Honeybee Losses and their Causes

Introduction

There has been consistent media interest in honeybees, their importance through pollination on food security, and the potential role of pesticides and other factors in loss of insect biodiversity. The role of pesticides in declines of honeybee populations has primarily focussed on the potential impact of insecticides, particularly neonicotinoid insecticides. Following their use as seed treatments, neonicotinoid residues may be detected in pollen and nectar due to their systemic properties. Detection of these residues has raised concerns about the potential for sublethal effects in individual bees (mainly detected under laboratory conditions), to result in effects on honeybee colonies.

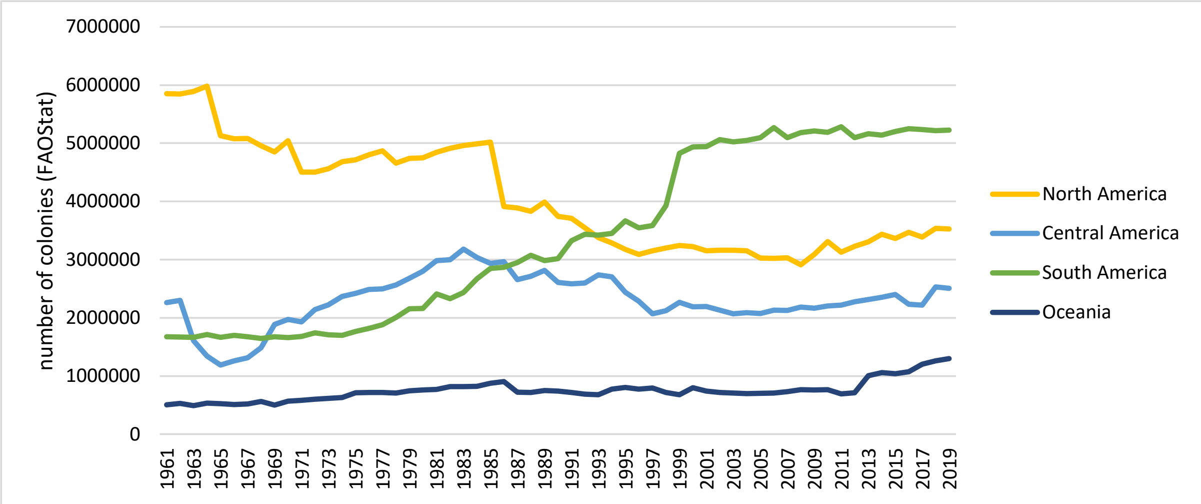
Three of these neonicotinoids (clothianidin, thiamethoxam and imidacloprid) have not been approved for use outdoors in Europe since 2018, after a partial ban in 2013 affecting uses in bee-attractive crops. Pesticides are highly regulated in Europe, taking into account potential impacts across human and environmental health, including non-target arthropods and bees. Relating pesticide use to honeybee colony loss is challenging, particularly as there are several aspects to the statistics around honeybees that can be confusing. This statement aims to clarify what these statistics are and our current understanding.

Basic Honeybee Facts: A European or western honeybee (*Apis mellifera L.*) colony comprises a queen, usually a peak of around 25,000-50,000 female worker bees, and nectar (honey) and pollen stores, together with brood (larvae) and drones (males) during the summer. Wild honeybee colonies occupy cavities such as those within old trees. Honeybee colonies managed by beekeepers are housed within a hive. Beekeepers may manage from one to several hundred colonies, keeping their colonies on apiary sites. As managed honeybee colonies are also often used to produce honey, which is removed (harvested) for human consumption, it is important that beekeepers ensure the colonies have sufficient remaining food stores to prevent starvation when forage is limited, or weather conditions reduce foraging opportunities. Normal colony management includes splitting colonies, to increase stocks or to replace those that have died. Colonies are split in spring, as they naturally increase in size, by dividing the frames of brood and adult bees from a larger colony between 2 new colonies/hives. Similarly in autumn, small colonies may be combined to increase the chances of a colony over-wintering successfully.

Honeybee Colony Numbers

As food-producing animals (honey and pollen), data on managed honeybee colony numbers are reported by the Food and Agriculture Organisation (FAO) of the United Nations. These data (Figures 1A and 1B) show that the numbers of colonies in Asia, South America and Africa increased consistently since the 1960’s, whereas in Europe and North America colony numbers have declined, with numbers of colonies in Oceania and Central America broadly stable over the period.

A)



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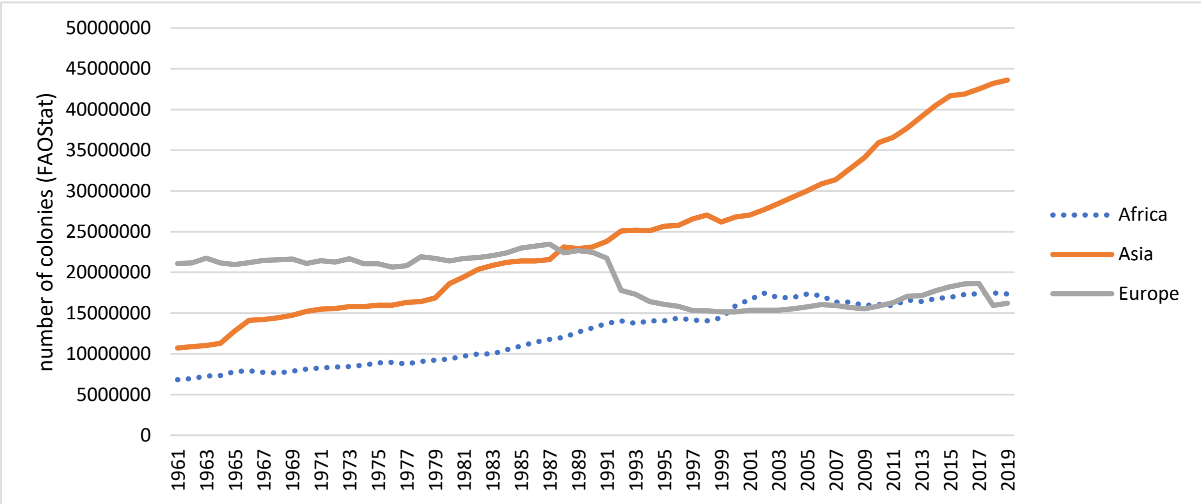

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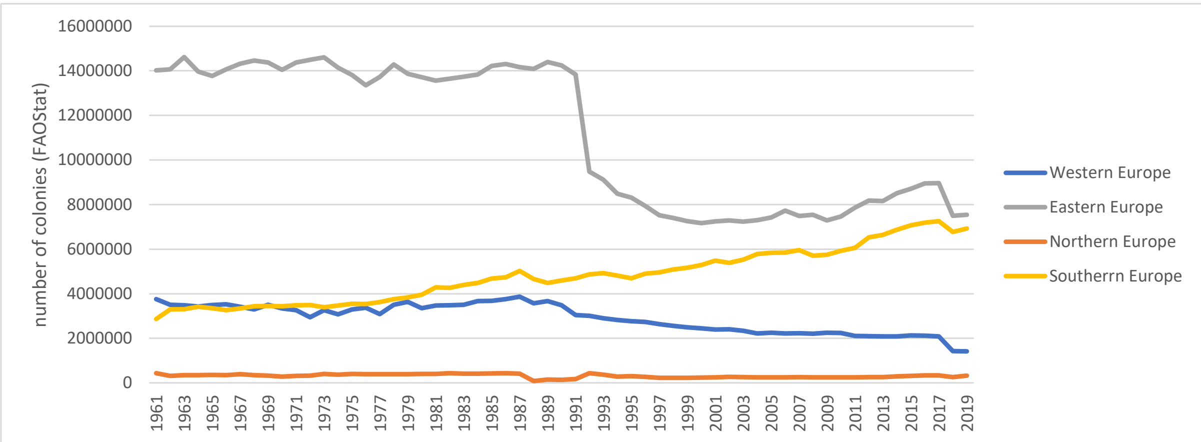

Figure 1. Changes in honeybee colony numbers 1961-2019. FAO region level data, full data for 2018-19 not yet available**.**

The decrease in colony numbers in Europe in the late 1980's/early 1990's (Figure 1B) is recognised as associated with: 1) changes in subsidies for beekeeping in the former Soviet eastern-European countries, with a drop from 14.2 million colonies in 1990 to 9.5 million colonies in 1992 in Eastern

Europe (Figure 1C) and 2) higher production costs, increased honey import, and increased affordability of sugar-based products in western Europe.

The total numbers of colonies reported for the USA have primarily been affected by 1) a change in colony counting methods during the 1980's and 2) reduced honey demand, falling prices and increased imports in the 1960s, together with, in the late 1980's/1990's, suspension of exports to Canada and federal support for honey prices.

The increase in cheaper honey imports into the USA and Europe highlighted above, primarily originated from countries such as China, Argentina and Vietnam and mirrors the growth of the numbers of colonies in those countries, at 20%, 53% and 76% respectively between 1990 and 2019.

Honeybee Colony Loss

Colony loss refers to an individual colony which is either identified by a beekeeper as dead or so weak as being unlikely to survive. Colony loss is not a modern phenomenon; losses in the UK between the 1940s and 1980s were only considered as significant when they were over 10%. Beekeepers usually replace colonies lost over winter by splitting remaining colonies as they build up in the spring.

Colony Collapse Disorder (CCD), the cause of which remains unclear, has only been reported as significant in the US. However, CCD is a widely mis-used term, it is a specific syndrome with clearly defined aetiology. In summary rapid disappearance of adult bees (without elevated numbers of dead bees) resulting in a high brood to adult ratio without elevated Varroa (parasitic mite) levels. The cause of CCD remains unclear and the number of reports declined from it being reported as the 4th highest cause of colony loss in 2007 (after starvation, poor queens and Varroa mites) to it being the 8th most reported contributor of colony loss by 2009. The Varroa mite (https://www.nationalbeeunit.com/index.cfm?pageid=93) is an ectoparasite of honeybees and is generally regarded as the biggest threat to beekeeping worldwide having moved from its natural host the Asian honeybee *Apis cerana.* The Varroa mite transmits and activates several single-stranded RNA viruses in the western honeybee (e.g. Acute bee paralysis virus, Black queen cell virus, Israeli acute paralysis virus, Kashmir bee virus, Sacbrood bee virus and Deformed wing virus).

The primary reported causes of colony loss are the parasitic mite Varroa (and associated viruses) and queen issues (e.g. poor mating, poor brood pattern, reduced longevity) with, where reported, smaller (hobbyist) operations generally reporting larger losses than commercial operations. The primarily European COLOSS survey reports winter loss rate of colonies varying widely between countries in 2018/19, from 5.8% in Bulgaria (survey comprised mostly professional beekeepers) up to 32.0% in Slovenia, with an overall 14.5% (95% CI 14.3–14.8%) loss across the 31 participating European countries. As shown in Figure 2, colony loss changes significantly between years even within a single country, in this case the UK. Pesticides cannot be directly associated with losses based on the COLOSS survey data although have been identified as a potential cause. However, pesticides are far less frequently reported as a cause of colony mortality than other factors; 4 European National Reference Laboratories identified pesticides compared with 21 reporting pests and diseases and 6 reporting other problems such as colony weakness, queen issues, mismanagement and starvation.

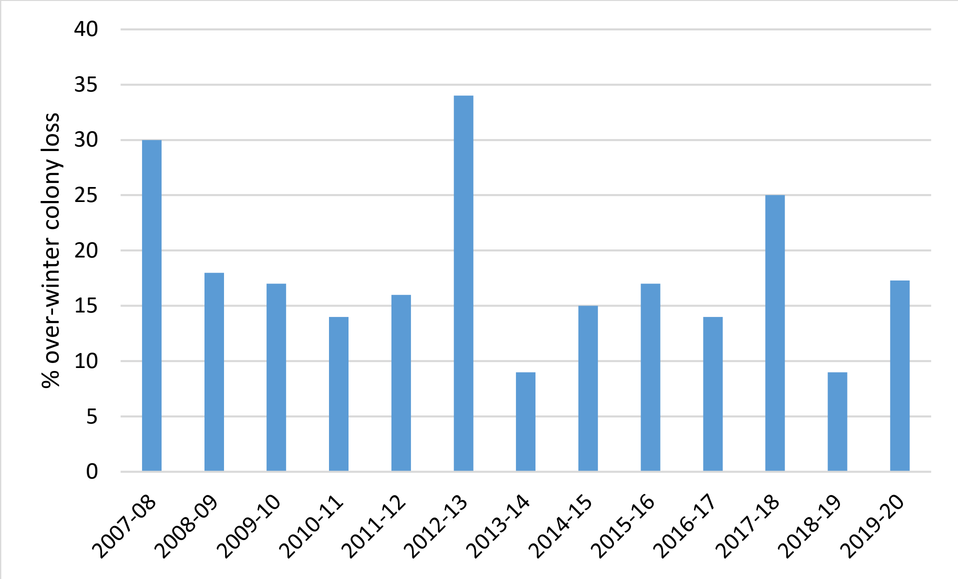

Figure 2. **Bee colony loss reported by beekeepers in the England and Wales (data for approx 120,000 colonies managed by 25,000 beekeepers)**

Honeybee Poisoning Incidents

These are reports by beekeepers identifying significant numbers of dead honeybees outside colonies. The size of an incident can vary in numbers of bees and numbers of colonies affected. In the UK, Germany and the Netherlands national government schemes exist to examine the potential cause of the observed mortality reported by beekeepers. In the UK, bees from reported cases are screened for disease and chemical analysis and field inspections are conducted to identify potential links to pesticide use; only if there is a causal link to pesticides is it classified as an incident. Background residues of pesticides may be detected e.g. varroacides, fungicides, but not causally linked to the incident. Data are reported quarterly alongside those of the broader Wildlife Incident Investigation Scheme. The numbers of incidents associated with pesticide use have decreased since the 1980's and 1990's with changes in use patterns (e.g. organophosphorus insecticides contributed to 80% of the incidents between 1981 and 1991 and 33% of the incidents between 1994 and 2003) and stewardship (e.g. highlighting importance of following label instructions such as bendiocarb use in feral bee control which contributed to 32% of incidents between 1994 and 2003) such that the number of incidents over the last decade has averaged 5 per year (Figure 3).

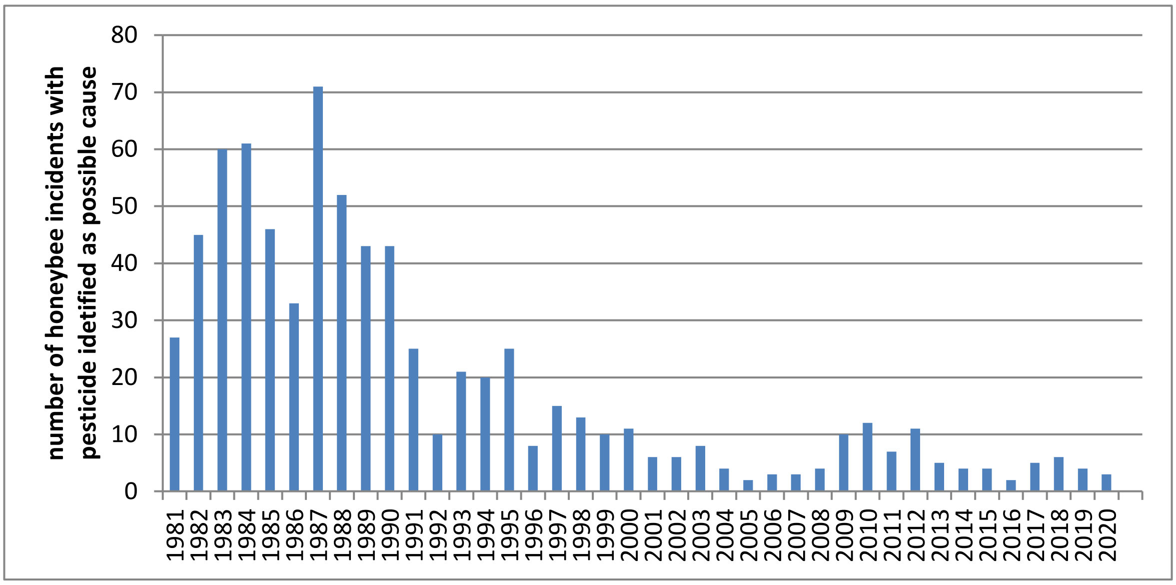

Figure 3. Annual numbers of honeybee incidents in which pesticides were identified as a possible cause

In Conclusion

It can be seen from the data above there is no clear evidence of a major role of pesticides in honeybee colony losses in Europe. Based on the FAO data colony numbers in Europe appear to be increasing, with a 21% increase over the last two decades (1997-17). Occasional incidents involving mortality of bees due to pesticides have been reported in Europe in recent years but there is no clear pattern related to a class of pesticide or use. Over-winter colony losses vary widely by country and year, with no observable "improvement" since the partial or complete ban of the three neonicotinoids, whereas Varroa and associated viruses have been identified as playing a key role. However, these data also cannot exclude the possibility that pesticides may play a role in interacting with a range of other factors e.g. nutrition, disease, but identifying the importance of pesticides relative to these other factors impacting honeybee colonies is far more complex than currently available data allow.

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