WEIGHING RISK FACTORS ASSOCIATED WITH BEE COLONY COLLAPSE DISORDER BY CLASSIFICATION AND REGRESSION TREE ANALYSIS

VANENGELSDORP D. (1,2), SPEYBROECK N. (3,4), EVANS J. (5), NGUYEN B.K. (6), MULLIN C. (2), FRAZIER M. (2), FRAZIER J. (2), COX-FOSTER D. (2), CHEN Y. (5), TARPY D.R. (7), HAUBRUGE E. (6), PETTIS J.S. (5), SAEGERMAN C. (8)

(1) Bureau of Plant Industry, Pennsylvania Department of Agriculture, 2301 North Cameron Street. Harrisburg PA 17110; (2) Department of Entomology, The Pennsylvania State University, University Park, PA 16802; (3) Institute of Tropical Medicine, Nationalestraat 155, 2000 Antwerp, Belgium; (4) Public Health School, Université Catholique de Louvain, Clos Chapelle-aux-Champs, 1200 Bruxelles, Belgium; (5) USDA – ARS Bee Research Laboratory, Bldg. 476 BARC-E, Beltsville, MD 20705 USA; (6) Department of Functional and Evolutionary Entomology, Agro-Bio Tech, University of Liege -5030 Gembloux, Belgium; (7) Department of Entomology, Campus Box 7613, North Carolina State University, Raleigh, NC 27695-7613; (8) Department of Infectious and Parasitic Diseases, Research Unit of Epidemiology and Risk analysis applied to the Veterinary Sciences (UREAR), Faculty of Veterinary Medicine, University of Liege, B-4000 Liege, Belgium. Corresponding author: claude.saegerman@ulg.ac.be

INTRODUCTION

Colony Collapse Disorder (CCD), a syndrome whose defining trait is the rapid loss of adult worker honey bees, is thought responsible for a minority of the large over wintering losses experienced by US beekeepers since the winter of 2006-2007.

MATERIALS AND METHODS

Using the same data set developed to perform a mono-factorial analysis (vanEngelsdorp et al. PLoS ONE, 2009), we conducted a classification and regression tree (CART) analysis in an attempt to better understand the relative importance and inter-relations among different risk variables in explaining CCD. Sixty one explanatory variables were used to construct two CART models: one with and one without a cost of misclassifying a CCD-diagnosed colony as a non-CCD colony.

RESULTS

The resulting model tree which permitted for misclassification had a sensitivity of 100% and a specificity of 67%. While factors measuring colony strength (e.g., frames of bees, bee to brood ratio) and bee physiology (e.g., mass of head, fluctuating asymmetry) were important discriminating values, 8 of the 13 variables having the greatest discriminatory value were pesticide levels in different hive matrices. Notably, coumaphos levels in brood (a miticide commonly used by beekeepers) had the highest discriminatory value and were highest in control colonies.

Classification tree [**Fig. 1**] and ranking by discriminatory power [**Tab. I**] of CCD colony risk factors for CCD colonies without a cost of misclassifying a CCD-diagnosed colony as a non-CCD colony

Fig. 1
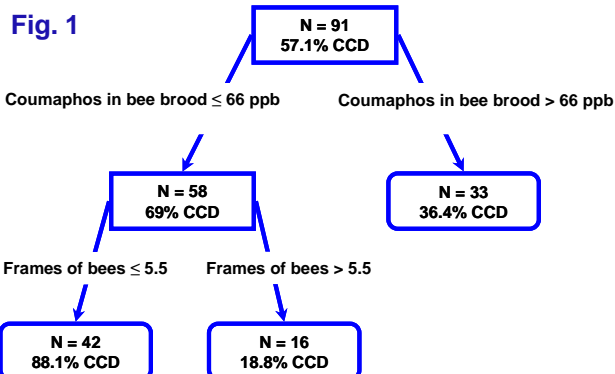
Tab. I

Variable	Power	Variable	Power
Coumaphos in bee brood	100.00	Dicofol in beebread	7.65
Frames of bees	52.80	Chlorothalonil in wax	5.03
Fluctuating asymmetry	46.09	Proteins of abdomen	4.49
Ratio brood/bees	30.79	Frames of brood	3.85
Coumaphos in wax	29.42	Deformed wing virus (DWV)	0.14
Acute bee paralysis virus (ABPV)	10.33		

Classification tree [**Fig. 2**] and ranking by discriminatory power [**Tab. II** ; only the first 13 higher ranks are presented] of CCD colony risk factors for CCD colonies with a cost of 1.8 points for misclassifying a CCD-diagnosed colony as a non-CCD colony

Fig. 2
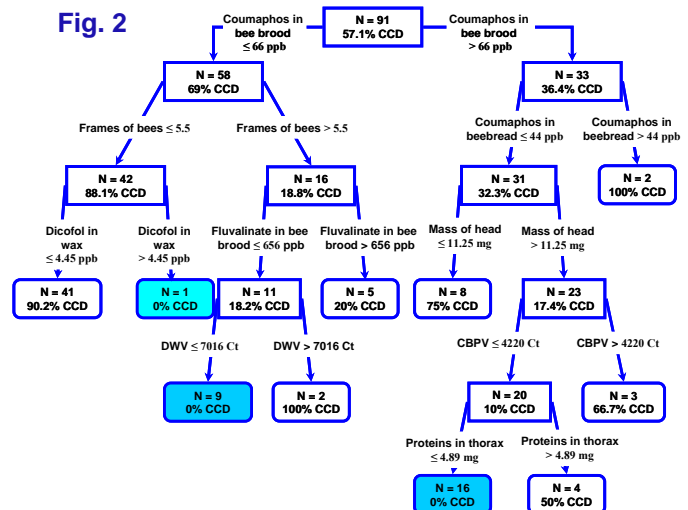
<u>Legend</u>: DWV: Deformed wing virus; CBPV: Chronic bee paralysis virus

Tab. II

Variable	Power	Variable	Power
Coumaphos in bee brood	100.00	Chlorpyrifos in wax	28.92
Coumaphos in beebread	80.23	Esfenvalerate in wax	28.92
Mass of the head	47.01	Deformed wing virus (DWV)	28.85
Frames of bees	44.41	Coumaphos in wax	27.39
Fluctuating asymmetry	42.53	Fluvalinate in bee brood	27.09
Endosulfan in wax	39.87	Ratio Brood/Bees	26.68
Dicofol in wax	39.87		

CONCLUSION

This CART analysis provides evidence that CCD is likely the result of several factors acting in concert, making afflicted colonies more susceptible to disease. This analysis highlights several areas that warrant further attention, including the effect of sub-lethal pesticide exposure on pathogen prevalence and the role of variability in bee tolerance to pesticides on colony survivorship.

ACKNOWLEDGEMENTS

SVEPM, 23-26 March 2010, Nantes, France