Colony Collapse Disorder (CCD)
A Review of the Possible Factors and Agents Involved

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Introduction

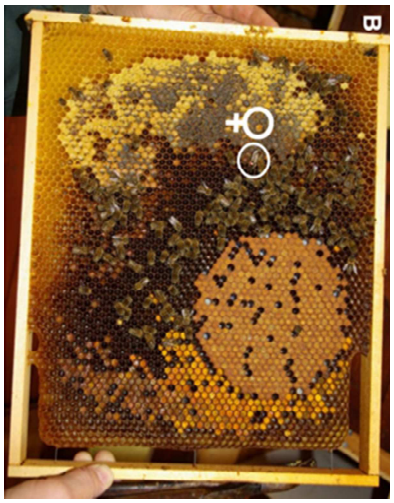
Definition

Colony collapse disorder is a complex phenomenon that affects managed honey bee (*Apis mellifera*) colonies, whose main trait is a rapid loss of adult worker bees. Adult worker bees are responsible of the majority of the hive tasks, so their absence means shortly after the collapse and dead of the colony. CCD has been reported mainly from USA, but also from Europe.

CCD and honey bee colony losses are not synonyms, CCD has a defined set of symptoms and is just one of the causes of colony losses. In the USA during the period 2007-2014 a substantial percentage of winter colony losses (20,5-60%) died with symptoms compatible with CCD.

Symptoms

1. Rapid loss of adult worker bees evidenced by colonies with excess brood population relative to adult bee population. The period of time of this sudden decline varies between 5 days and 3 weeks.
2. Noticeable lack of dead worker bees both within and surrounding the affected hives.
3. The workers that remain are young and the queen is also present. At the final stage there are no adult bees in the hive.
4. Ample food stores (honey and bee bread) in the hive.
5. Delayed invasion of hive pests (small hive beetles and wax moths) and kleptoparasitism from neighboring honey bee colonies.
6. The distribution of CCD-infected colonies in apiaries is not random, CCD colonies are more likely to neighbor each other.



Comb from a hive with CCD
Font: Daniat et al. (2012)

Comb from a healthy hive
Font: Randy, O,.

Possible Agents and Factors Involved

Pesticides

Two types have been associated with CCD: **neonicotinoid insecticides** used in crops, and **miticides** (e.g. pyrethroids and organophosphates) used in beekeeping. They can cause acute lethal effects (when received doses higher than LD50 24-48h) and chronic sub-lethal effects (doses usually lower than LD50/10). A lot of attention has been paid to sub-lethal effects.

Acute lethal symptoms : piles of dead and dying bees accumulate near hives, or sudden decline in the adult population of the colony.
Chronic sub-lethal symptoms: sluggish and paralyzed bees, unable to fly and crawl properly, resting on nearby hive places, unusual aggressiveness between nestmates, greater homing failure in foragers.

Infectious Agents

- ***Varroa* mites (especially *V. destructor*):** cause direct damage to the developing bee by ingestion of hemolymph, and indirect damage by vectoring virus, fungus and bacteria.

  Symptoms: direct observation of the mite, malnourished, deformed bees, smaller than usual, with impaired mobility and inability to fly.

- ***Nosema apis* and *N. ceranae*:** these unicellular fungus cause damage to the gut epithelial cells. *N.ceranae* is more virulent, with a briefer multiplication cycle.

  Symptoms (not always evident): swollen abdomen, diarrhea (*N. apis*), excitability and then lethargy, inability to fly, bees crawling in the hive entrance and trembling on top of the frames.

- **Acute bee paralysis virus (ABPV), Israeli acute paralysis virus (IAPV) and Kashmir bee virus (KBV):** these 3 closely related ssRNA viruses are largely symptomless, but they can be lethal when transmitted by *Varroa* (mechanical vector), causing a systemic infection.

  Symptoms (for ABPV and IAPV): paralysis that progresses rapidly, trembles, inability to fly, darkening and loss of hair from thorax and abdomen. KBV has not any symptomatology associated.

- **Deformed wing virus (DWV):** ssRNA virus normally asymptomatic, but it can be lethal, specially when transmitted by *Varroa* (biological vector), causing a systemic infection.

  Symptoms : bees with crumpled and/or vestigial wings, swollen abdomen, smaller than usual, discolored. DWV also affects sensory response, learning and memory in adults.

- **Iridescent virus (AIV):** dsDNA virus typically asymptomatic, although it can be lethal, causing a systemic infection.

  Symptoms : lethargy, inability to fly, trembles.

Nutrition

Deficiencies of pollen, necessary for synthetize peptides of the immune system, may compromise the capacity of bees to deal with infections. Nutritional imbalances are not well understood.

Symptoms : bees with wings longer than abdomen, lack or little food stores in the hive.

Others

Factors like **climate change** and **stress** have also been told to be relevant, but more research that correlate them with CCD is needed. There are no scientific studies about the implication of other factors, like the harmful effects of mobile phones or genetically modified crops, in the specific case of CCD.

Discussion and conclusions

The final conclusion of all the research done until now is that no single agent or factor is suggested to be the cause of CCD. It is supported by the fact that there is no complete correlation between the symptomatology of any of the possible agents and factors involved and CCD. However, it can not be dismissed that interactions between them result in the concrete set of CCD symptoms, and taking into account that some of them can act synergistically, currently the major trend is to consider that the etiology of CCD is multifactorial.

Nevertheless, there are some limitations in the investigations conducted that should be mentioned: (I) all the analysis and laboratory tests have been done on the remaining bees, not on the vanished adult worker bees, (II) laboratory tests are based on specific diagnosis techniques of known pathogens, and (III) all those studies that look for new pathogens focuses only on genetic analysis of the gut microbiota. Finally, more research about the potential effects of pesticides and nutritional factors in CCD colonies compared to non-CCD colonies is required.