supplying sugar syrup and/or icing sugar every 7-10 days except during the major nectar flow (Levinsohn and Lensky 1981) or irregularly (our studies). The relatively high queen

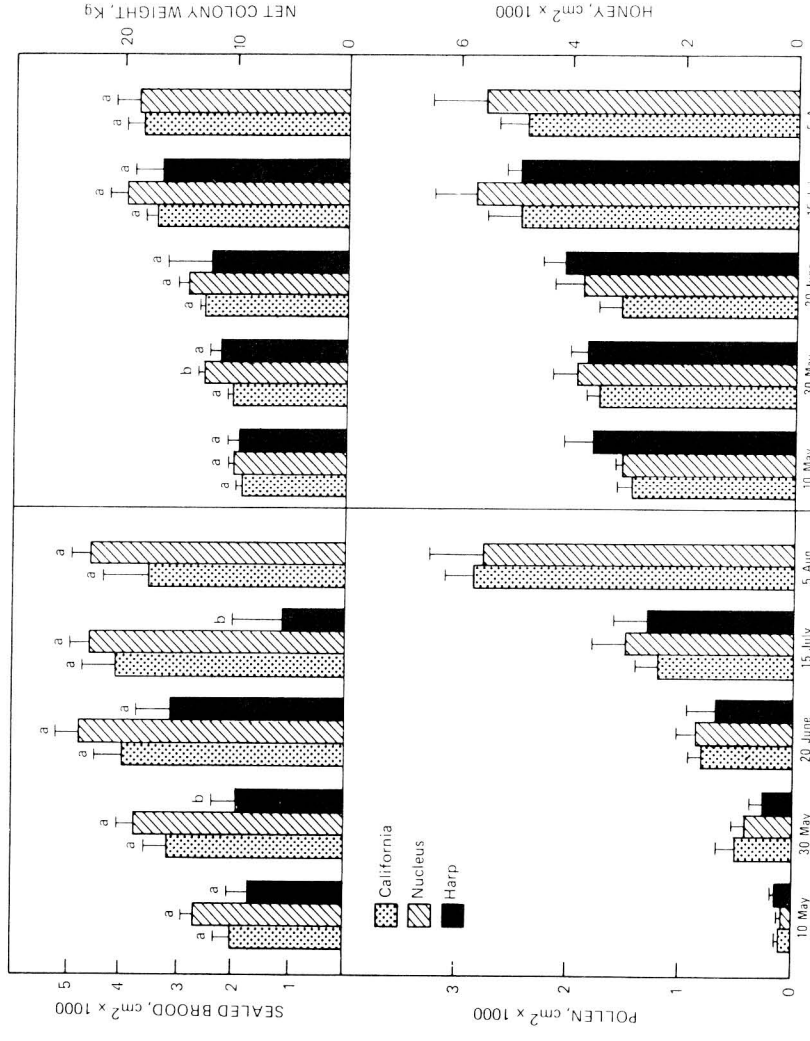

Fig. 1. Productivity of Harp and nucleus-overwintered queens and spring-reared queens imported from California.

survivals found in Israel and Wisconsin may have been due to the availability of nectar and addition of brood in Israel during the storage, and to regular movement of honey closer to queens in the Wisconsin studies. But the importance of carbohydrate and the addition of brood in winter survival needs to be more rigorously examined before drawing conclusions concerning its importance in queen overwintering.

The loss of queens overwintered in 2-frame nuclei was likely due to the low initial worker population and subsequent dwindling through winter. Indoor wintering was considerably more successful than outdoor. Most beekeepers use a nucleus of 3-5 frames for outdoor overwintering, and from our experiments using 2-frames it appears that the larger nucleus is necessary.

By most means of evaluation, the surviving Harp queens were inferior to the nucleus and California queens. Susceptibility to supercedure and lower productivity of Harp queens, particularly in worker production as measured by sealed brood area, suggest that either the mode or duration of storage altered their physiological condition. Support for this view is derived from the observation that after removing 10 Harp queens from winter storage (April 1983), six were not accepted in temporary storage bank, and 5 of 6 Harp queens introduced to colonies were superceded by August. In his study of overwintering, Szabo (1977) reported that 5 out of 12 queens surviving from a Harp storage system were superceded or lost over a 5-month season. However, this replacement was not significantly different from that seen in colonies with queens which had been overwintered either in screened compartments which prevented entry of attendant bees, or in nuclei.

The lack of significant differences in net colony weight may have been due in part to the cool, wet spring and early summer which shortened nectar flows and depressed forager activity. Scale hive records (unpublished) from the Ministry of Agriculture and Food show that May and June were dearth periods in the immediate area. Seasonal and short term weight gain have both been used as indicators of queen productivity in the selection of breeding stock (Szabo 1982), but in the Fraser Valley, which is characterized by unpredictable and sporadic nectar flows, net colony weight was not a reliable parameter for queen productivity.

Our experience with the Harp overwintering system suggests that if it is to be used, queens might be established in nuclei made up by bees from the overwintering bank after a maximum of 4 months of storage, since queen survival begins to decline rapidly at that time. However, the usual nucleus size of 3-5 frames may prove difficult to populate in late winter. An alternative would be the use of smaller nuclei which would require fewer bees. Such units would have to be adequately protected from low temperatures. Establishment of queens in small nuclei would allow the beekeeper to evaluate acceptance and egg laying capacity and pattern before using the queen for packages or individual sales. The judicious use of sugar syrup, candy or icing sugar in these nuclei would enhance the survival of queens until spring nectar sources are available.

The performance of nucleus queens in 1983 reaffirms the use of this storage method, but larger nuclei are necessary for outdoor storage due to high mortality in 2 frame units. An acceptable level of outdoor overwintering may be achieved by establishing nuclei in late August or September, allowing an extension of brood rearing into fall and ensuring that some young bees would be present through winter. Nuclei made up in late summer would also be able to take advantage of late nectar and pollen sources which may reduce the feeding requirements.

Recent findings of the mite *Acarapis woodi* in the United States will stimulate Canadian package bee and queen production. The demand for queens in the spring may be met by a combination of nucleus overwintering, spring-reared queens, and importation from areas of the United States and New Zealand declared free of pests. However, mass overwintering should be further investigated since it requires fewer resources than nuclei and as such is a desirable long-term solution.

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APHIDS TRAPPED IN OKANAGAN CHERRY ORCHARDS AND THE FAILURE OF NINE SPECIES TO TRANSMIT LITTLE CHERRY DISEASE

A. R. FORBES[1], C. K. CHAN[1], J. RAINE[1] AND R. D. McMULLEN[2]

[1]Agriculture Canada Research Station, Vancouver, B.C. V6T 1X2
[2]Agriculture Canada Research Station, Summerland, B.C. V0H 1Z0

ABSTRACT

In a search for possible vectors of little cherry disease (LCD) more than 118 aphid species, including 13 new records for B.C., were trapped in yellow-pan water traps set out in Okanagan cherry orchards. Eleven species were trapped more than 250 times. In descending order of occurrence, they were *Aphis pomi* de Geer, *Aphis nasturtii* Kaltenbach, *Myzus persicae* (Sulzer), *Pemphigus populivenae* Fitch, *Aphis citricola* van der Goot, *Hyperomyzus lactucae* (Linnaeus), *Capitophorus horni* Borner, *Metopolophium dirhodum* (Walker), *Rhopalosiphum padi* (Linnaeus), *Capitophorus hippophaes* (Walker) and *Hayhurstia atriplicis* (Linnaeus).

Nine species of aphids reproducing on *Prunus* spp. including *Aphis pomi*, *Asiphonaphis pruni* Wilson & Davis, *Brachycaudus cardui* (Linnaeus), Brachycaudus helichrysi (Kaltenbach), *Dysaphis plantaginea* (Passerini), *Hyalopterus pruni* (Geoffroy), *Myzus cerasi* (Fabricius), *Myzus persicae*, and *Rhopalosiphum cerasifoliae* (Fitch) failed to transmit LCD to test trees of c.v. Sam.

INTRODUCTION

As part of a search for the possible vectors of little cherry disease (LCD), we made a survey of the aphids occurring in Okanagan cherry orchards from June to October in 1975 and 1976. This paper reports more than 118 species collected during the survey, including 13 new records for B.C. We also include a record of attempts to transmit LCD with 9 species of aphids from *Prunus* spp.

METHODS

Survey

Traps similar to those used by Moericke (1951) and Taylor (1960) were used in the survey. They consisted of 29 x 13 cm bright yellow, round plastic pans each with a screened 2.5 cm hole about 2.5 cm below the rim to prevent overflow and loss of specimens in the event of rain. Each pan was filled with about 8 cm of water and a few drops of liquid detergent were added to reduce surface tension and to cause any aphids alighting on the surface of the water to sink. The pans were set on adjustable stands and were maintained at the same height as the orchard undercover. Aphids were removed from the pans at weekly or semiweekly intervals and preserved in 70% alcohol for later identification. When the pans were cleaned, fresh water and detergent were added. Identifications were made by A. R. Forbes and C. K. Chan. Some specimens were submitted to W. R. Richards, Biosystematics Research Institute, Ottawa, Ontario, for confirmation of identifications.

Six traps were placed in each of 3 cherry orchards in 1975 and 6 were placed in each of 11 cherry orchards in 1976. Half of the traps were placed within the orchards and half were placed on the periphery. The orchards were located in the Penticton, Naramata and Summerland areas where LCD was still spreading. One orchard was located about 1.5 km east of the centre of Penticton, where the disease was first detected; 5 were located 2.5 to 10 km north of Penticton toward Naramata and 5 more were located in the Summerland area, 2 at the Research Station and 3 located 1.5 to 5 km north of the Station.

The orchards in which the traps were located were of mixed sweet cherry varieties, including Bing, Lambert, Van and Sam. The ground cover varied from dense to sparse and consisted mainly of mowed grasses and broadleafed weeds; a few orchards were clean cultivated or with sparse weed growth. Flora adjacent to the orchards consisted of grasses or other fruit trees including apples, pears, plums, peaches and apricots or sometimes, shrubs such as chokecherry, saskatoon, snowberry, rabbitbush, sagebrush, Oregon grape and sumac. Occasionally, Douglas fir, ponderosa pine, maple and poplar were also nearby.

Transmission tests

More than 700 transmission tests were conducted with 9 species of aphids reproducing on cherry and other *Prunus* species. For each test 50 or more aphids were confined in small cylindrical leafcages, first on LCD source trees for 2 or 3 days then on Sam indicator trees for 4 or 5 days.

The indicator trees were then sprayed to kill the