



HONEY BEE HEALTH IN CRISIS:



ASSESSING COLONIES AND PREDICTING SURVIVAL

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Abstract

Separation of plant protection product (PPP) effects on bees from infectious and non-infectious disorder effects requires comprehensive full colony assessments, and evaluation of the impact of single and multiple factors. A Colony Condition Assessment and Survival Prediction Analysis (CCA/SPA) approach has been used with apparent success in several locations in Canada and the US since 2003. Thresholds and interaction considerations used by CCA/SPA help sort out the potential implications of multiple stressors. When colonies die from Multiple and Various Causative Agents Syndrome (MVCAS) the cause is often considered mysterious and this leads to various allegations of what caused the losses. CCA/SPA can determine the most likely causes, and survival prediction takes the mystery out of why bees are dying. Brood success measurement is also a useful tool for determining PPP and environmental effects on bees. Using a brood overlap matrix and very precise brood age classification it is possible to accurately determine and directly compare brood develop times and success rates for control and test colonies. Time of brood replacement can also be determined from the matrix.

Introduction

Certain effects of plant protection products (PPP) on honey bees may appear very similar to effects of infectious and non-infectious disorders (Figure 1). Without question, there are cases where PPP have killed bees, especially when used incorrectly and without consideration when bees are present. Some studies have attempted to measure sub-lethal side-effects related to extreme low-doses of certain PPP. However, there is no evidence to-date that links any single PPP to the massive bee losses that are taking place in many countries. So what is the cause of deteriorating bee health and substantial colony losses? To gather evidence to answer this question, a system for assessing a comprehensive array of factors that affect honey bee health was developed. The system also utilizes provisional thresholds and interactions to predict the impact of various factors on colony survival. The colony condition assessment (CCA) and survival prediction analysis (SPA) approach has been continually refined since 2003. This paper highlights some of the key methods and results of this work.



Laboratory analysis

- Multi-purpose analysis of bees → number of *V. destructor* per 100 bees, percent of bees infected with *Acarapis woodi*, number of spores of *Nosema* spp per bee & *Nosema* species identification.
- Confirmation of American foulbrood using Vita® AFB diagnostic kit.

Survival prediction analysis

Provisional thresholds

- Four levels of provisional thresholds established for each factor to reflect impact of that factor on bee health (Table 1)

Prediction model

- Considers interactions → cumulative and synergistic stress effects from multiple factors. Stress vessel theory is basis for determining influence of multiple stressors (i.e. capacity for stress is constant & cumulative stressors exceed capacity).

Results & Discussion

CCA Summary for 2006/2007

- V. destructor* in almost every colony at mean level (9/100 bees) above the lethal threshold of >8 VM/100 bees. Resistance to fluralanate and coumaphos well established in some areas.
- American foulbrood epidemic in some areas and resistance to oxytetracycline not uncommon

- Deformed-wing virus common and responsible for 20% of bee mortality in one study
- Chalkbrood common even in summer colonies
- K-wing common (Does K-wing have any diagnostic value?)
- Small hive beetle common in some areas & range expanding
- A. woodi* common; in one study all summer colonies infected (4-20% of bees in each colony).
- Nosema* spp found in 40% of summer colonies at up to six million spores per bee. Most *Nosema* finds *N. ceranae* (Williams et al, submitted). Preliminary spring 2007 counts up to 50 million spores per bee.
- Also common in some areas: black bees (CPV), bald-brood (?), beekeeper applied concoctions.
- Normal brood success appears to be in 90-95% range. Detected a possible lengthening of worker brood development time in one study. If true, this would favor more rapid population build-up of *V. destructor*. Time of brood replacement correlated well with timing of treatment. Only very young larvae were removed. Brood success returned to normal within 2-3 days.

Survival predictions

- Colonies predicted to have no chance of surviving winter ranged from 25-100% since 2003 → Actual losses ranged from 38-100% (Figure 4)
- 50% or more of colonies with a poor chance of survival did not survive until spring
- Very few colonies assessed with good chance of survival

Factors contributing to predicted mortalities

- Many factors contributing to colony losses → No single factor, or single combination of factors responsible (Figure 5)

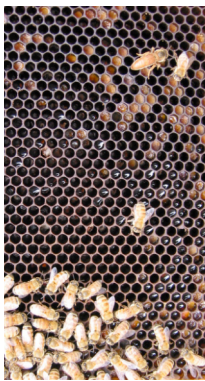


Figure 2. Drop-zone dead-bee trap for monitoring bee mortality (based on Accorti et al, 1991).

Figure 1. A queen and a handful of workers, PEI, Canada, 2002. This case linked to poor management, nutritional deficiency, & exposure to phosmet.

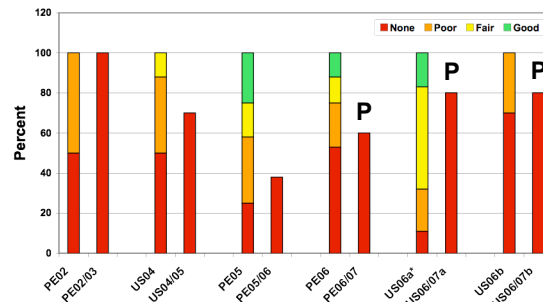


Figure 4. Honey bee colony mortality over winter was predicted using CCA/SP. Results are strongly correlated with actual reported colony losses. Very few colonies assessed with good chance of surviving winter. P = preliminary, * = early summer assessment.

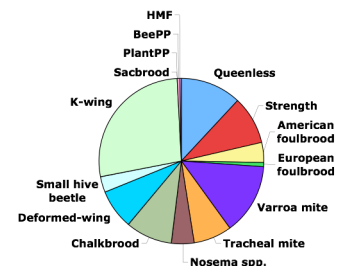


Figure 5. Relative proportion of incidence of factors in colonies predicted to have no chance of winter survival.

Materials & Methods

Colony condition assessment

Colony assessment in field

- Strength of colony → area of comb covered by adult bees, capped brood, open brood, honey, and pollen; queen status (presence of eggs, visual sighting of queen)
- Health of colony → quantitative measurement of American foulbrood, European foulbrood, chalkbrood, sacbrood; presence of Varroa, deformed-wing condition, small hive beetle, K-wing, bald-brood, black bees, unusual behavior, other disorders

- Bee mortality & deformities → number of adult and pupal normal winged versus deformed-wing dead bees per day; based on counts from drop-zone dead-bee traps (Figure 2)

- Brood effects → brood cycle duration, percent success, time of brood replacement; brood overlap matrix (Figure 3) assists with these determinations

- Varroa destructor resistance to miticides (start test in field and end in lab)

- Sample bees, honey, pollen, and wax for residue screening

- Sample bees from side of brood comb for multi-purpose laboratory analysis

Cycle Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Time	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	T20	T21
Stage	E1	E2	E3	L1	L2	L3	L4	L5	L6	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	A1	
2	X	E1	E2	E3	L1	L2	L3	L4	L5	L6	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	A1
3	X	E1	E2	E3	L1	L2	L3	L4	L5	L6	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	A1
4	X	E1	E2	E3	L1	L2	L3	L4	L5	L6	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	A1
5	X	E1	E2	E3	L1	L2	L3	L4	L5	L6	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	A1
6	X	E1	E2	E3	L1	L2	L3	L4	L5	L6	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	A1
7	X	E1	E2	E3	L1	L2	L3	L4	L5	L6	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	A1
8	X	E1	E2	E3	L1	L2	L3	L4	L5	L6	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	A1
9	X	E1	E2	E3	L1	L2	L3	L4	L5	L6	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	A1
10	X	E1	E2	E3	L1	L2	L3	L4	L5	L6	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	A1
11	X	E1	E2	E3	L1	L2	L3	L4	L5	L6	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	A1

Figure 3. Brood overlap matrix. E = egg, L = larva, P = pupa, A = adult, X = dead, empty, honey, or pollen. Instructions: Identify and mark locations of 2-day old eggs. Assessing larvae (L1) at T2 is optional, but is useful to verify age of starting egg and possible early brood replacement. The T7 and T8 assessments function as another check for brood replacement and starting age of initial eggs. Pupae at T17 are removed with forceps and the stage of pupal development is determined by eye and body color, pupal activity, and completeness of overall development. If starting eggs are slightly older than E2, then it is likely to extract pupae in the 11th day of development (P11) at T17. If the development is delayed because of temperature or other factors, then apparently younger pupae will be present (P89). Time of brood replacement (TBR) can be determined by reading down the column to the identified stage at T17 and then following back along the matrix row to E1. The corresponding column heading is the time or lifecycle day at which brood was replaced. © R.E.L. Rogers, Wildwood Labs Inc.

Table 1. Stratified provisional thresholds for assessed measurable honey bee disorders (for late summer assessment timing in northern latitudes only). Green = Disorder or condition not apparent or not a concern. Chance of colony survival until spring is GOOD. Yellow = Disorder or condition is present and needs to be managed. If the disorder or condition is mitigated through proper management, then chance of colony survival until spring will improve. However, if no action taken, chance of survival is only FAIR. Orange = A serious problem exists. Extreme management measures are required. If no action taken, chance of colony survival until spring is LOW. Red = Situation is beyond hope and no degree of management will save colony, or colony is already dead. NO CHANCE of colony survival until spring. (Langstroth deep approach, 18 sq dm)

Disorder	Green (fs=0)	Yellow (fs=1 or 2)	Orange (fs=3 or 4)	Red (fs=5)	Units
<i>Nosema</i> sp	0	>0 to 0.5	>0.5 to 1.0	> 1.0	# Spores (x 10 ⁶)/be e
Varroa mite	<1	1-3	>3 to 8	> 8	Mites/100 bees
Tracheal mite	<1	1 to 5	>5 to 15	>15	% of bees infested in a colony
American foulbrood	0	>0 to 0.05	>0.05 to 0.5	> 0.5	Cells / dm ² capped brood
European foulbrood	0	>0 to 0.5	>0.5 to 1	> 1	Cells / dm ² uncapped brood
Chalkbrood	0	>0 to 1	>1 to 2	> 2	Cells / dm ² brood

Conclusions

- Antemortem colony condition assessment (CCA) & survival prediction analysis (SPA) can predict winter mortality
- Provisional thresholds & cumulative stresses are key to colony survival predictions
- Brood success determination, based on the brood overlap matrix method, can detect subtle PPP effects & when the effect took place
- Unmanaged, or poorly managed, honey bee colonies have no chance of survival
- Colonies are dying because of Multiple & Various Causative Agents Syndrome (MVCAS). The combination of factors responsible can be determined by CCA/SPA.

Acknowledgments

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References

Accorti, M., F. Luti, and F. Tarducci. 1991. Methods for collecting data on natural mortality in bees. *Ethol. Ecol. Evol. Special Issue* 1:123-126.

Rogers, R.E.L. (in prep). Investigations of the multiple factors affecting honey bee health. PhD thesis, Wageningen U.

Williams, G.R., A.B.A. Shafer, R.E.L. Rogers, D. Shuttler, and D.T. Stewart. (submitted). First detection of *Nosema ceranae*, a microsporidian parasite of European honey bees (*Apis mellifera*), in Canada and central U.S.A.