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March 26, 2007

U.S. National Bee Colony Loss Survey
www.beesurvey.com
Preliminary Findings with Respect to Colony Collapse Disorder (CCD)

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Financial Support for online and field surveys, exploratory research from U.S. Army Center for Environmental Health Research under a U.S. Army SBIR II award; individual beekeepers, and Bee Alert.

Disclaimer: This report presents preliminary information based on analysis of approximately one-half of the surveys returned to date. Increased data coverage and addition of more cases of putative CCD should improve our ability to discern whether pathogenic, management, or environmental factors are contributing to this outbreak. The results, conclusions, and views of this preliminary report are those of the authors and are not necessarily those of any funding agency or individual.

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INTRODUCTION:

To better assess the magnitude of the Colony Collapse Disorder (CCD) problem, we developed a survey questionnaire. The survey began in December 2006, was posted online at www.beesurvey.com in January, and is still ongoing. It also has been distributed at several apicultural conferences and was advertised in March in all of the bee journals in an effort to obtain as wide a cross section as possible of large and small, as well as migratory and non-migratory, beekeepers. Extensive press coverage and spring bee inspections have resulted in a sudden increase of recent submissions.

It is important to understand that the voluntary responses summarized below do not represent a statistically designed sample. It represents a summary of information from those beekeepers who were willing to share information. For example, we have been told by some of the most severely impacted beekeepers, that they are busy trying to save what is left of their operation and haven't had the time to complete the survey. Despite the potential bias that selective reporting may introduce into our data, we expect that as the number of respondents increases, a larger sample size will yield objective insights into factors associated with this outbreak of CCD.

METHODS:

The survey questionnaire that we are using is extensive. Because of the nature of some of the information that is requested, we have kept the identity of participants and their responses confidential, allowing access to data by other researchers only if specifically approved by the participants.

Respondents are asked to share information about the size of their operation, extent of losses and location. They are also asked to report as completely as possible about breeding and stocking history, management practices, disease conditions, crop associations, and chemical exposure. A copy of the survey form is appended to this report, but a summary of topics is listed below.

We should also note that at the time that the survey was being initially developed, CCD was still being referred to as dwindling or disappearing disease. Since the latter term is descriptive and was familiar to beekeepers, we elected to continue to use it on the survey, and we explain CCD/Disappearing Disease in the instructions to the respondent.

Our discussions with beekeepers and members of the CCD working group have generated several working hypotheses that are being investigated for causal links to CCD. We summarize these as follows:

(1) CCD is due to the emergence of a new or newly more virulent pathogen.
(2) Acute or cumulative exposure to new classes of agricultural pesticides is responsible for CCD.
(3) A combination of known pathogens, environmental, or management factors may have precipitated the occurrence of CCD, which may be cyclic, and may have occurred in the past.

Table 1. Summary of topics queried in survey questionnaire distributed to North American bee keepers.

Data Subject	Details
Movement	Whether local, regional, or national
Estimated Loss	Extent and timing of colony loss
Location of loss	State or Province and region
Honey bee breeding	Queen race, source, and colony replacement activities
Colony conditions surrounding loss	Health of colonies and symptoms observed before and at time of loss
Environmental conditions surrounding loss	Weather, agricultural and industrial
Agricultural conditions surrounding loss	Crops used as pollen and nectar sources, primary and adjacent to colonies
Food resources	Natural and supplemental feeding activity
Disease history	Extent and timing of incidence of currently known colony pathogens and parasites
Medications	Type and timing of chemical applications, both approved and off-list
Pesticide exposure	Observations of type and timing of any pesticide applications at site of loss

The hunt for specific pathogen or pesticide effects is being conducted by several of the research teams in the CCD working group, notably Pennsylvania State University, the Pennsylvania Department of Agriculture, the USDA ARS bee laboratory at Beltsville, and Bee Alert. Personnel help for field sampling has been provided by the state agricultural departments of Pennsylvania and Florida. Additional virus and chemical analyses are being coordinated by Biological Virus Screening, Inc. in cooperation with Bee Alert.

The volume of data that is being collected is extensive and the structure of the data set is complex. The categorical nature of much of the data requires substantial recoding and manipulation into different subsets for analysis. Furthermore, the number of respondents is increasing steadily.

Because of the complexity of the analysis and ongoing data accumulation, refined analyses are not complete. They will be submitted as they are completed, but even then will be subject to revision as the data base grows. In this report we submit some preliminary findings, based on our initial explorations of key areas of interest. To date we have received nearly 400 responses to the survey, over half of which have yet to be statistically processed.

In the following discussion, statistical summaries are based on the first 221 responses; the Tables and Figure 1 on 411 surveys received. Respondents include mostly intermediate and smaller scale operators, but we have also received data from a number of large commercial bee keepers (Table 2). Eighty percent of our respondents operate fewer than 1,000 colonies

Table 2. Frequency of survey respondents by number of colonies owned.

Number of Colonies	Frequency	Percent	Cumulative Percent
<100	272	66.3	66.3
<1000	52	12.7	79.0
>1000	50	12.2	91.2
>10000	36	8.8	100.0

Table 3. Reported severity of bee Loss submitted by bee keepers responding to CCD survey.

Severity of Loss	Frequency	Percent
low	88	21.5
average	103	25.1
moderate	48	11.7
severe	171	41.7

Table 4. Reported number of colonies lost submitted by bee keepers responding to CCD survey.

Number of Colonies Lost	Frequency	Percent
none	169	41.2
< 10	171	41.7
< 500	48	11.7
> 500	24	5.9

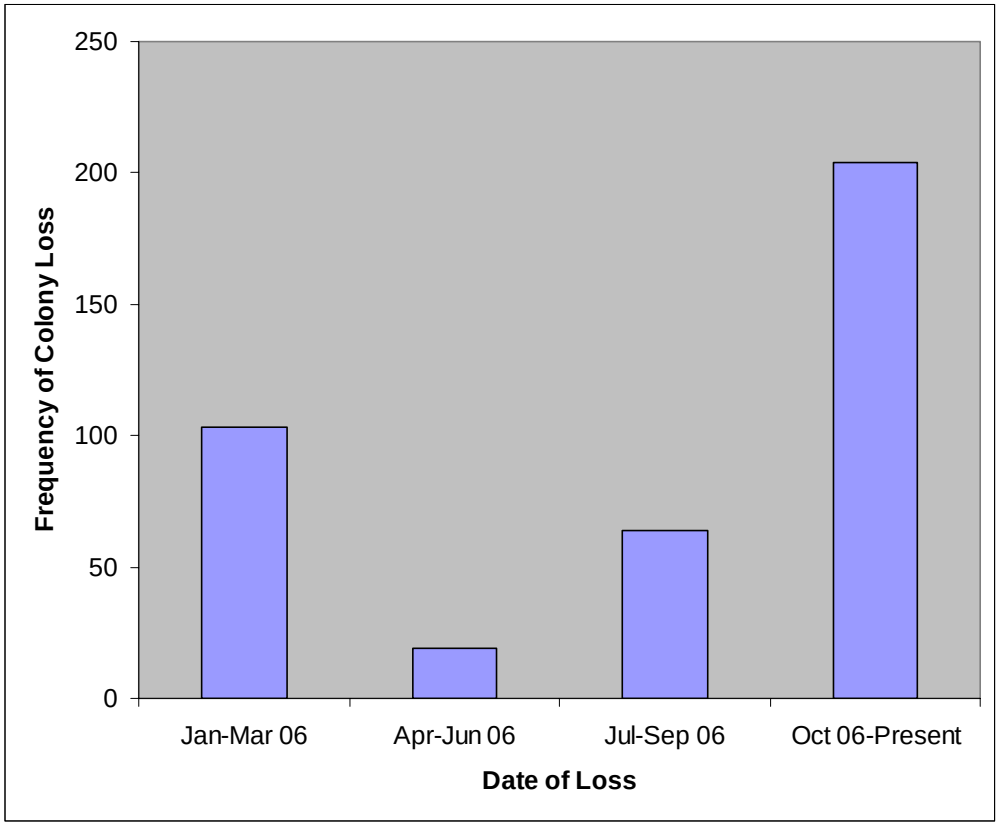


Figure 1. Frequency of Colony Loss by Time of Year. The last SURVEY period is twice as long as the rest – we did not anticipate continual receipt of surveys when we released the survey in December, 2006.

Table 5. Frequencies of loss occurrence due to different implied causes, as categorized by beekeepers. Data are cross tabulated by loss severity and size of operation.

		Number Of Colonies in Operation			
Bee Loss	Cause for Loss	<100	<1000	>1000	>10000
low	none	27	0	3	
	overwinter	28	9	6	
	pesticide	0	0	1	
	disappear	10	2	2	
	mite/disease	8	6	3	
	multiple causes	5	6	4	
average	none	17	2	0	13
	overwinter	34	8	2	6
	pesticide	1	1	1	0
	disappear	17	5	1	3
	mite/disease	6	8	1	2
	multiple causes	10	7	1	2
moderate	none	3	0	1	0
	overwinter	12	4	5	1
	pesticide	0	2	1	0
	disappear	21	2	5	2
	mite/disease	5	1	3	2
	multiple causes	9	3	4	2
severe	none	4	2	2	0
	overwinter	41	7	10	2
	pesticide	3	0	2	2
	disappear	73	20	20	10
	mite/disease	17	6	8	2
	multiple causes	27	8	12	3

We tabulated severity of loss by beekeepers' suspected cause and size of operation (Table 5). Initial impressions about causes as reported by respondents are that multiple factors for colony demise were most frequent in smaller operations numbering less than 100 colonies. The highest number of disappearance syndrome (CCD) also occurred in small operations where it was the single biggest cause for severe loss. Nonparametric correlations showed that none of the patterns in Table 5 are significant ($P > 0.05$).

A more detailed summary of pathogen incidence included a list of fourteen different agents. Information collected included nearly all parasitic, fungal and bacterial agents. Frequency of occurrence of each pathogen (as identified by beekeepers) at different severities of colony loss showed no distinct patterns (Table 6).

As expected, *Varroa* and tracheal mite infections were common to all loss categories. Several other pathogens like *Nosema* and chalkbrood were less common, but prevalent at average loss rates. Correlation analysis of each pathogen with the various levels of colony loss failed to indicate any significant associations.

Table 6. Honey Bee pathogen frequency as categorized by beekeepers at different levels of colony loss.

Pathogen	Colony Loss				
	low	average	moderate	severe	Total
varroa	6	73	38	119	236
tracheal	31	37	18	51	137
American foulbrood	9	15	6	30	60
European foulbrood	6	6	4	22	38
nosema	11	24	11	28	74
chalkbrood	17	24	12	43	96
purplebrood	1	2	1	6	10
stonebrood	4	4	1	6	15
sacbrood	5	6	1	10	22
dwv	24	27	15	51	117
apv	4	8	2	12	26
hiveBeetle	20	28	11	36	95
waxMoth	29	32	15	51	127
African	3	3	3	5	14

Preliminary multivariate ordination also failed to indicate any combination of diseases that were prevalent in severely affected colonies. The ordination was performed using binary cluster analysis. The grouping of different respondents, labeled by severity of loss showed no clusters that were significantly different from others ($P > 0.05$), and none of the clusters were defined by severity of loss.

DISCUSSION AND CONCLUSIONS:

When Losses were tabulated across respondents (Table 3), slightly more than half (53.4%) reported moderate or greater bee losses. Of these cases, 171 or 41.7% reported severe losses.

However, because approximately 66% of the beekeepers surveyed kept less than 100 colonies, and because slightly less than half (46.6%) reported low to average bee losses, colony losses were mostly less than 10 per keeper (Table 4).

By contrast, we have reports of individual, large scale beekeepers who have lost as many as 8,200 colonies. Based on recently submitted reports from ten operations in the 1,000 to greater than 10,000 colony size, the average loss was 1,800 colonies.

We conclude from the initial summary of the survey data that there is no obvious cause for differences in bee losses by size of beekeeping operations. For the smaller beekeeping operations, early results indicate a low incidence of disappearing disease in those operations reporting low to average bee losses. For these same operations, the predominant reason attributed to bee loss was overwintering death.

For those small beekeepers reporting moderate to severe losses, the proportion of reports of disappearing disease or CCD increased dramatically. For beekeepers reporting severe losses, CCD was cited as the most common symptom, including all scales of beekeeping from less than 100 colonies to more than 10,000.

It is clear to us that the survey results to date provide do not indicate a single causal pathogen for CCD. In addition, there is no evidence for any specific combination of pathogens or cumulative effects of multiple pathogens among those we documented as a possible causative agent for CCD.

If a pathogen is the agent responsible for CCD, it is likely that it will either prove to be a new organism or something not identified in our list of potential pathogens. We also need to note that reports of the possible causal agents addressed in the survey rely on self-diagnosis by beekeepers.

Our survey data, while unable to confirm pathogen or toxic exposure as the cause of CCD, should nevertheless show whether there are patterns suggestive of pathogen or pesticide involvement. Some bee pests like varroa mites are relatively easy to detect and quantify. Others like tracheal mites and Africanized bees require laboratory diagnosis and verification.

There still remains the issue of management and environmental factors as causative agents. Either individually or in concert with pathogens, they may be linked to CCD. We are currently analyzing those data and will report on them as we complete the analysis.

It should be noted that we continue to increase the size of our data base. More than 200 new surveys have recently been added, bringing the total to over 400 in the last few days. Many of these reports included surveys completed by large, migratory beekeepers. Their input is critical for a more complete and accurate statistical analysis of factors contributing to CCD.

MAPPING

Bee Alert and Lupine Logic are conducting mapping of affected beeyards on two different scales. For use by the investigative team, all reported locations are entered into a RichPoint data base. This database allows us to enter information in any digital format, from text to photographs and video, as well as sound files. It is also linked to Google Earth.

The members of the CCD Working Group are asked to provide their data, so that it can be entered into this common database. Access to the database is via client servers that are login and password protected.

For reasons of confidentiality, this database is not available to the general public. In addition, survey respondents are asked to indicate whether we can share specific information, and if so, by whom. Interestingly, the most common restriction is that we not share information with state regulatory agencies.

We periodically issue an updated map of states reporting CCD. Again, to protect confidentiality, we shade in entire states and do not provide names of affected beekeepers, unless authorized to do so by the beekeeper.

It must be kept in mind that this map reflects areas where CCD has been reported over a 17 month period. Although the map now shows 27 affected states, that does not mean that CCD is happening in all states at the same time.

As revealed by the surveys, our own visits to affected states to inspect and sample bees, bees, and numerous conversations with the nation's beekeepers, it appears that CCD began to show up in the spring of 2006 in areas like Michigan, Wisconsin, and Iowa, although at the time, most of the losses were attributed to unusually high overwintering death.

By early summer, states like the Dakotas and others across the heartland began reporting CCD. Again, unusually hot, dry weather in some of these areas was initially thought to be the cause of colony failure. That may well be true, but in some of the cases, colonies were displaying CCD symptoms before the weather event.

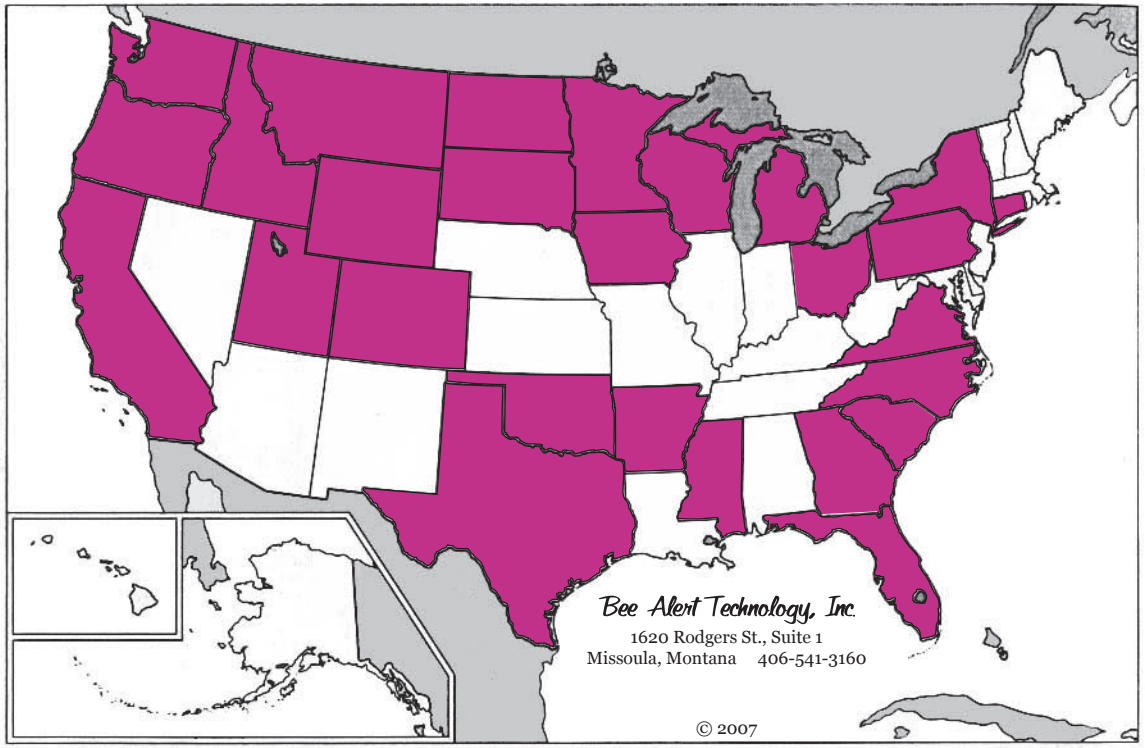
In August, 2006, it began to be seen in Florida and Georgia. By late fall, it had achieved national status, when it was reported and investigated in several southeastern states. Because there were no existing statistics, it was assumed that the cases in the southeast were the first to be seen, and the first reports of findings called this fall dwindling disease.

In December, in response to requests by beekeepers, Bee Alert sent field personnel to Pennsylvania, Georgia, Florida, and California. In a conference call, we discovered that each of us was hearing about earlier incidents of the disorder and about other states. That prompted us to launch a national survey. By January, during the national bee meetings, we began to get telephone calls from beekeepers in California. Over the last three months, major bee losses have occurred in California, Oklahoma, Texas, Oregon, and Washington. Most of these cases display symptoms of CCD.

Most recently, we've begun to see collapses of apparently strong colonies – with frames of fresh pollen, lots of nectar/honey, and 3-5 frames of new and capped brood. These have occurred in both the eastern and western states.

This brings us to another caution when viewing the map? Just because a state is not colored in does not mean that it does not have or has not experienced CCD. Many of the unshaded states are listed as undecided in our database – too few reports or questionable symptoms. Our maps change almost weekly, as we receive new information.

Bee Alert intends to continue these mapping exercises. We'd like to move into a long-term reporting and monitoring mode, providing information to the beekeeping industry about trends across the nation and with seasons. We are hoping that patterns will begin to appear that will help us and the industry identify emerging problem areas or identify locations that may warrant further examination. For example, are there areas where specific pathogens or pests are particularly common, severe, or cyclic? Are there any areas where CCD is not found? What are the actual bee losses for any given region or time of year?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