Red River Apiarists' Association

The Bee Cause

Volume 7, Issue 2 February 2010

Points of Interest:

- Next general meeting is **7:30** Tuesday, **February 9th** at the **River Heights Community Centre, 1370 Grosvenor Ave., Winnipeg.**

Speaker: **Jim Campbell**
CHC/ABF Trade show and Convention: Bee Tour, Mead Workshop, Honey show

- Reminder to renew your **2010 Registration**

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Original article
Small-cell comb foundation does not impede Varroa mite population growth in honey bee colonies*

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Abstract – In three independently replicated field studies, we compared biometrics of Varroa mite and honey bee populations in bee colonies housed on one of two brood cell types: small-cell (4.9 ± 0.08 mm cell width, walls inclusive) or conventional-cell (5.3 ± 0.04). In one of the studies, ending colony bee population was significantly higher in small-cell colonies (14994 ± 2494 bees) than conventional-cell (5653 ± 1082). However, small-cell colonies were significantly higher for mite population in brood (359.7 ± 87.4 vs. 134.5 ± 38.7), percentage of mite population in brood (49.4 ± 7.1 vs. 26.8 ± 6.7), and mites per 100 adult bees (5.1 ± 0.9 vs. 3.3 ± 0.5). With the three remaining ending Varroa population metrics, mean trends for small-cell were unfavorable. We conclude that small-cell comb technology does not impede Varroa population growth.

1. INTRODUCTION

The mite *Varroa destructor* Anderson and Trueman is a natural ectoparasite of the eastern honey bee *Apis cerana* F, but now parasitizes the western honey bee *Apis mellifera* L. throughout much of its modern range. Mite reproduction is limited to the brood cells of its host bee, and it is clear in free-choice studies that Varroa preferentially enter comparatively large brood cells. When Message and Gonçalves (1995) compared brood reared in small worker cells produced by Africanized bees with brood reared in large cells produced by European bees, they found a 2-fold increase in mite infestation rates in the larger cells. When Piccirillo and De Jong (2003) compared Varroa infestation rates in three types of brood comb with different cell sizes (inner width), 4.84 mm, 5.16 mm, or 5.27 mm, they found Corresponding author: K.S. Delaplane, ksd@uga.edu
*Manuscript editor: Peter Rosenkranz that percentage of cells infested was significantly higher in the largest cells compared to the other two groups.

These kinds of observations have led to an interest among beekeepers in downsizing comb foundations as a cultural control against Varroa. In North America, the resulting "small-cell" foundation measures 4.9 mm
per cell (Dadant & Sons, Hamilton, IL, USA) compared to that of conventional foundation measuring between 5.2 mm and 5.4 mm. These numbers are derived by measuring the width of 10 cells in a straight line, inclusive of wall widths. In this study we challenged a null hypothesis of no difference in Varroa and bee population metrics between bee colonies housed on combs of small-cell or conventional-cell foundation.

2. MATERIALS AND METHODS

In three independent experimental replicates, we compared biometrics of Varroa mite and honey bee populations in bee colonies housed on one of two brood cell types: small-cell or conventional cell. In spring 2006, foundation of both types was drawn during natural nectar flows prior to set up of the experiment. Small-cell foundation was drawn out by colonies containing honey bees which had themselves been
(continued on page 4)

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Pollination Info from the Ontario Beekeepers Association

1. Bees help set as many of the early vigorous blossoms as possible.

2. Larger and more uniform fruit and increased pounds per acre are associated with an increased number of bee visits.

3. A Higher Concentration of Bees In Your Orchard can Make you Money

Effectiveness

The effectiveness of the bee is determined by the visits it makes between compatible varieties within the orchard. If the visits are confined on one variety they are not as effective. Repeated cross-pollination of the flowers must occur to produce the optimum set. It has been proven that some cross-pollination actually occurs within the hive. Contact between the bees causes transfer of pollen grains from the body hairs of one bee to another. The return flight of the bee even to the same variety of tree results in cross-pollination

Pollination Recommendations

Many crops require honey bees to transfer pollen in order to have a good seed set and ensure that a good fruit develops around these seeds. Recommended density of beehives per acre for Ontario Fruit and Vegetable crops:

Hive Stocking Rates

Apples	Standard	1 hive per acre
	Semi-Dwarf	2 hives per acre
	Dwarf	3 hives per acre
Pears	Plums	1 hive per acre
Peaches	Nectarines	1 hive per acre
Cherries	Apricots	1 hive per acre

Small Fruit Crops

Cranberries	3 hive per acre
Blueberries	3 hives per acre
Raspberries	1 hive per acre
Strawberries	1 hive per acre

These Field Crops Need 1 Hive per acre

Cucumbers	Melons	Pumpkins
Squash	Zucchini	Ginseng
Canola	Buckwheat	Sunflowers
Clovers	Trefoil	Alfalfa

For more detailed recommendations on other crops refer to OMAF Publication 72 or AGOEX 616.

Distribution and Placement of Colonies

When possible place groups of 15 or more colonies in sunny clearings within the boundaries of an orchard. Completely shaded locations will contribute to shortened flight time. Growers can assist beekeepers by setting out hive stands ahead of time. Hives placed on the ground often end up with their entrances partially blocked by growing grasses and weeds and sometimes even mower clippings. The result is reduced access for the bees and less pollination for the grower

Ontario Recommended Rental Fees 2009

Spring Pollination $70

(May be adjusted to crop and area)

Summer Pollination $120

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Minutes of the RRAA General Meeting
River Heights Community Club – January 12, 2010

7:30 PM: John Russell welcomed eighteen members and guests to the regular RRAA meeting and made several announcements.
1) Charles has left for a several weeks to Mexico.
2) Membership dues for 2010 are payable to John Speer, our treasurer, either by mail or in person at a meeting.

Minutes of the November 10 meeting approved: Moved by Ken Rowes and seconded by Albert Anderson to approve the minutes as published in the January *Bee Cause*.

Meeting Room at RHCC: Rhéal Lafrenière noted that out present meeting room is often noisy from activities that take place on the ice surface below. Moved by Rhéal and seconded by Arvin C. that our Association should investigate the cost and availability of the room on the ground floor for our meetings. Carried

Election Committee Report: Our election committee reported that the present executive was agreeable to continuing in their respective positions for one more year. John asked for nominations from the floor. No further nominations were received from the floor.
Motion to reinstate the executive from 2009 made by John Russell and seconded by Brian Smith. Motion was carried.

MBA Report: Jim Campbell, the MBA representative for RRAA, is attending the joint Canadian Honey Council – American Beekeeping Federation conference in Orlando, FL.

Jim will have a report on the CHC/ABF Conference and tour in February.

MAFRI Report: Rhéal reported that the price of honey bee lab analysis is increasing from $20 to $25 per sample because of the Provincial Government's cost recovery program. Additionally, the Manitoba Beekeepers' Association has agreed pay $15,000, this year, for disease inspections.

Rhéal also discussed the progress of the On Farm Food Safety program in Manitoba. As a part of this program, financial assistance (up to $1000) will be made available for beekeepers to upgrade extracting equipment that does not meet food safety standards. More information will be provided to all Manitoba beekeepers when it becomes available.

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Loonie Draw: Mike Grysiuk had his name drawn for a pair of bee towels, Howard Alexander won the jar containing Chocolate flavoured Honey, Ron Rudiak won the Lemon flavoured Honey, Rhéal's name was drawn for a jar of blueberry honey, Rhéal and Gilles Lantagne each won a package of dark roasted yerba mate tea. Ken Rowes won a jar of roasted nuts and Ken Fehler won a book on the history of Ontario beekeeping. Thank you to those who donated draw items and also those who purchased tickets.

Ron Rudiak, recorder – RRAA

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Beekeeping in Canada – Challenges and Opportunities: A presentation by Rhéal Lafrenière

Honey – Keeping it Natural, Pure (and Plentiful)
We need to protect honey's purity to preserve its' premium value.

Canada has seven-thousand beekeepers, some with several colonies and others with large numbers of honey bee colonies for a total of 603, 824 at last count. While each province produces honey, 75% of it is produced in the three prairie provinces.

Colony losses during the winter months have increased significantly since varroa mites were discovered here about 20 years ago. While wintering losses were typically 5 to 10 percent during the years preceding the discovery of mites in Canada, today colony losses are now exceeding 30 percent.

Each year, beekeepers struggle to get their colony counts back to where they were the preceding year. This results in smaller colonies used for honey production and much higher input costs. Generally, these smaller colonies produce significantly less honey than wintered colonies. Queens are not always available when they are needed for splitting wintered colonies and much needed replacement packages and nucs have become very expensive.

Hive health is one of our highest priorities followed closely by market access and market share. Food safety is also very important as honey buyers will soon insist that the honey we produce also includes traceability to meet the requirements of packers and processors.

Farm labour is difficult or next to impossible to obtain from within the province and has recently become exceedingly difficult to get through the foreign worker programs. This is causing major problems for many of our larger producers.

Following the presentation, Ken Rowes later commented that smaller scale producers, such as members of the RRAA, need to be aware of what we should be doing in the area of food safety. We need to scrutinize our own production in the best way possible to ensure that we, too, can meet the requirements of On Farm Food Safety programs.

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reared in small-cell combs. Conventional foundation was similarly drawn out by colonies whose bees were derived from conventional combs. Once combs were drawn we determined realized cell width (walls inclusive) by counting the number of cells in 10 cm linear (n = 60 samples each cell type). Cell width from small-cell combs was 4.9 ± 0.08 mm and from conventional- 5.3 ± 0.04 mm. In August 2006, bees were collected from a variety of existing colonies (irrespective of rearing history) and combined in large cages to achieve a homogeneous mixture of bees and Varroa mites. Twenty screened packages were made up, each containing ca. 2.0 kg (15966) bees. Packages were transported to a test apiary in Oconee County, Georgia, USA (33◦ 50_N, 83◦ 26_W) where each was used to stock one of 20 single-story deep Langstroth hives. Ten of the hives each contained ten frames of drawn small-cell comb, and the other ten contained drawn conventional-cell comb. One alcohol sample of ca. 300 bees was collected from each package to derive starting mite: adult bee ratios and, by extrapolation, beginning mite populations (colonies were broodless so all mites were phoretic on adults). Queens from a single commercial source were introduced into colonies. All colonies received sugar syrup and pollen patties as needed. Colonies were removed from the experiment if they died or their queens failed.

In March 2007 a second experiment of twenty colonies was established in the same manner as before with the following differences: each package contained ca. 1.45 kg (11612) bees, and colonies were established on foundation instead of drawn comb. A third experiment was set up in April 2008, each colony with 1.36 kg (10886) bees and started on drawn comb of the appropriate experimental type stored from the previous year; honey was removed from combs to remove variation in beginning food stores.

In June 2007 (for colonies started in August 2006 and March 2007) and in August 2008 (for colonies started in April 2008) we collected the following ending parameters: daily mite count on bottom board sticky sheet (72-h exposure), average mites per adult bee recovered from alcohol samples (ca. 100–300 bees), mites per 100 cells of capped brood, and brood area (cm2). A measure of ending bee population was made by summing the proportions
of whole deep frames covered by bees (after Skinner et al., 2001) then converting frames of adult bees to bee populations with the regression model of Burgett and Burikam (1985). Brood area (cm2) was converted to cells of brood after determining average cell density as 3.93 per cm2 for conventional-cells and 4.63 for small-cell. From
cells of brood we calculated the number of cells sealed by applying the multiplier of 0.53 derived by Delaplane (1999). From mites on adult bees and mites in brood we could derive ending mite populations and percentage of mite population in brood – a positive indicator of the fecundity of a mite population (Harbo and Harris, 1999). Finally, for the August 2006 colonies we sampled adult bees in October 2006 for average body weight.

The duration of time between experiment start date and collection of ending Varroa population metrics was ca. 40 weeks for August 2006 colonies, 2 weeks for March 2007 colonies, and 16 weeks for April 2008 colonies. A field test of no more than 9–10 weeks is adequate to accurately appraise Varroa population change (Harbo, 1996).

An initial analysis was run as a randomized block analysis of variance recognizing the three experiment start dates as blocks and using the interaction of treatment and block as test term (Proc GLM, SAS 2002–2003). There was an interaction between treatment and block for ending colony bee population, so for this variable the analysis was performed separately for each start date and residual error used as test term. Differences were accepted
at the $\alpha \leq 0.05$ level and where necessary means separated by Tukey's test.

3. RESULTS

Significant effects of cell size were detected for ending mites in brood (F = 38.3; df = 1,2; P = 0.0252), percentage of mite population in brood cells (F = 57.4; df = 1,2; P = 0.0170) and ending mites per 100 adult bees (F = 23.8;
df = 1,2; P = 0.0396). The ending number of mites in brood, percentage of mite population in brood, and mites per 100 adult bees were significantly higher in small-cell colonies (Tab. I). There was a significant interaction
between start date and treatment for ending colony bee population (F = 5.14; df = 2,33; P = 0.0114)which is explained by the fact that

Table I. Mean values (± se) for bee and Varroa population metrics in bee colonies housed on conventionalsized brood cells or small cells. Colonies of both cell types were set up in August 2006 (15966 bees), March 2007 (11612 bees), or April 2008 (10886 bees). Ending data were collected in June 2007 (August 2006 and March 2007 colonies) and August 2008 (April 2008 colonies). A one-time measure of adult bee live weight was made October 2006 for August 2006 colonies. Numbers in parentheses = n. The occurrence of significant treatment effects ($\alpha \leq 0.05$) is indicated by *.

Variable	Conventional-cell	Small-cell
Beginning colony mite popn.	303.1 ± 61.4 (19)	308.6.2 ± 54.1 (21)
Adult bee weight (mg) in October 2006 (Aug. 2006 colonies only)	41.3 ± 6.7 (4)	129.3 ± 5.7 (3)
Ending cm2 brood	6320 ± 681 (19)	5627 ± 490 (21)
Ending cells of brood	24838 ± 2675 (19)	26053 ± 2271 (21)
Ending mites per 24 h sticky sheet	17.4 ± 5.0 (19)	28.3 ± 6.0 (21)
Ending mites per 100 brood cells	0.9 ± 0.2 (19)	2.8 ± 0.6 (21)

(continued on page 5)

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Ending colony mite popn.	409.7 ± 93.4 (18)	670.5 ± 112.5 (21)
Ending mites in brood	134.5 ± 38.7 (19)	359.7 ± 87.4 (21)*
Ending % mite popn. in brood	26.8 ± 6.7 (16)	49.4 ± 7.1 (20)*
Ending mites per 100 adult bees	3.3 ± 0.5 (18)	5.1 ± 0.9 (21)*

Table II. Mean values (± se) for ending colony bee population in bee colonies housed on conventional-sized brood cells or small cells. Colonies of both cell types were set up in August 2006 (15966 bees), March 2007 (11612 bees), or April 2008 (10886 bees). Ending data were collected in June 2007 (August 2006 and March 2007 colonies) and August 2008 (April 2008 colonies). Means for this variable are reported by experiment start date which interacted significantly with treatment. Numbers in parentheses = *n*. The occurrence of significant treatment effects ($\alpha \leq 0.05$) is indicated by *.

Variable	Conventional-cell	Small-cell
Ending colony bee popn.		
	August 2006	
	5653 ± 1082 (3)	14994 ± 2494 (3)*
	March 2007	
	10960 ± 2115 (6)	13717 ± 1309 (9)
	April 2008	
	14629 ± 1111 (9)	12461 ± 2177 (9)

populations tended to be higher in small-cell colonies except for the April 2008 start date. The advantage for small-cell colonies was significant for the August 2006 start date ($F = 11.8$; df = 1,4; $P = 0.0264$) (Tab. II). We failed to detect significant effects of cell size on cm2 brood, cells of brood, mites per 24 h sticky sheet, mites per 100 brood cells, and colony mite populations (Tab. I).

4. DISCUSSION

Although a significant and favourable trend for small-cell colonies was indicated for ending bee populations for the August 2006 start date (Tab. II), the chief interest in small-cell technology resides in its potential as a non-chemical limiter of Varroa population growth. By this criterion, the present results are not encouraging. The ending number of mites in brood, percentage of mite population in brood, and mites per 100 adult bees were significantly higher in small-cell colonies (Tab. I). Moreover, with all remaining ending Varroa population metrics, mean trends were unfavourable for small cell (Tab. I).We conclude that small-cell comb technology does not impede Varroa population growth. This null conclusion is reinforced by the facts that: (1) the experiment was replicated independently three times with start dates varying between spring and fall and test periods ranging from 12–40 weeks, (2) there were no interactions between start date and treatment for ending Varroa metrics, showing that responses were consistent across experiments, (3) the question of Varroa population growth was examined holistically with six dependent variables, and finally (4) the bar for performance should be high before a candidate technology is recommended for field use. It is worth noting that Varroa densities in this study (3.3–5.1 mites per 100 bees, Tab. I) were not within the action threshold of ca. 13 mites per 100 bees shown for the region by Delaplane and Hood (1999).

Interest in small-cell foundation has been fueled in part by observations of Martin andKryger (2002) that conditions which constrict the space between the host pupa and male protonymph mite promote male mite mortality. However, as these authors point out, "reducing cell sizes as a mite control method will probably fail to be effective since the bees are likely to respond by rearing correspondingly smaller bees". The present study supports this deduction directly, and its premise indirectly: average bee live weight in October was numerically smaller in small-cell colonies than conventional (Tab. I).

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MBA Report

Jim Campbell, MBA Rep 2010

During the first part of 2010, MBA finalized speakers for the upcoming 104th Beekeepers Convention. All beekeepers are invited to the 5-6 March 2010 Convention and Symposium to be held at the Canad Inns-Keystone Centre, Brandon. One of the keynote speakers will be Randy Oliver, Beekeeper, Pollinator (i.e. Almonds), and Researcher from Grass Valley, California. Others include Dr. Medhat Nasr, Alberta Provincial Apiculturist, along with Doug McRory, Retired Ontario Provincial Apiarist.

MBA is winding down the two-year research project for Saskatoon Pollination. Although the project conclusions will be provided at the upcoming symposium, there has been some disappointment with the adverse weather conditions during the project. The past two years have had a cool spring, and this has slowed the activity of our pollinators. Despite this, there is promise for better and more fruit set.

Beekeepers are to note fee increases to take place at the Apiculture Diagnostics Lab as of January 1, 2010. The lab at 205 University Crescent, Winnipeg provides analysis of bee samples collected by inspectors at the request of beekeepers, samples dropped off on site, or sent in directly by beekeepers. Fees for full Varroa, Nosema and Trachael mite analysis will be $25.00, and $10.00 for each of Nosema and/or Varroa analysis.

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Red River Apiarists' Association

Editor's Note by Ken Rowes

In January's editorial I made reference to Clostridium botulinum spores getting into honey. In discussion with Rhéal Lafrenière he affirmed that no spores have been found in Canadian honey by the Canadian Honey Council and CFIA. assessments. We attributed that to the practice that the honey is removed as soon as it is ready and partially capped and that none is removed from the brood chambers.

For members who haven't a copy of Honey Bee Diseases & Pests 2nd Edition by the Canadian Association of Professional Apiculturists, Rhéal can sell the booklet for $5 at our meetings or + shipping he can provide via the Postal service.

This article provides excellent photographical details of these organisms and clear descriptive assessment techniques which you can refer to when assessing your own hives and bees.

It is always wise to define your summer beekeeping plans early around February. The edge is listing the tasks to be done before moving bees and manipulating for feeding and queen rearing.

I've been using a plastic poster board with cheap recycled computer paper taped to it in my indoor colonies where I remove dead bees every 2—3 weeks and can assess the mite drop (mite density), the number of frames bees are working (size of cluster), and the type of wax in the drop. I found this new white wax to coincide with the onset of queen brooding which has just started to appear. Now is the time to get the old wax out. Its also a good time to clean and sterilize your hive tools.

The Bee Cause is the official publication of the Red River Apiarists' Association for distribution to its members and their colleagues in the beekeeping industry. It is published eight times a year on a monthly basis except December and the summer months of June, July, and August when membership meetings do not occur.

Articles can be best submitted in word documents as email attachments. Though they may be edited for spelling and basic grammar, no changes will be made to their contents, message and opinions. They are those of their originator and not of the Red River Apiarist Association.

Deadline for any submission to this newsletter is the second Saturday preceding the membership meeting to allow for publishing and mailing delays. Regular membership meetings are normally scheduled 7:30 PM on the second Tuesday of every month at the River Heights Community Centre located at 1370 Grosvenor Avenue in Winnipeg except the months as noted above.

The Red River Apiarists' Association, formed in 1963, represents the beekeepers of the Red River Valley and environs in southern Manitoba. The association provides a forum for the promotion of sound beekeeping practices through education, networking opportunities, meetings, field days, workshops, presentations by local apicultural experts, as well as the dissemination of this monthly newsletter.

We are on the web!
www.beekeepingmanitoba.com

CLASSIFIED

1. For Sale: 25 Gallon single walled honey sump. Electric uncapping knife with preset thermostat, like new. 1 complete Top Bar Hive.
Contact: **Lance Waldner** Home 433-2517 Cell 712-6783 lancewld@gmail.com

2. Wanted: Honey pump and semi automatic honey container filler. Contact Lance Waldner (204)433-2517, cell 712-6783 or lancewld@gmail.com

3. Wanted: S.S Bottling Tanks Single wall or double wall with water jacket, good condition or repairable. Also needed—Belt Barrel Heater for drums: **call Brian Rich 204 739-5481**

4. For Sale: 30 Frame Maxant Extractor.

please call **Javad Niazi At 885-0576 or javadniazi@yahoo.ca**

5. FOR SALE: Clearance of a variety of Beekeeping Equipment-Honey Supers, Brood Boxes, Wax Dipped Feeder Boxes, Queen Excluders, Bottom Boards, Lids, Empty Shells, Bare Frames, etc. Reasonable Prices on all items. Call Charles Polcyn at 284-7064 or email at: charles _polcyn@ymail.com

6. For Sale: Downsizing
100 hives and contract with Bee Maid availabe. Also selling 3,4 and 5 frame nucs available May 15th. Will sell 10 frame honey supers all white frames, June 1- many in new boxes, equipment in excellent condition; and excluders, wintering inner covers, bottom boards etc.
Contact Dennis Ross 878-2924 or Rosskr@mts.net

7. For Sale: Equipment for sale, 10 double brood chambered colonies. a 10 frame Maxant extractor, commercial winter wraps, supers and frames, tools, covers, stands, bottom boards, feeder pails, sump pump , refractometer, much more contact Leo Demers 204-379-2518.

Ecology:

Clarity on Honey Bee Collapse?

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Over the past few years, the media have frequently reported deaths of honey bee (*Apis mellifera* L.) colonies in the United States, Europe, and Japan. Most reports express opinions but little hard science. A recent historical survey (*1*) pointed out that extensive colony losses are not unusual and have occurred repeatedly over many centuries and locations. Concern for honey bees in the United States has been magnified by their vital role in agriculture. The California almond industry alone is worth $2 billion annually and relies on over 1 million honey bee hives for cross-pollination. So what is killing honey bee colonies worldwide, and what are the implications for agriculture?

In fall 2006 and spring 2007, many U.S. beekeepers encountered hives without adult bees but with abandoned food and brood. It was widely believed that these were symptoms of a new and highly virulent pathogen. In the absence of a known cause, the term "Colony Collapse Disorder" (CCD) was coined. What have we learned about this condition since then? Are the symptoms really novel?

CCD has stimulated a flurry of explanations, ranging from mobile phones and genetically modified crops, which have been dismissed by scientists (*2*, *3*), to pests and diseases, environmental and economic factors, and pesticides, which have received more serious consideration and stimulated much research. This week, for example, comprehensive surveys of honey bee losses in general in 16 countries in North America and Europe are reported (*4*). Although full explanations for these losses are still debatable, the consensus seems to be that pests and pathogens are the single most important cause of colony losses.

There is also growing evidence that the ability of a particular pathogen to kill colonies may depend on other factors, such as the ectoparasitic mite *Varroa destructor*. CCD-like symptoms have often been reported in Europe in colonies infected with this mite (*5*). Its original host was the Asian honey bee *Apis cerana*, but it colonized *A. mellifera* when this bee species was introduced to Asia. *V. destructor* is now present in all major beekeeping regions worldwide except Australia, where CCD symptoms have not been observed. It is not the mite itself that causes bee death, but a range of normally innocuous bee viruses that it carries. Experimental studies (*6*) have shown that *V. destructor* transmits viruses previously considered unimportant to honey bee biology, including slow paralysis virus and Kashmir bee virus, thus causing colony death. Field studies have demonstrated that the incidence and abundance of viral infections in *A. mellifera* have increased substantially since the mite colonized this species of bee. For example, in one study in the UK, the incidence of infection of experimental colonies with deformed wing virus increased from 0% in 1994–1995 to 100% once the mite was firmly established in the bee population during 1997–1998 (*7*). *V. destructor* has been controlled in various ways, including by acaricides, but in many areas, especially the United States and Europe, the mite has evolved resistance to the most effective chemicals used.

Mite interactions alone cannot, however, account for all losses attributed to CCD. One paradox noticed by researchers early on in the U.S. CCD story is that although *V. destructor* is universally present in affected colonies, mite numbers were often claimed to be small, whereas *V. destructor*–related colony losses elsewhere typically reported thousands of mites per colony (*8*). A possible resolution for the former lies in studies involving *V. destructor* and Kashmir bee virus (*9*), which report that the virus can persist in a colony's worker bees even in the absence of the mite, indicating that direct bee-to-bee virus transmission also occurs. This is not surprising, as this virus was present in *A. mellifera* before the bee was colonized by *V. destructor*. A study of U.S. CCD colonies using whole-genome microarrays found much evidence of viral infection, including by Kashmir bee virus (*10*).

In 2007, a metagenomic study (*11*) compared worker honey bees from dead or dying colonies showing CCD symptoms with workers from thriving hives. The analysis showed that Israeli acute paralysis virus, a previously esoteric virus, was the pathogen most commonly associated with CCD. Although the authors did not claim a causal relationship, this seemed reasonable, given that closely related viruses such as acute bee paralysis virus and Kashmir bee virus can kill colonies when in association with *V. destructor*. However, a 2009 study paints a less clear picture (*12*). Further studies on the pathology of bee infection by Israeli acute paralysis virus are needed and may be guided by studies on the related viruses linked to colony death.

Another pathogen that may be killing colonies is the microsporidian gut parasite *Nosema ceranae*, which also originated in the Asian hive bee *A. cerana*. *N. ceranae* affects adult bees and was recently found in collapsing *A. mellifera* colonies in Spain. Experimental results suggest that it is more virulent than *Nosema apis*, which has long been known to infect *A. mellifera*. However, molecular studies show that *N. ceranae* occurs in thriving colonies in many countries, and analyses of stored bee extracts showed that it was present in *A. mellifera* decades before the onset of CCD. More research is needed to determine how virulent *N. ceranae* really is (*13*).

Foraging honey bees and even whole colonies can be killed by chemicals intended to target other insects. Neonicotinoid systemic insecticides have been blamed for extensive colony collapse, and this has caused much debate. In France, the neonicotinoid compound imidacloprid was banned as a treatment on sunflowers and maize because of concerns that it could contaminate nectar or pollen and thus kill bees, but colony losses continued. After 10 years of research (*14*), it seems unlikely that imidacloprid was responsible for the French bee deaths, but it is conjectured that subtle, sublethal effects of either the compound or its metabolites may occur, perhaps making bees more susceptible to disease.

The first annual report of the U.S. Colony Collapse Disorder Steering Committee, published in July 2009 (*15*), suggests that CCD is unlikely to be caused by a previously unknown pathogen. Rather, it may be caused by many agents in combination—the interaction between known pests and pathogens, poor weather conditions that diminish foraging, lack of forage (*16*), and management factors such as the use of pesticides and stress caused by long-distance transport of hives to nectar sources or pollination locations. The increasingly technical process of beekeeping itself merits further research as far as its impact on colony health. For example, although pollen substitutes are now widely used, little is known about the interactions between nutrition and disease susceptibility. Further research is also needed to develop effective ways of keeping colonies healthy through good hive management based on appropriate chemical, and other treatments such as "hygienic" bees that remove diseased brood and can be bred using conventional methods. In Europe, the COLOSS (Colony LOSS) network, consisting of 161 members from 40 countries worldwide, is coordinating research efforts and activities by scientists and the beekeeping industry to address these and other issues related to honey bee losses, including CCD (*2*).

In February 2009, the high pollination fee, combined with a temporary reduction in pollination demand due to drought and reduced almond prices, resulted in a surplus of hives in California available to pollinate almonds. But this leaves no room for complacency. Almond pollinating beekeepers had a poor summer in 2009 in the Dakotas and neighboring states, where hives spend the summer making honey, with heavy rains delaying and reducing the honey crop. This delayed chemical treatments for *Varroa* mites, and many colonies were probably in worse than usual condition going into

(continued on page 9)
winter back in California. It will be interesting to see what happens in February 2010 when the almonds bloom. On a longer time scale, there is a worrying downward trend in U.S. hives, from six million after World War II to 2.4 million today. Is the future of U.S. commercial bee-keeping going to be based on pollinating a few high-value crops? If so, what will be the wider economic cost arising from crops that have modest yield increases from honey bee pollination? These crops cannot pay large pollination fees but have hitherto benefited from an abundance of honey bees providing free pollination.

Given the importance of the honey bee to mankind, the progress made in understanding CCD and colony losses in general is encouraging. But further research on honey bee health and well-being is needed.

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