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NOTES AND COMMENTS

Colony losses, managed colony population decline, and Colony Collapse Disorder in the United States

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The beekeeping industry in the United States has faced a number of obstacles to healthy bee management in recent decades. These obstacles range from arthropod pests such as the tracheal mite (*Acarapis woodi*), *Varroa destructor* mites, and small hive beetles (*Aethina tumida*) to pathogenic diseases including RNA viruses and the microsporidian *Nosema* spp. According to the National Agricultural Statistics Service (2009), the number of managed honey bee colonies used for honey production in the U.S. has decreased steadily since the late 1940's (Fig. 1).

Even though it is clear that the number of managed colonies in the U.S. has declined over the last half century (Fig. 1), it has been difficult to determine actual yearly colony losses, since beekeepers in the U.S. routinely split (divide) their existing colonies every spring to recover losses they experienced the previous winter. According to vanEngelsdorp *et al.* (2008), surveyed beekeepers losing ~22% (95% CI: 15.9 – 27.5%) of their colonies during the 2007-8 winter, felt that this level of loss was "normal". Despite the replacement of lost colonies through splitting, there was a net loss (-5.81%) in the total number of honey producing colonies from 2007 to 2008 (calculated from data provided by NASS, 2009), thus suggesting that "splitting" colonies is not sufficient to maintain the sustainability of beekeeping in the U.S. This probably has been exacerbated by the introduction of *V. destructor* into the U.S. Before its introduction, the total number of honey producing colonies in the U.S. decreased on average 0.06% ± 0.5 (mean ± s.e.) per year while the rate of decline increased to 1.5% ± 0.7 afterwards. Arguably, this decline reflects both the biological loss of existing colonies and the fact that some beekeepers chose to leave the industry in the face of extra expenses and the efforts needed to combat mite infestations, a trend documented in Europe (Potts *et al.*, 2010).

In fall of 2006, some beekeepers in the U.S. reported losing 30-90% of their colonies and the symptoms associated with the dead colonies did not match those produced by known bee pests / pathogens. Although annual losses above 30% are not uncommon for beekeepers in the U.S., the number of beekeepers reporting elevated losses appeared alarming as did the unique symptoms associated with the colony losses. Consequently, the apiculture community in the U.S. called the new phenomenon of elevated colony losses "Colony Collapse Disorder" or CCD.

In an attempt to remove the ambiguity surrounding CCD, U.S. bee scientists defined some of the symptoms often associated with the phenomenon. In collapsed (dead) colonies, CCD may produce the following symptoms: 1. the complete absence of adult bees in colonies with few or no dead bees in / around colonies; 2. the presence of capped brood; and 3. the presence of food stores that are not robbed by other bees or typical colony pests. CCD symptoms often associated with collapsing (weakening) colonies may include: 1. an insufficient number of bees to maintain the amount of brood in the colony; 2. the workforce is composed largely of younger adult bees; 3. the queen is present; and 4. the cluster of bees is reluctant to consume food provided to them by the beekeeper.

It has been difficult to assess the impact of CCD in the U.S. The Apiary Inspectors of America (AIA) and USDA-ARS estimate that honey bee colony losses for fall / winter 2006-7 and 2007-8 were 31% and 36% respectively (vanEngelsdorp *et al.*, 2007; 2008). These loss estimates were based on telephone surveys of beekeepers, who managed between 10-18% of the 2.4 million colonies in the U.S. Numerous causes, including CCD, were reported as contributing to the colony losses during the 2006-7 and 2007-8 winters (vanEngelsdorp *et al.* 2008). The AIA and USDA-ARS conducted a similar survey for

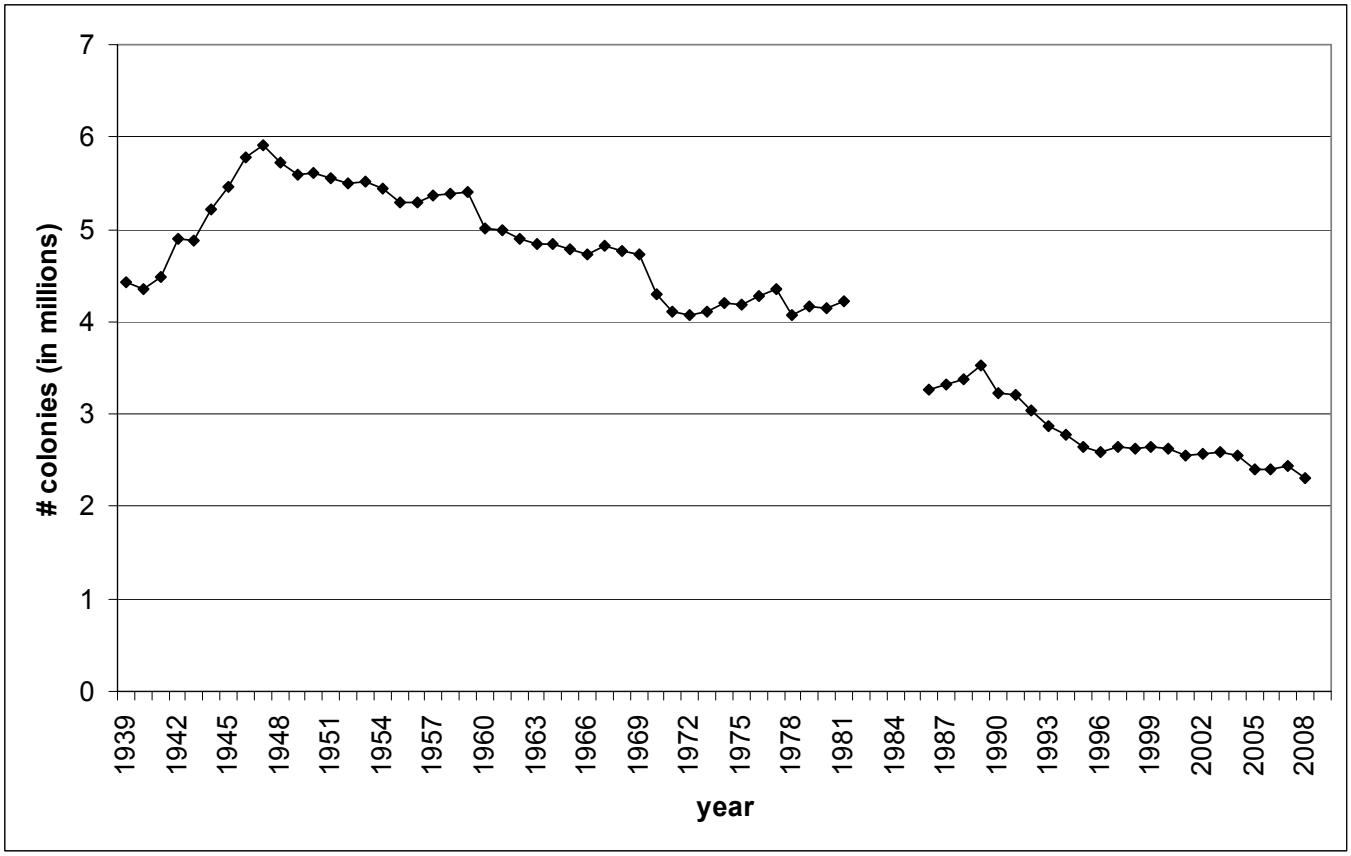

Fig. 1. Number of honey producing colonies in the United States (NASS, 2009). Data were not available from 1982 to 1985 . For colony calculations: 1. the National Agriculture Statistics Service includes honey producers having five or more colonies; and 2. colonies which produced honey in more than one state are counted in each state (NASS 2009). Overall, the number of managed honey producing colonies in the U.S. has declined since the late 1940's when the total number of colonies peaked at almost 6 million.

the 2008-9 winter (vanEngelsdorp *et al*., 2010). Over 20% of U.S. bee colonies were included in the survey with a total reported colony loss of 28.6%. Interestingly, vanEngelsdorp *et al*. (2010) report that only 15% of colonies lost during the 2008-9 winter exhibited CCD-like symptoms. This is down from 60% during the 2007-8 winter. Instead, beekeepers surveyed in 2008-9 reported higher rates of queen loss and losses associated with high mite levels.

The cause(s) of CCD in U.S. bee colonies remains under investigation but are similar to those for colony losses in general. For example, Israeli acute paralysis virus (IAPV) has been found in many samples taken from colonies exhibiting CCD-like symptoms although it is not believed to be the sole cause of CCD (Cox-Foster *et al*., 2007). Similarly, *Nosema ceranae* has become widespread in the U.S. (Klee *et al*., 2007; Chen *et al*., 2008), though its role in colony losses is not understood fully (Paxton, 2010). Consequently, many conceivable and realistic hypotheses remain plausible. Not listed in any particular order, the primary hypotheses include, but are not limited to: 1. traditional bee pests and pathogens (for a listing of bee pests / pathogens present in the U.S., see Ellis and Munn, 2005); 2. how the bees were managed (management stress); 3. queen source (poor genetic biodiversity); 4. chemical use in bee colonies to control bee pests / pathogens; 5. chemical toxins present in the environment; 6. *V. destructor* mites and associated pathogens; 7. bee nutritional fitness; 8. undiscovered / newly discovered pests and pathogens or increasing virulence of existing pathogens; and 9. potential synergistic interactions between two or more of the above hypotheses.

The effects of colony losses in general and CCD specifically in the U.S. are significant, especially considering the increasing demand for pollination (e.g. almonds in California). The value of honey bees to U.S. agriculture has been estimated to be > $US14 billion (Morse and Calderone, 2000), principally through pollination of many of the nation's crops. In fact, it has been shown that a considerable amount of the food we eat comes from honey bee pollination, either directly via pollination of fruit / nut / vegetable crops or indirectly via pollination of cattle fodder crops such as clover and alfalfa or other indirect routes. Consequently, large scale research efforts have begun in the U.S. to determine the underlying cause(s) of colony losses, including CCD, in an attempt to mitigate or slow the rate of losses.

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