Care for bees: for many reasons and in many ways

Tjeerd Blacquière
Bees@wur, Plant Research International, Wageningen University & Research, PO Box 69, 6700 AB Wageningen, The Netherlands, E-mail: tjeerd.blacquiere@wur.nl

Pollinating insects are in decline, probably worldwide. This may imply a pollination crisis, for (food) crops as well as wild plants. Eventually this decline might result in great economic losses, a human food crisis and loss of natural biodiversity. Although the world population of honeybee colonies still increases (despite decreases in many countries) it is urgently needed to take care for bees and other pollinators.
Possible drivers for the decline of insect pollinators in general are (1) habitat loss and intensive land use, (2) globalization and introductions of foreign species, (3) pollution including pesticides, and (4) climate change. For honeybees in particular: (5) worldwide presence of the invasive parasitic mite *Varroa destructor* (as a consequence of [2]), (6) introduction and spread of other (new) parasites, (7) loss of the honeybee's genetic diversity, and (8) detrimental beekeeping practices. Simultaneously the beekeeping sector in many countries is vanishing for demographical reasons and a lack of incentives for beekeeping.
The Dutch beekeeping almost fully depends on hobbyists, which results in little professional education and the absence of a professional extension service. Nevertheless the beekeeping standard has to improve to help the beekeeping sector to cope with the upcoming challenges and to safeguard the need for pollination in professional agriculture.

Keywords: pollination crisis, *Varroa destructor*, colony collapse disorder, globalization, pesticides, professionalism

In recent years the public in Europe and the USA has been overrun with stories about vanishing bees (*cf.* Stokstad 2007, Benjamin & McCallum 2008), and with the curse in the quote attributed to Einstein: when the bee disappears, mankind will not survive for more than a few years... What is true about these stories and how severe are the effects? Yes, there are serious problems. Yes, bees are very important for nature and man. Yes, we need to act. But where to start? What is causing the troubles? This paper gives a short overview of the status of pollinators, with special focus on honeybees, of possible consequences of losses of pol-

linators and of the most probable causes for pollinator/honeybee decline. Finally, special attention is given to the Dutch situation.

Pollinator declines

In recent decades pollinating insects have been under threat, illustrated by declining species diversity and abundance, and by many species entering national red lists. The declines concern butterflies and moths, hoverflies, solitary bees and social bees altogether. Two recent reports illustrate the scope and seriousness of the trend. Biesmeijer *et al.* (2006) showed that in the UK and The Netherlands from the 1950s till 1980, and from 1980 till 2005 a parallel decline of pollinating insects and pollinator-dependent flowering plants has occurred. Although driver and consequence cannot be decided upon, 'these findings strongly suggest a causal connection between local extinctions of functionally linked plant and pollinator species'. The 2007 report 'Status of pollinators in North America' (Committee on the status of pollinators in North America, National Research Council; NRC 2007) also stated a decline of wild as well as managed pollinators of all sorts in North America, and a forthcoming threat to flowering plant species and ecosystem functions.

The most important drivers mentioned for the decline are (1) habitat loss and intensive land use by man, (2) globalization, which introduces new (possibly invasive) species and pathogens, which may spill over to wild populations, (3) pesticide use, and (4) climate change (NRC 2007), although not much conclusive evidence exists for 3 and 4.

Consequences of declining pollinators

A decline of wild pollinators may lead to loss of dependent (vulnerable) plant species (NRC 2007) because of (partial) loss of the pollination services. As wild pollinators also provide the ecosystem function of pollination to many cultivated crops, especially in small-scale agriculture, pollination of crops may be at risk or become more dependent on managed pollinators (Winfree 2008). In the USA the ecosystem function was calculated to amount 17% of the total pollination value (Losey & Vaughan 2006).

Taking all animal mediated pollination together, Gallai *et al.* (2008) concluded that the pollination value for food crops (fodder not included) equalled 10% of the world food production value, an amount of 153 billion Euro per annum. But even more alarming was the prediction of the resulting impoverished food parcel, since vegetables, nuts, fruits and stimulant crops would be affected most, resulting in vitamin and mineral shortages, when all pollinators would get lost.

Worldwide honeybee declines?

From the recent public fuss about the honeybee colony losses in Europe and North America's 'colony collapse disorder' (vanEngelsdorp *et al.* 2009, Coloss Conference 2009) the impression arises that the world population of honeybee

colonies is rapidly declining. Be it true for those regions, it is far from true worldwide. Based on FAO statistics about the world honeybee stock, Aizen & Harder (2009) showed that since 1960 the stock has steadily increased, with a retardation in the nineties, due to the collapse of the huge Soviet Union honeybee industry. However, they also show that together with a slow increase of the bee stock there is a very fast increase in the cultivation area of pollinator-dependent crops. This implies that even a continuous increase might not be sufficient – moreover, by ongoing declines of wild pollinators and by intensification of cultivation, crops will more and more depend on only honeybees as the pollinator (Winfree 2008).

Honeybee colony losses

Apart from the down pending trend in the numbers of bee hives and bee keepers, in recent years more colonies seem to be lost during winter (winter losses) and autumn. Traditionally, losses of colonies only became apparent in spring, when after winter beekeepers visited their hives for the first spring check. A small loss of colonies during winter, 10-15% of the stock, was generally accepted and regarded normal. Hunger and queen mortality were considered as principle causes.

In some cases bee colonies suddenly appeared to be 'empty', with only abandoned brood and food stores, and a queen with a few young worker bees left behind. This phenomenon was called 'dwindling disease' (spring dwindle, autumn dwindle). In the USA the rapid population loss of colonies, especially in autumn, has been named 'colony collapse disorder' (CCD). This rapid dwindling of entire bee colonies very much appealed to the imagination of the public, as if the bees had gone to find a better world. However, it soon became clear that this dwindling was nothing really new, since comparable dwindle events and years with great colony losses had been reported many times in the history of beekeeping of the last centuries (Oldroyd 2007, Stokstad 2007, Benjamin & McCallem 2008).

What seems to be new is that high losses of bee colonies are not exceptional anymore, but have become the general rule, repeating almost every year (Coloss Conference 2009), but solid figures are lacking. Therefore, the Coloss network (www.coloss.org) tries to co-ordinate and deliver sound and comparable data about colony losses in as many countries as possible worldwide. So far, most bee researchers do not suspect a single cause for the losses, but rather interpret them as the result of several contributing factors.

Causes of honeybee colony losses

Varroa destructor

Threat number one for honeybees and beekeeping is without doubt the parasitic mite *Varroa destructor*. Since its introduction in the European and later American beekeeping, it has set a destructive track of killed colonies. Nowadays

only Australia is free from varroa (Ellis & Munn, 2005), and possibly some African countries. Not only does varroa weaken the bees' condition, but it also vectors and favours secondary infections, by viruses and possibly other parasites (Martin, 2001). Since varroa is always present in honeybee colonies, every single attack of a parasite on honeybees is an attack on an already diseased patient (Neumann, 2009).

Introduction of foreign species (including parasites)

Globalization has already taken its share of honeybee health in the past decades, by introducing *V. destructor* (originating from Asia, as a parasite of the Asian honeybee *Apis cerana*). Recently it was recognized that *Nosema ceranae*, a microsporidian parasite of the Asian honeybee *A. cerana*, had been introduced in Europe and America and seems to dispel the native parasite *Nosema apis* (Fries *et al.* 2006, Paxton *et al.* 2007). The Small hive beetle *Aethina tumida* has been introduced from sub-Saharan Africa into America, Egypt, and Australia. This species, as well as the parasitic mite *Tropilaelaps* sp., have been nominated for Europe as the near next most probable bee parasite introductions. Introductions of plants can turn out to be beneficial to honeybees, but equally likely can turn out to be catastrophic (see van der Weijden *et al.* 2007).

By the way, the honeybee itself has been introduced in the past in the continents America and Australia, where it can be considered an invasive species.

Beekeeping practice

Professional beekeeping is under threat in many countries, because of decreasing honey prices (Daberkow *et al.* 2009), increasing bee health problems, and an ageing beekeeper population. In some countries the original professional beekeeping has turned into a hobby-beekeeping sector. In a recent review on the threats to honeybees in Europe, the lack of incentives for beekeeping was posited as one of the main reasons for the problems (De la Rúa *et al.* 2009). This seems even to hold for hobby beekeepers!

But the beekeepers often also take a leading part in the problems. Amongst the highest rankings is an inadequate control of varroa, which leads to weakened colonies and rapid depopulation during autumn. Spread of (invasive) parasites and diseases is also very often caused by migratory beekeeping, combined with limited hygiene and disease control.

Loss of the honeybees' genetic diversity

Before varroa entered the scene, almost everywhere feral colonies existed next to kept bee colonies. Actually wild and kept colonies were one and the same genetic pool, since mating cannot be controlled easily in honeybees. However, with the arrival of varroa, in Europe as well as in North America almost all feral colonies died. This implies that the genetic pool of the honeybees has since been in the hands of the beekeepers. Especially in countries where the stock of used

queen bees is in the hands of few queen breeders this is an alarming situation. The most important challenge now is to conserve as many as possible (local) subspecies and populations of the native honeybee (De la Rúa *et al*. 2009). For instance, to eventually reach a bee that can cope with a varroa infestation, we might need as many genes as are present. So far, the best practices in varroa tolerance have been obtained by nature (Seeley 2007, Le Conte *et al*. 2007). Genetic exchange might also be impaired where honeybee colony densities become low because of a poor forage situation (Moritz *et al.* 2007).

New pesticides

A new generation of insecticides, the neonicotinoids, has often been claimed to be responsible for honeybee colony losses (Comité Scientifique, final report 2003). These are effective insecticides, lethal at very low dosages, also for honeybees. Their systemic action in plants facilitates very low dosages as a seed dressing. But this property also causes the chemical, or its metabolites, to be present in nectar and pollen, the food for honeybees and other pollinators. Although the substances are highly toxic to bees, no convincing relationship with colony deaths and losses could be demonstrated, and two large monitoring programs did not show any relationship between colony losses and the presence of neonicotinoids (Chauzat *et al.* 2006, 2009, Anonymous 2008). Nevertheless, it is highly recommended to adopt the registration procedures for crop protection agents to the new substances, since possible hazards that would not be recognized in the present tests, need to be tracked down.

Other factors: cell phones and GMO's

Many other possible causes have been raised, including electromagnetic radiation from cell phone networks, and the use of genetically modified (GM) crops. For the first option no solid data can be found. GM crops possibly are a threat to bees, because some of the products are potentially harmful to bee larvae. Although none of these effects have occurred in practice (Malone 2004), it is wise to remain careful. Colony losses do occur equally frequent in countries without any GM crops.

Situation in The Netherlands

On behalf of the Dutch ministry of Agriculture, Nature and Food Quality, last year Bees@wur analyzed the situation and threats to the Dutch beekeeping sector (Blacquière *et al*. 2009). The Dutch beekeepers are almost all hobby beekeepers, that often only start with beekeeping after their retirement. Together with a lack of education in beekeeping (no beekeeping in any curriculum left) and the cancellation of a (governmental) extension service for beekeepers, this leads to a low degree of professionalism of our beekeepers. The last few decades beekeeping has become increasingly difficult due to varroa (and resistance of varroa against some control agents), the entrance of *N. ceranae*, and the loss of forage

for the bees, especially in rural agricultural areas. More and better (professional) education and extension was recommended, as well as an increase in applied research, to help the beekeepers in taking the challenge. The government has started some monitoring research and recommends more bee subjects into the education programs, as well as measures to stimulate sowing of flower strips in agricultural fields.

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