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National Honey Bee Loss Survey

Updated Survey Results, June 1, 2007: Correlation of Common Pathogens with CCD.

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Introduction:

The number of respondents to the Bee Alert National Bee Loss Survey has increased steadily. The data base now includes a total of 625 valid surveys, received as of 1 June 2007. The survey includes both paper (mail, fax) and electronically submitted data. Surveys are provided voluntarily by beekeepers, who have responded to requests for information at meetings, trade magazines, electronic discussion groups, beekeeping equipment suppliers, and our web site (www.beesurvey.com).

Responses that are entered into the data base are screened to ensure that no duplicates are entered, but other than that the data are not modified. There has been no attempt to apportion sampling by size and scope of operation, or by geographical region. The data represent the subjective observations of the individual respondents; no attempt at validation has been made. Furthermore, the data is from respondents who are motivated to provide the data requested. Beekeepers who are unwilling, do not know about, or are too busy to participate are not represented in the data reported below. Because of the voluntary nature of data accumulation, the data do not represent a statistically designed sampling effort.

Despite these limitations on the data, the large number of respondents has provided us with extensive coverage of the current state of the CCD problem in the U.S. and Canada. To date, we have received surveys from beekeepers in 43 states and five provinces, obtained more than a quarter of a million data points, and have reports of CCD occurring over the last 16 months in 35 states and at least one province.

The large amount of information gathered from survey questions is also providing us with a broad base from which to explore whether there are patterns of disease, toxic exposure and management practices that may be linked to the occurrence of CCD.

Survey Representation:

Updating the makeup of the beekeepers who contributed the data, two-thirds of respondents operate fewer than 100 colonies (Figure 1). The remaining third roughly evenly represent larger scale operations of more than 100, 1,000, and 10,000 colonies. In addition, we now have data provided by nearly 70 large beekeeping operations that manage apiaries greater than 10,000 colonies.

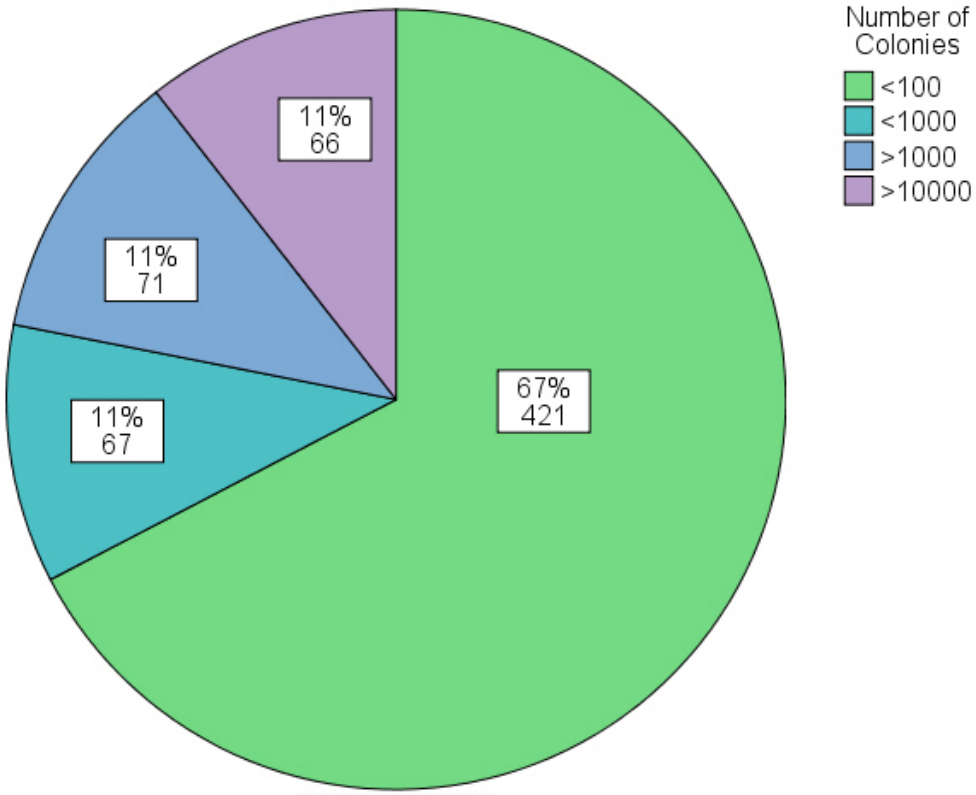

Figure 1. Distribution of size of beekeeping operation among respondents to the BeeAlert survey. 625 total responses have been received as of June 2007.

Geographical distribution (Table 1) of the respondents is nearly as wide as the reported incidence of CCD (Figure 6). Respondents did not all indicate the state or province from which they were reporting. Those who did, however, included forty-three states, Puerto Rico, and five Canadian Provinces (Table 1).

It is important to note that our summary findings are based on wide area, national level coverage, and that no one region dominates the survey data. California and North Carolina, which have the largest number of respondents identified, only account for less than 10 percent each of the survey.

Survey Bee Loss Results:

Respondents across all sizes of operation indicate high frequencies of severe bee losses over the past six months. Reversing our earlier report, smaller operations are more likely to have suffered more severe losses than normal (Figure 2). The extent of severe losses increases in intermediately sized operations, but drops again among the largest beekeepers reporting through our survey. Overall, however, 40 percent of respondents report severe losses this past winter compared to 48 percent who reported average or lower losses.

We asked respondents to indicate whether the general cause for demise of colonies was due to overwinter losses, mites, pesticide exposure, or disappearance (CCD). More than 80 percent of respondents (Figure 3) attributed bee loss to overwintering death or CCD.

Table 1. Geographical distribution of respondents who listed site locations with their responses to the BeeAlert survey. Table is current as of June 2007.

State / Province	Frequency	Percent	Cumulative Percent
Alabama	2	.8	.8
Alaska	1	.4	1.1
Arizona	2	.8	1.9
Arkansas	1	.4	2.3
British Columbia	9	3.4	5.6
California	26	9.8	15.4
Colorado	13	4.9	20.3
Connecticut	2	.8	21.1
Florida	18	6.8	27.8
Georgia	13	4.9	32.7
Idaho	4	1.5	34.2
Illinois	10	3.8	38.0
Indiana	8	3.0	41.0
Iowa	11	4.1	45.1
Kansas	1	.4	45.5
Kentucky	6	2.3	47.7
Maine	1	.4	48.1
Maryland	3	1.1	49.2
Massachusetts	2	.8	50.0
Michigan	5	1.9	51.9
Minnesota	1	.4	52.3
Missouri	9	3.4	55.6
Montana	3	1.1	56.8
Nebraska	1	.4	57.1
Nevada	1	.4	57.5
New Brunswick	1	.4	57.9
New Hampshire	4	1.5	59.4
New Jersey	4	1.5	60.9
New Mexico	1	.4	61.3
New York	12	4.5	65.8
North Carolina	23	8.6	74.4
Nova Scotia	1	.4	74.8
Ohio	12	4.5	79.3
Ontario	1	.4	79.7
Pennsylvania	9	3.4	83.1
Puerto Rico	1	.4	83.5
Quebec	1	.4	83.8
South Carolina	2	.8	84.6

South Dakota	1	.4	85.0
Tennessee	7	2.6	87.6
Texas	4	1.5	89.1
Vermont	1	.4	89.5
Virginia	8	3.0	92.5
Washington	1	.4	92.9
West Virginia	3	1.1	94.0
Wisconsin	16	6.0	100.0
Total	266	100.0	

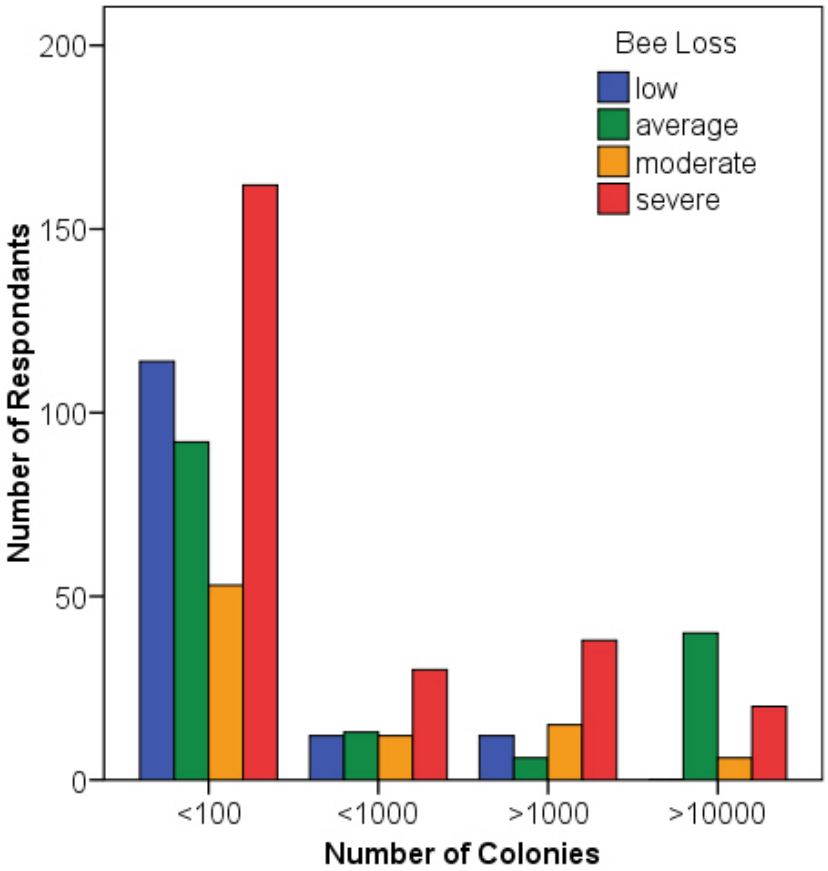

Figure 2. Severity of colony loss reported by beekeepers relative to size of operation.

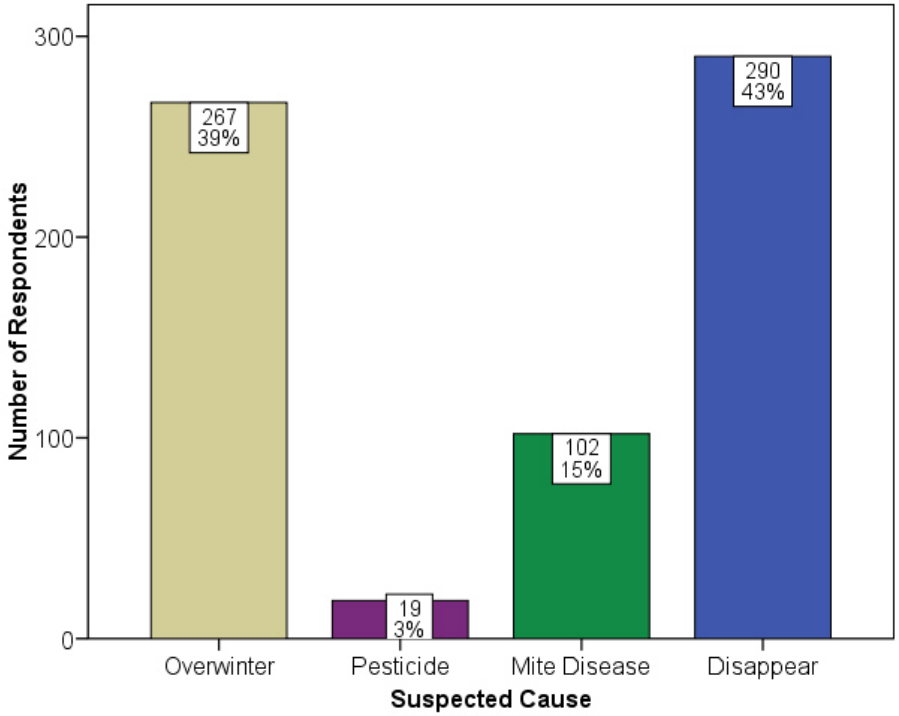

Figure 3. Reported cause for bee loss by all respondents to Bee Alert survey as of June 2007.

Broken down by size of beekeeping operation, the data again indicate a high level of bee disappearance, equaled only by overwinter losses (Figure 4). Colony disappearance and overwintering loss were greatest among the smallest bee operations. Although disappearance is most often indicated as the cause of loss by intermediate and large scale beekeepers, it is not claimed substantially more often than overwintering kill. Interestingly, regardless of operation size, pesticides are indicated as the cause of colony failure about four percent of the time.

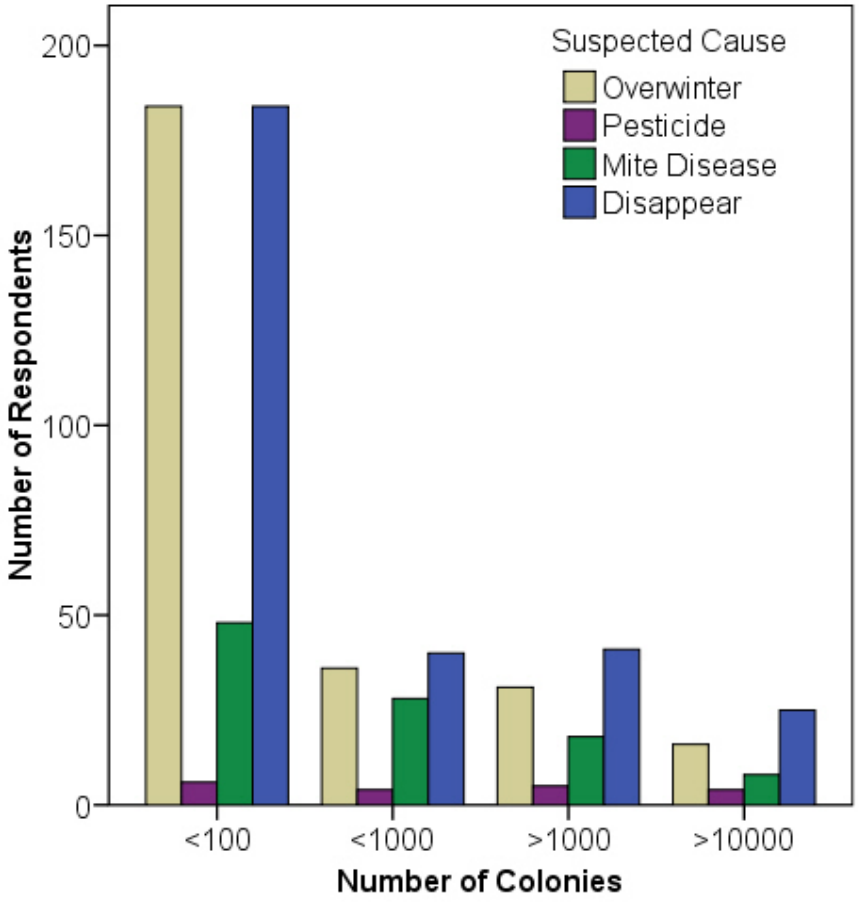

Figure 4. General cause for colony collapse relative to operation size as reported by BeeAlert survey respondents.

When we compared the reported cause of colony collapse with severity of loss, we observed that those beekeepers who reported average or lower bee loss rates attributed their primary losses to overwintering stress (Figure 5). Reports of mites and diseases, as well as pesticide losses, remained relatively low and constant across all categories of loss severity. As the severity of bee loss increased, attribution to overwinter loss decreased slightly, while the prevalence of CCD reports increased. When severe loss was reported, bee disappearance or CCD was implicated nearly twice as often as any other factor.

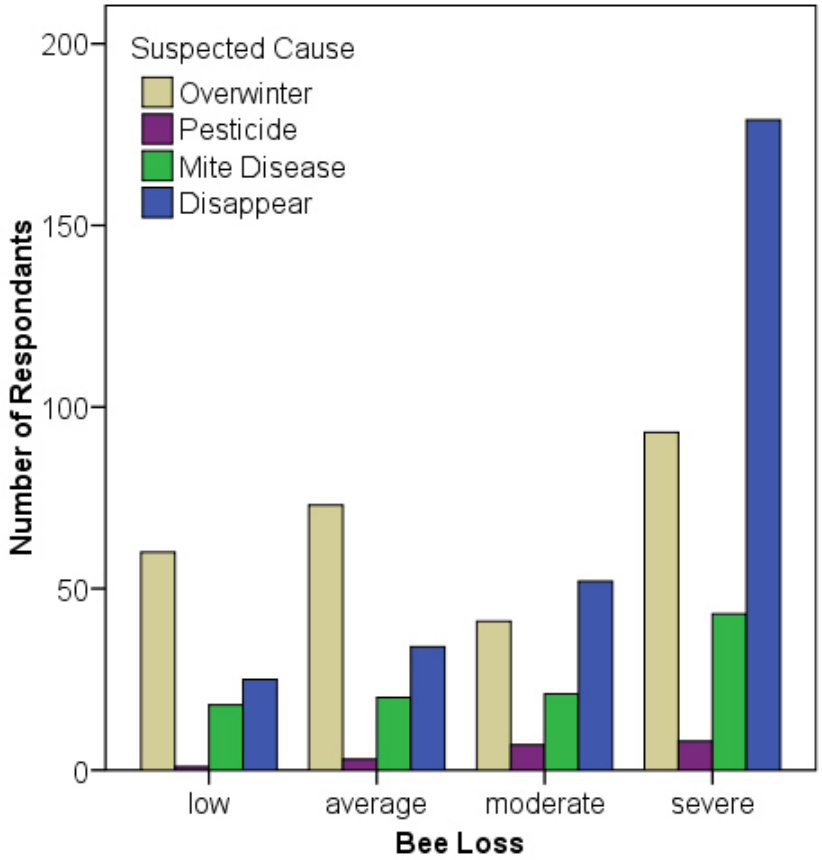

Figure 5. Cause of colony collapse relative to severity of loss as reported by respondents to BeeAlert survey.

The scale and impact of CCD is still striking. Nearly forty percent of respondents report severe bee losses from all causes. In their estimates of total colony loss as a fraction the total, losses in the severely affected group exceed 75 percent on average. By nearly two to one ratio, the implicated cause for these losses was CCD.

Type of Syrup Fed:

Many of our respondents do not feed their bees. Of those who fed (Figure 6), a small percentage used drivert, with sucrose used by about twice as many beekeepers as high fructose corn syrup. Comparing incidence of CCD versus syrup type, about half the beekeepers who fed sucrose or drivert experienced CCD. Those who fed high fructose corn syrup had a somewhat higher likelihood of their bees getting CCD (~16% versus 11%). However, it is clear that sucrose and drivert did not provide protection against CCD, and the majority of beekeepers experiencing CCD did not use high fructose corn syrup.

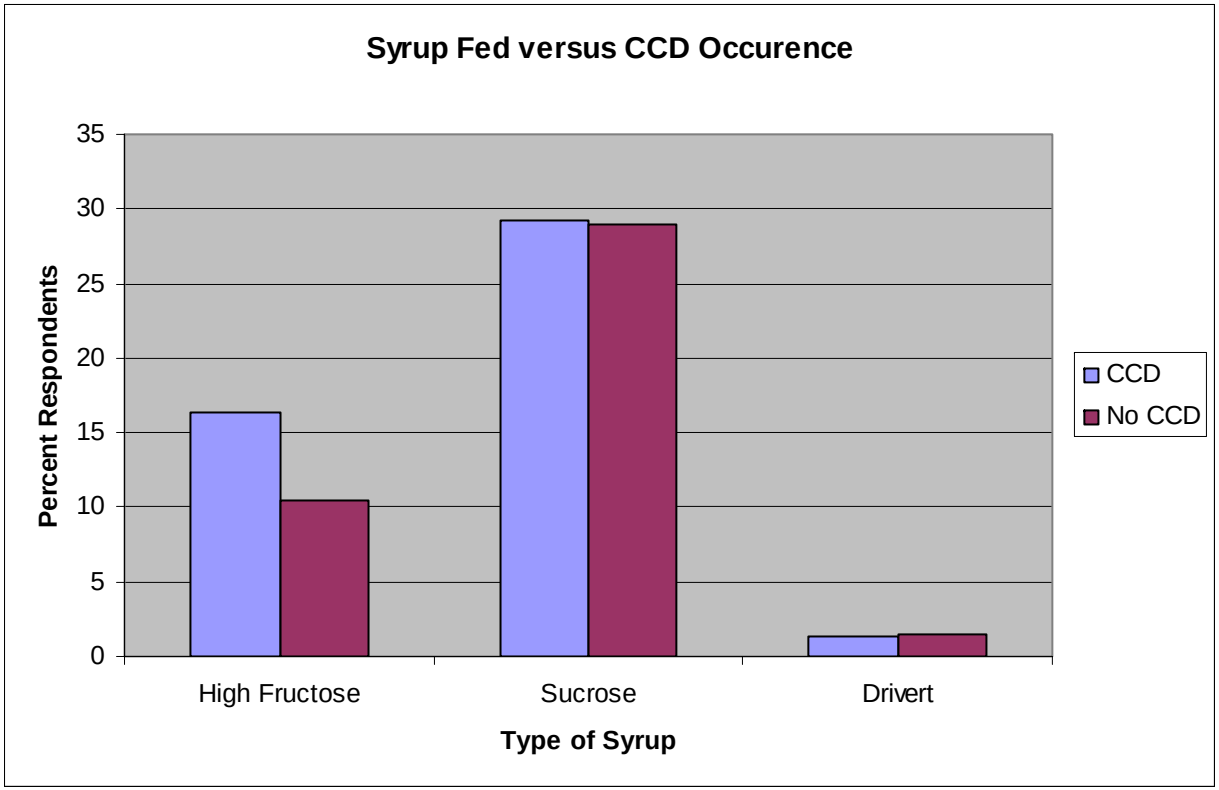

Figure 6. Frequency of CCD relative to feedstocks. The majority of the survey respondents did not feed syrup.

Pathogen Correlation Analysis Results:

One of the postulated causes for the emergence of CCD that has been put forward is an interaction among currently prevalent pathogenic agents. Under this hypothesis, the cumulative effects of a combination of otherwise less lethal agents might be responsible for the phenomenon.

We asked for more details about pest and disease conditions that were observed in failing colonies. The pathogens for which we surveyed included:

> Varroa mites, tracheal mites, American foul brood, European foul brood, Nosema, chalkbrood, purplebrood, stonebrood, sacbrood, viruses (DWV, APV), hive beetle, and wax moth.

Respondents were asked to record the intensity of infestation of each agent on a four-point scale. We performed Pearson rank-correlation among each of these agents and with the occurrence of CCD (Table 2).

Given the high number of respondents, we selected the subset of cases that reported severe losses and also reported on the presence of the pathogens listed above (N=249). The most frequent pattern of significant correlation was a positive co-occurrence of related pathogens.

For example, as evidenced by Table 2, *Varroa* and tracheal mites appear to occur together as do related bacterial and viral agents. Even given adjustment for multiple pairwise comparisons, the level of significant co-occurrence of pathogens was striking.

For all that, even more striking was the complete absence of any correlation between CCD and any specific pathogenic agent. There was one nominally significant association with CCD—tracheal mite ($P = 0.041$, $r^2 = 0.13$).

However, given the high number of comparisons made and the low correlation, the tracheal mite, CCD relationship appears to be an artifact. It is also surprising that this pathogen was indicated, inasmuch as tracheal mites are difficult to confirm unless the bees have been dissected. Overall, the lack of association between CCD and pathogens appears to be evidence that CCD is not linked to any of the agents listed in our survey, either singly or in combination.

Table 2. Spearman rank-correlations among different pathogenic agents and CCD reported in failing colonies.

		Disappear (CCD)	Varroa Mite	Tracheal Mite	American Foul Brood	European Foul Brood	Nosema	Chalkbrood	Purplebrood	Stonebrood	Sacbrood	DWV	APV	Hive Beetle
Varroa Mite	Correlation	**.003**												
	Sig. (2-tailed)	**.**961												
Tracheal Mite	Correlation	**.130(*)**	.312(**)											
	Sig. (2-tailed)	**.**041	.000											
American Foul Brood	Correlation	**.061**	.161(*)	.173(**)										
	Sig. (2-tailed)	**.**336	.011	.006										
European Foul Brood	Correlation	**.099**	.156(*)	.176(**)	.539(**)									
	Sig. (2-tailed)	**.**119	.014	.005	.000									
Nosema	Correlation	**-.057**	.279(**)	.296(**)	.140(*)	.248(**)								
	Sig. (2-tailed)	**.**368	.000	.000	.028	.000								
Chalkbrood	Correlation	**-.025**	.339(**)	.183(**)	.331(**)	.492(**)	.313(**)							
	Sig. (2-tailed)	.695	.000	.004	.000	.000	.000							
Purplebrood	Correlation	**.098**	.070	.165(**)	.221(**)	.366(**)	.202(**)	.222(**)						
	Sig. (2-tailed)	.122	.272	.009	.000	.000	.001	.000						
Stonebrood	Correlation	**.063**	.128(*)	.161(*)	.234(**)	.528(**)	.153(*)	.350(**)	.711(**)					
	Sig. (2-tailed)	.318	.043	.011	.000	.000	.015	.000	.000					
Sacbrood	Correlation	**.037**	.154(*)	.197(**)	.333(**)	.487(**)	.382(**)	.425(**)	.415(**)	.553(**)				
	Sig. (2-tailed)	.564	.015	.002	.000	.000	.000	.000	.000	.000				
DWV	Correlation	**.107**	.376(**)	.284(**)	.300(**)	.298(**)	.285(**)	.378(**)	.279(**)	.327(**)	.286(**)			
	Sig. (2-tailed)	.091	.000	.000	.000	.000	.000	.000	.000	.000	.000			
APV	Correlation	**.066**	.169(**)	.066	.300(**)	.213(**)	.173(**)	.088	.434(**)	.265(**)	.259(**)	.350(**)		
	Sig. (2-tailed)	.296	.008	.300	.000	.001	.006	.164	.000	.000	.000	.000		
Hive Beetle	Correlation	**.089**	.165(**)	.073	.109	.194(**)	.095	.100	.129(*)	.143(*)	.224(**)	.249(**)	.276(**)	
	Sig. (2-tailed)	.162	.009	.249	.087	.002	.134	.115	.042	.024	.000	.000	.000	
Wax Moth	Correlation	**.039**	.136(*)	.177(**)	.117	.170(**)	.197(**)	.245(**)	.137(*)	.073	.207(**)	.089	.044	.263(**)
	Sig. (2-tailed)	.543	.032	.005	.064	.007	.002	.000	.031	.248	.001	.163	.485	.000

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Map of CCD:

We have exact locations for many of the CCD reports, and these are recorded in a RichPoint database that includes the location and associated data. The database is linked into Google Earth, so that the user can examine each site in the context of its geographical surroundings (i.e., aerial photograph). The location referenced database is intended for use by investigators working on CCD.

Our published CCD maps are deliberately vague in terms of beekeeper location. We found that many beekeepers will not answer a survey, if specific data about their day to day bee operations is released. Their concerns are about possible damage to their reputations as good beekeepers and possible loss of income. For example, growers may not rent bees from a beekeeper who has severe CCD or who runs bees in an area with CCD, and purchasers of queens and packages of bees would have similar concerns.

The following map (Figure 7) depicts those states for which we have reports of CCD over the past 16 months. To date, we have received surveys from beekeepers in 43 states. As of June 1, 2007, we had reports of CCD occurring in 35 states, with at least one report of CCD in 7 additional states (not shown on the map). Also, we have several reports of CCD in Puerto Rico. Interestingly, Wilson and Menapace (1979) published a map of Disappearing Disease in the United States in 1975 that encompassed 27 states. Disappearing Disease is similar to, if not the same as CCD. Interestingly, two regions that did not report disappearing disease in 1975, and so far have not reported it in 2007. These are the maritime states of the northeast, and the arid lands of the southwest.

Percent Charts:

Our results show similar trends, but may not always agree with the findings of the surveys conducted by the Apiculture Inspectors of American (AIA) (in Press, ABJ) and the Pennsylvania Department of Agriculture. Their surveys provide a very detailed report of CCD incidence, primarily from three states (Pennsylvania, Ohio, and Florida, over 60% of the returns). Our surveys cover 43 states, a 16 month period, and as such provide wider area, national level coverage. Based on the frequency of survey reports submitted by state (Table 1) to us, no one region dominated our survey data.

We chose to present our survey results in terms of the numbers of respondents so that our readers would have access to the actual numbers of respondents by size of beekeeping operation, suspected cause, and severity of bee losses. We have noted that beekeepers and researchers like to compare numbers and extract information so that they can make their own estimates and decisions.

However, reporting by number of respondents can make it somewhat more difficult to envision trends. The results have to be carefully considered since the number of respondents by category may vary widely. Therefore, we are including the following three charts that summarize severity of colony loss relative to size of operation (Figure 8), general suspected cause of colony loss relative to operation size (Figure 9), and suspected cause of loss relative to severity (Figure 10) displayed as the percent of respondents, rather than the actual numbers of respondents.

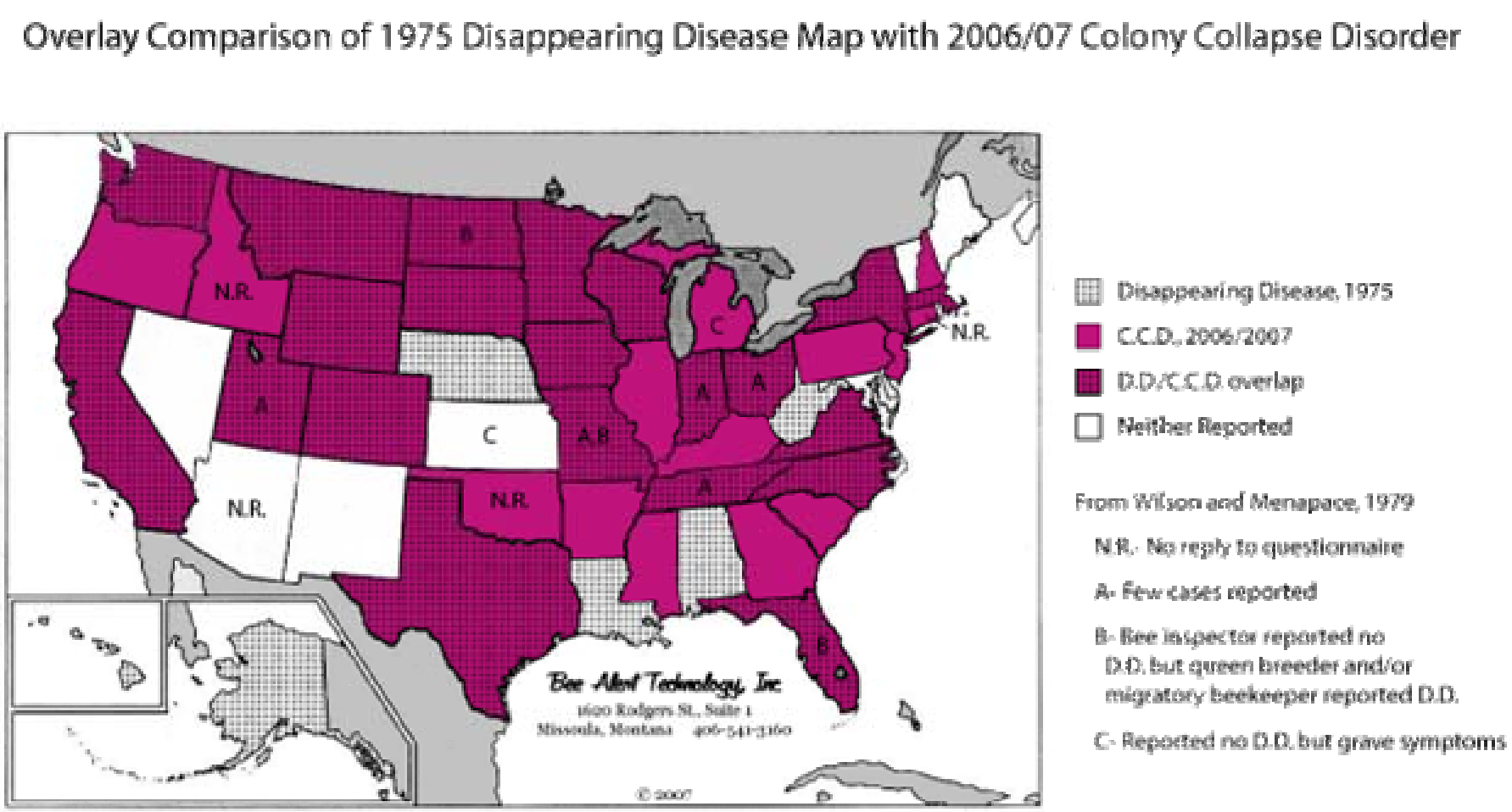

Figure 7. Overlay of 1975 Disappearing Disease Map (from Wilson and Menapace, 1979) with CCD Affected States in 2006/2007 as of June. Wilson and Menapace based their survey on bee inspector reports. By June 1, we had reports of CCD in 35 states plus Puerto Rico, with preliminary reports from 7 additional states.

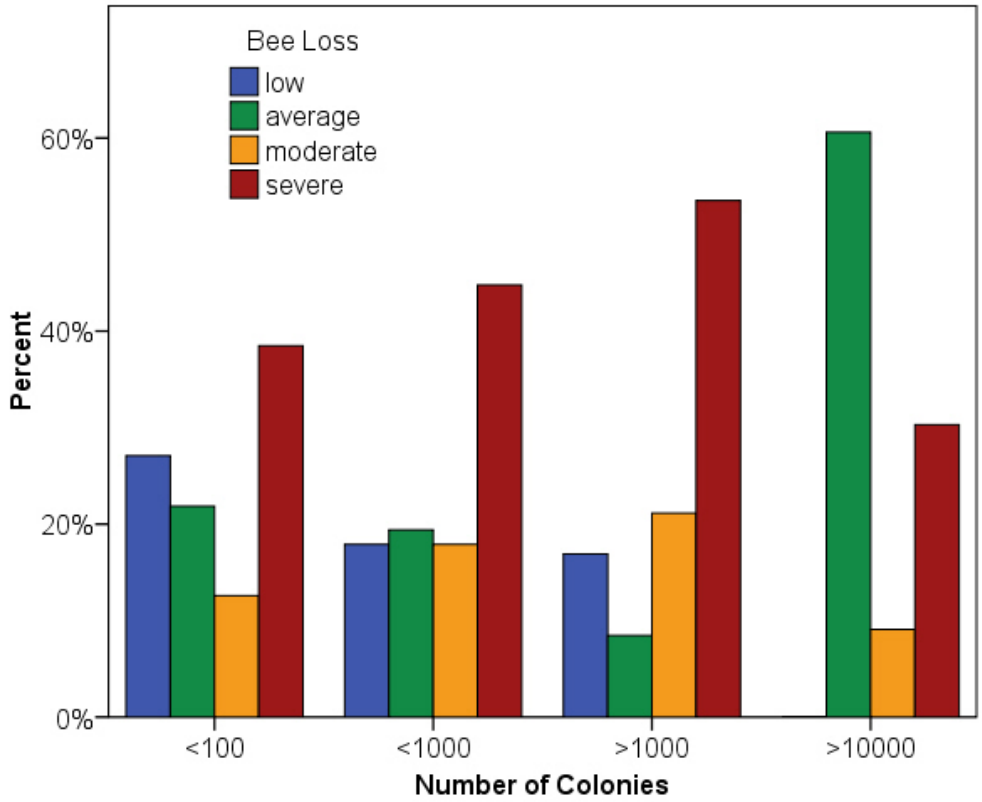

Figure 8. Severity of colony loss relative to size of operation plotted as a percent of the number of beekeeper reports.

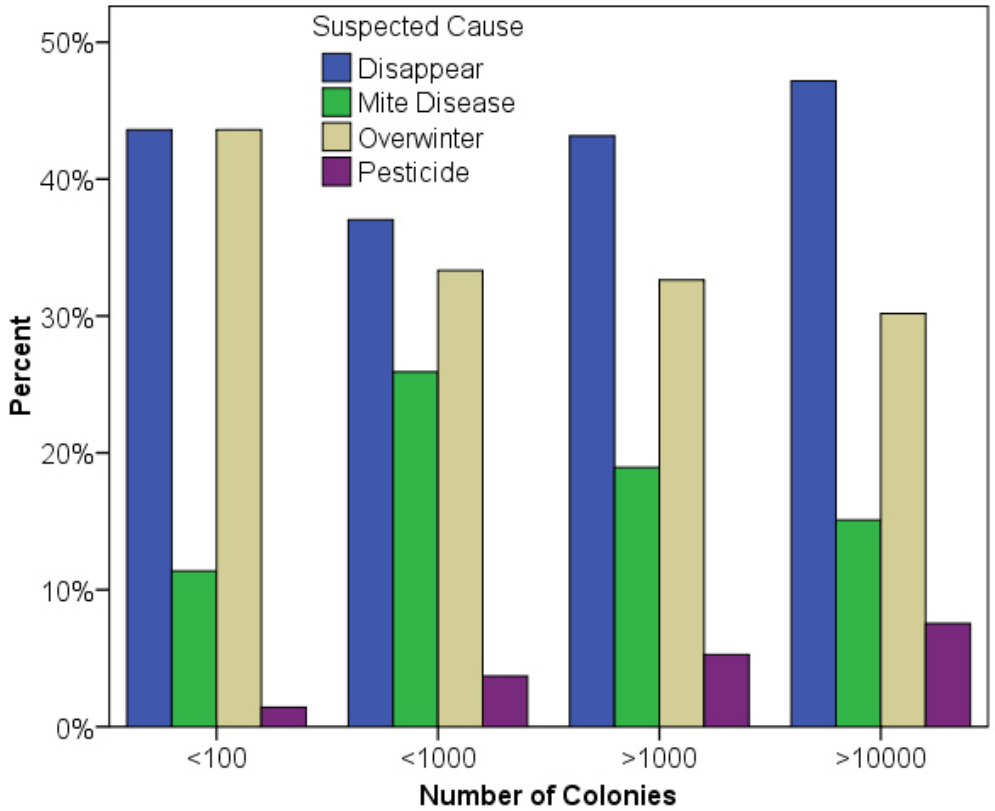

Figure 9. General cause for colony loss relative to operation size plotted as a percent of the number of beekeeper reports.

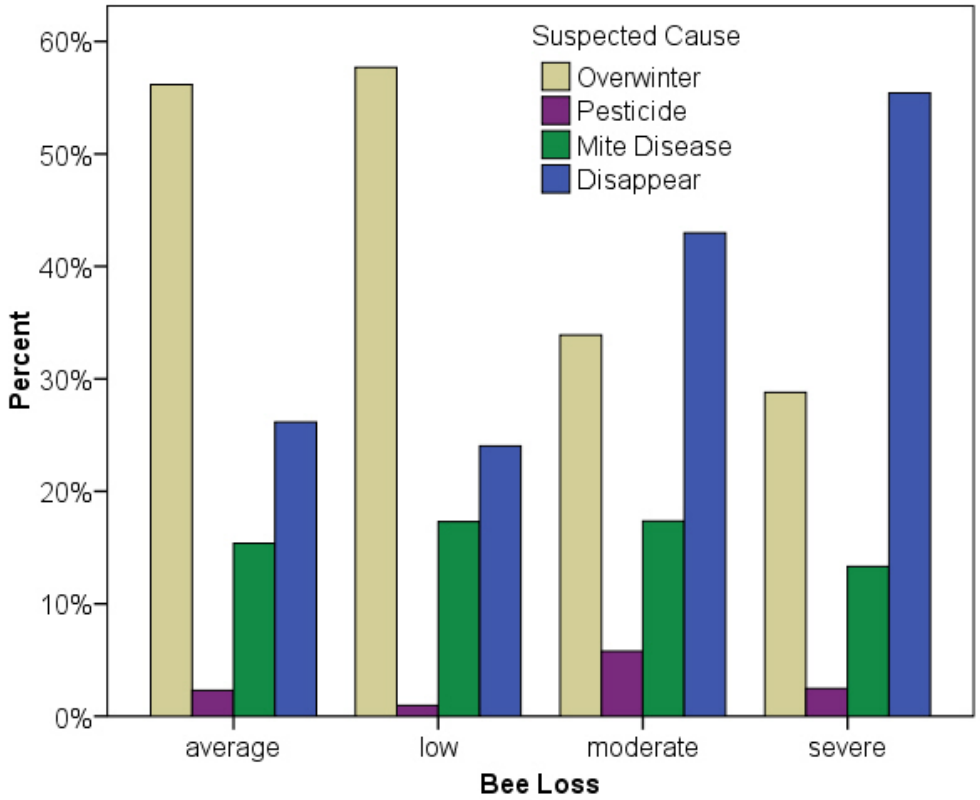

Figure 10. Suspected cause of colony loss relative to severity of loss size plotted as a percent of the number of beekeeper reports.

Future Survey Work:

We are continuing to extract information from the more than a quarter million answers to our surveys. We're currently looking at medications used, which is a complex task given the diverse array of management practices, ranging from organic beekeepers to those who use multiple materials in attempts to control or treat for diseases and mites. All in all, we are impressed by the candor of our reporting beekeepers. Our preliminary observations are that the use of fumagillin and related products to control nosema is on the rise among large scale (>1,000 colony) beekeepers. Also, some organic beekeepers have experienced CCD.

As of June 1, 2007, we have more or less completed a seasonal cycle. Bees are now in the rapid growth phase of spring, merging into summer. At this time, we are working on revising our survey so that we can capture information that we did not obtain from our initial questionnaire. Since CCD or disappearing disease has a history of vanishing before it can be resolved, we ask the nation's beekeepers to continue to report on the status of their colonies. We are particularly interested in quickly identifying new or emergent cases of CCD, so that we can investigate and obtain fresh samples. We also want to continue to gather data on all causes of bee losses so that we can obtain a more accurate assessment of the trends and the overall state of health of our nation's bees.

References:

Wilson, W. and D. Menapace, (1979). *Disappearing Disease of the Honey Bees: a Survey of the United States.* **Am. Bee Journal,** March, 184-186, 217.