MACOSPOL

Western honey bee (*Apis mellifera*) die-off

Presentation of the case study and comments about its manageability by the Web platform prototype

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PART I: THE STATE OF AFFAIRS

Beekeepers have detected abnormally high mortality and a general weakening of honey bee colonies for more than the last ten years. In Europe people talk of a "die-off" or "meltdown" (*dépérissement* in French), whilst in the US the term "*Colony Collapse Disorder*" or CCD has been coined. France was the first country to sound the alarm, doing so in 1995. It was followed by a series of European countries (Belgium, Germany, Spain, Italy, and so on) and others elsewhere (USA, Canada, Argentina, etc.). Many possible explanations have been proposed, albeit not without creating controversy amongst the various parties concerned by the problem. According to the studies that have been carried out and continue to be conducted, the phenomenon seems to be due to many causes, most of which must be sought out in the hives' environments.

The aim of this document is to understand the problem taking the case of the *Apis mellifera* die-off in Wallonia as our reference point. We shall thus oscillate between general considerations and the specific conditions of the case studied. To improve the readability of this document and facilitate understanding we have appended a list of the most commonly used abbreviations in the field along with a glossary of technical terms. The reader will also find a brief chronology of the measures that the Belgian and Walloon authorities have taken to deal with the honey bee die-off and a list of Web sites about bees, beekeeping, and the die-off problem. Finally, we have also appended a list of the articles and reports available on line that were used in writing up this document.

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THE SYMPTOMS OF THE HONEY BEE DIE-OFF

Winter is a period of dormancy for honey bees. Each colony's population drops to about 20,000 individuals at this time. Spring marks the resumption of laying for the queen and pollen and nectar harvesting for the foragers. This generally starts in February, but can vary in line with weather conditions. The "peak season" stretches from May to July. Over this period the queen can lay up to 2,000 eggs a day and the colony grow to 60,000-80,000 individuals. For the worker bees (cleaners, nurse bees, foragers, etc.), the period of nectar or honey flow is one of intense activity. The colony's population then gradually declines starting in August. The queen stops laying around mid-October, at which time the winter stores have been completed (RESEAU BIODIVERSITE POUR LES ABEILLES, no date).

Now, major dysfunctioning of the colony's development cycle is precisely what has been ascertained these past few years. The decimation is seen in various stages of the colony's life. In the springtime, the hives are normally in the midst of their recovery activity. Yet in recent years hives have regularly been found to be empty in the spring, with practically no bees in the hive and no corpses on the hive's floor. This is what beekeepers call the "empty hive syndrome". The brood (the entire collection of eggs, larvae, and pupae) that should be the focus of all the nurse bees' attention is completely abandoned and dies through lack of care. It also happens that the hive is normally dynamic in the spring and develops normally, then suddenly collapses. This generally occurs between April and May. Beekeepers have also noticed "a gradual but significant loss of forager bees" at the height of the foraging season and an abnormally high death rate at the end of the season and over the wintering period. Other forms of dysfunctioning, notably in the bees' behaviour, are also seen: Some individuals are disoriented, which can explain why bees "vanish" without leaving corpses (the foragers simply fail to find their way back to the hive); the hive's internal organization is upset; the queens' renewal rate is abnormally high (every six months, whereas a queen bee lives three years on average and can live up to five years); whole colonies disappear although they leave well-stocked larders behind, and so on. (CARI, 2003).

According to beekeepers, these dysfunctional events do not resemble the symptoms of the disorders that traditionally affect their bees. Whilst beekeepers have known hard times in the past (varroasis epidemics, for example), they have never seen their bees die off at such a rate (CARI 2003). The death rates of Western honey bees are usually situated between 8 and 10% of the colonies per year – some talk of 2-5% – but this level has been greatly exceeded in a number of countries in the past few years. The situation does, however, vary greatly from one country to the next and from one year to the next in the same country, and even in a given region (HAUBRUGE and NGUYEN et al., 2006).

BEEKEEPING IN WALLONIA

There are some 4000 beekeepers in Wallonia, scattered across the region's entire territory. However, it is difficult to confirm this figure, for whilst many beekeeping networks exist – in the form of federations, associations, discussion groups, etc. – the beekeeping network is not organized. The result is a lack of data, which lack is all the greater because beekeepers are sometimes reluctant to make themselves known[1]. The foregoing estimate is thus based on the number of members in the Region's various federations and other beekeepers' associations, but also allows for unaffiliated beekeepers, the number of which is relatively high (about 20% of the total). Wallonia's beekeepers are amateurs for the most part; there is only one known professional beekeeper in Wallonia. There are an average of fourteen hives per beekeeper, but this figure varies greatly from one person to the next. Finally, the number of hives for the whole of Belgium has remained stable over the years (110,000 hives, of which slightly more than half are located in Wallonia), whereas the number of beekeepers has been falling steadily (about 3% fewer beekeepers each year). This last remark is important, for colony restocking by beekeepers grappling with the problem of high mortality tends to mask the magnitude of the die-off (CARI, 2003; COMMISSION DE L'ENVIRONNEMENT DES RESSOURCES NATURELLES DE L'AGRICULTURE ET DE LA RURALITE, 2004; APISERVICES, 2006; SAINTOURENS and LAMOTTE, 2008).

THE WESTERN HONEY BEE DIE-OFF: INVENTORY OF THE POSSIBLE CAUSES

According to scientists, the problem is due to multiple factors, but depending on the point of view that is taken, the ranking of causes is not the same. Whilst internal divergences exist, we can say that, overall, beekeepers and their "supporters" deem systemic insecticides to be the main culprits in the honey bee die-off, whereas the agrochemical concerns and politicians incriminate diseases, especially Varroa infestations. In France, Representative Saddier's report to Prime Minister Fillon (SADDIER, October 2008), moreover, triggered shock waves for, according to the beekeepers, he accused them unjustly of not monitoring the health situations of their beehives enough and made no mention of pesticides as a cause of the die-off.

Systemic insecticides

France is the first country to have launched the international alert, which it did in 1995. It should be remembered that the observed symptoms ("empty hive syndrome") corresponded to nothing known at the time and for which neither the beekeepers nor specialists could give any explanation. The beekeepers thus sometimes thought that they had made a mistake in handling their hives and, as they were not always registered, preferred not to report their losses. Others,

[1] Beekeepers have been required to register with Belgium's Federal Agency for Food Chain Safety (AFSCA) since 2006, but do not register, as they consider this to hobble their freedom.
AFSCA (16 January 2006). Arrêté royal fixant les modalités des agréments, des autorisations et des enregistrements préalables délivrés par l'Agence fédérale pour la Sécurité de la Chaîne alimentaire. AFSCA. **2005023114**.

who were more confident, revealed the problem and once the phenomenon became visible, the majority of affected beekeepers made themselves known.

In Belgium, the first observed cases of honey bee die-off were reported in 1999 and rose steadily until 2002, at which point the new case index started to decline. In Wallonia, the phenomenon seems to have been concentrated north of the Sambre and Meuse River Valleys, especially in the Condroz and the loamy region, which are Wallonia's two largest agricultural areas in terms of acreage, accounting for 17.8 and 35.6%, respectively, of Wallonia's usable agricultural area (UAA). The bulk of Wallonia's field crops (cereals and sugar beets) and forage crops (maize) are concentrated in these areas. In 2003, a report by the Beekeeping Research and Information Centre, CARI, tended to show, in a first approximation, that the areas that were not touched by the die-back phenomenon were far from the field crops, whilst the affected beehives were surrounded by either field crops or maize, which corresponded well to the Walloon agricultural landscape described above. Even though we still do not have precise explanatory factors today, certain avenues are nevertheless favoured. These include the introduction in farming in the 1990s of two new "systemic" pesticides, Gaucho® and Regent®, marketed by the firms Bayer CropScience and BASF-Agro, respectively[2]. These insecticides are used to coat certain seeds, such as those of maize, sunflowers, beets, and cereals. There are various advantages to such insecticidal coatings: savings of time and money for the farmer, who no longer has to spray his crops; release of the active substance throughout the plant's growth cycle; and lower pesticide application rates per hectare. The active ingredients in these products – imidacloprid and fipronil, respectively – have been accused of causing the honey bee die-off. These two chemicals belong to the neonicotinoid and phenylpyrazol families, respectively, which are recognised as being highly neurotoxic in bees. Now, the behavioural disorders that have been observed (disorientation and lack of coordination) are symptomatic of neurotoxic effects. In France, where these two pesticides were put on the market in the early 1990s, the Farm Ministry first suspended their use for the period necessary to conduct studies of their possible involvement in the *Apis mellifera* die-off, then banned them: It instituted a total ban on fipronil and a partial ban on imidacloprid (ban only on coating sunflower and maize seeds). No such decision has been taken in Belgium, where the use of Gaucho® to coat maize seed is still allowed[3]. For the time being, the federal and region authorities with powers in this field (Federal Public Service Health, Food Safety, and the Environment and Wallonia's Directorate-General for Agriculture (DGA)) have not taken a stand on systemic insecticides. The federal ministry had set up a working party to investigate the matter from late 2005 until 2007, but a read through the conclusions of the working party's final report, which came out in June 2007, shows that its members could not agree on whether or not systemic insecticides were involved in the die-off phenomenon. Since then, the situation has not moved forward (HOC and HUCORNE et al., June 2007). The Belgian situation, and in this case the situation in Wallonia, must be differentiated from the French one, however. First of all, Walloon beekeeping circles are less powerful, because they are less economically important than their French counterparts, who consist of amateur but also professional beekeepers[4]. The Walloon beekeepers' ability to exert pressure is thus relatively limited. In addition, the sunflower, which was the main problem in France, is not widely grown in Belgium and imidacloprid is not approved for coating sunflower

[2] These insecticides are called "systemic insecticides" because they spread to all the plant's tissues. They are thus found in the nectar and pollen.

[3] It should nevertheless be pointed out that the suspension of these products should have been enforced in every Member State of the European Union, for they had not been tested on the broods, although this was required by Directive 91/414/EC. This is what motivated the French decision. These tests have been carried out recently, however. BRUNEAU, E. (2008). Evaluation des pesticides et risque pour les abeilles. XXVII^{e} Congrès National de l'Apiculture Française, Villefranche-sur-Saône, UNAF, Syndicat d'Apiculture du Rhône.

[4] There is only one professional beekeeper amongst Wallonia's estimated 4,000 beekeepers. France, for its part, has 1,800 profession beekeepers out of a total of 69,000 registered beekeepers, but these professionals, who account for 2-3% of the country's beekeepers, alone keep 45% of the country's bees.

seeds[5]. The main crops in Wallonia are cereals (24.3% of Wallonia's UAA), forage crops (11% of Wallonia's UAA, the bulk of which consists of feed maize), and industrial crops (10.4% of Wallonia's UAA, the bulk of which consists of sugar beets). Now of these three types of crop, only maize produces pollen. The bees are poisoned mainly via pollen (and nectar in the case of nectar-secreting plants). A first report by scientists at the Gembloux Agricultural College (*Faculté universitaire des sciences agronomiques de Gembloux* (FUSAGx)) on the matter that was commissioned by the Walloon Region underlined, however, that imidacloprid-coated maize seed accounted for only 3% of the sown area in Belgium. The poisoning can also occur during sowing, through the bees' exposure to the dust that the machines raise. According to the Gembloux report, the bees could also be poisoned by residual amounts of the chemicals in the soil. Due to such persistence, in the course of crop rotation, plants that were not treated with the incriminated insecticide but followed crops that had been treated with it might nevertheless be toxic to bees. However, according to FUSAGx's scientists, we do not yet have enough information about how the product is transferred from the soil to the plant to confirm this hypothesis. Still, this would provide a handy explanation for how bees could be poisoned by imidacloprid without having had any interactions with the plants (sugar beets and cereals) that are treated with Gaucho®[6] (CARI, 2003; HEROUET, 2004; APISERVICES, 2006; DIRECTION GENERALE DE L'AGRICULTURE, 2006; HAUBRUGE and NGUYEN et al., 2006; RIVIERE-WEKSTEIN, 2006). In practice, we find both scientific studies that exonerate the systemic insecticides and others that give reason to doubt their harmlessness. The latter put pesticide approval procedures at the heart of the debate, for according to their authors, such approval schemes are not suitable for the new types of insecticide (see farther on.)

Diseases of the Western honey bee

Varroasis

The other possible causes put forward include disease, with varroasis heading the list. This disease is due to the presence of the mite *Varroa destructor*. It has been present in Europe for slightly more than twenty years, which makes some people say that it cannot be the cause of the die-off, even though it cannot be excluded from the risk factors. This mite is originally from South-East Asia, where it parasitises *Apis cerana*. Today it is found throughout the world, with the exception of a few places. Its spread was made possible by the trade in queen bees. Whilst the indigenous South-east Asian bee *Apis cerana* is more or less resistant to this mite, as are certain Russian bees, it causes serious damage to *Apis mellifera*. Today this parasite is well known to beekeepers and scientists, but the arsenal of approved Varroa control products is rather limited and the products' efficacies are falling, for resistances had already cropped up a few years ago. Studies carried out by the French national federation of departmental apicultural health organizations (*Fédération Nationale des Organisations Sanitaires Apicoles Départementales* - FNOSAD) in France showed that the best way to control this mite was to use two treatments in alternation, but this was easier said than done, given the lack of miticides at beekeepers' disposal (COLIN, 2008; VANDAME, 2008). When Varroa does not kill the bee, it weakens it enough to make it more vulnerable to other environmental influences (increased sensitivity to disease, viruses, pesticides, etc.). The miticide itself might not be without a role in this "weakening". There might be a synergy between the miticidal treatment and other substances such as pesticides that could

[5] Growing sunflowers took off in France in the 1980s, giving rise to the French beekeepers' "golden age". However, the 1992 reform of the European Union's Common Agricultural Policy (CAP) greatly reduced the acreage allocated to this crop at the same time as it brought in new varieties of sunflower with shorter flowering periods, which upset the producers of sunflower honey's applecart. In Vendée, for example, where this honey accounted for 80% of honey output at the time, the acreage planted in sunflowers was halved between 1993 and 2000.

[6] There are no interactions between honey bees and these crops, for these crops produce neither pollen nor nectar.

produce an overall harmful effect on bees. Some people also point their fingers at the amateurism and ignorance of beekeepers who allegedly misuse these treatments or use unapproved products. CARI's report shows that whilst Varroa is not the determining cause of the current problem of honey bee die-off, it cannot be ruled out as a risk factor, because in "weakening" the bees it makes them more sensitive to negative influences in their environments. It is estimated that if the post-treatment Varroa population is greater than or equal to fifty in a hive, the hive will have problems the next year. That is why beekeepers are encouraged to monitor their colonies closely and to do periodic Varroa counts (CARI, 2003; COMMISSION DE L'ENVIRONNEMENT DES RESSOURCES NATURELLES DE L'AGRICULTURE ET DE LA RURALITE, 2004; DIRECTION GENERALE DE L'AGRICULTURE, 2006; HAUBRUGE and NGUYEN et al., 2006).

Nosema disease

Nosema disease is another frequent disease of the Western honey bee. It is caused by the microsporidia *Nosema apis* and *Nosema ceranae,* which affect the adult bee's digestive tract. The two species of *Nosema* do not trigger the same symptoms (diarrhoea is present or absent), which makes it easier to reach the correct diagnosis if *Nosema* disease is suspected. A FNOSAD team is carrying out studies to compare their pathogenicity (*Nosema ceranae* is thought to be more dangerous) and develop treatments to control these parasites. For the time being, there is no approved treatment for Nosema disease in Europe. The efficacy of Fumidil B, in which the active ingredient is the antibiotic fumagillin, is recognised, but the product is not authorised for use because it poses residue problems. Analyses conducted by FNOSAD to identify the type of *Nosema* involved showed a correlation between the presence of *Nosema ceranae* and hives affected by die-off, just as a study by some Spanish investigators found (HIGES and MARTIN et al., 2006), but there are no grounds as yet for asserting a cause-and-effect relationship between the two. These fungi are effectively found in many hives that show no signs of infection. This makes some people say that Nosema disease is more probably a consequence than a cause of the colonies' weakened states. Like all parasites, these microsporidia are effectively opportunistic parasites (DELBAC, 2008).

Viruses

To try to explain the abnormally high mortality in bee colonies, the idea has also been put forward that it might be linked to the advent of new viruses. One team of scientists has shown a correlation between the presence of Israeli Acute Paralysis Virus (IAPV) and beehives affected by Colony Collapse Disorder in the USA, but has not yet been able to show a cause-and-effect relationship between IAPV and the observed die-off (COX FOSTER, october 2007). Moreover, not all their colleagues share their opinion (ANDERSON and EAST, February 2008) and beekeeping circles often tend to think that it is a "red herring" designed to throw people off the scent by multiplying the possible causes of the phenomenon so that the real culprit is harder to find.

The loss of biodiversity

Fingers are also being pointed at certain processes at work "on the ground". One often-cited factor is the intensification of agriculture. This process has spawned a host of consequences, especially environmental ones, that are well known today and not innocuous for the bee populations. The disappearance of hedges – a consequence of the regrouping of agricultural land and the mechanisation of farming – , the mainstreaming of pesticide

applications, and the development and extension of monocropping areas have all gradually led to a decrease in the bees' food sources. The huge areas of monocropping pose a dietary threat for the bees, which either no longer find sufficient amounts of pollen or collect poor quality pollen (even toxic pollen in the case of pesticide treatments). The bee's diet is effectively composed of nectar (sugars) and pollen, which is its only source of protein. The protein content varies greatly from one pollen variety to the next: maize pollen has very little nutritional value, for example. The quality and quantity of nutrient resources depend as well on weather conditions, for a period of drought will shorten the flowering period whilst rain and wind will temporarily halt pollen and nectar collection. They also depend on the forager populations: The more numerous and healthier the forager bees are, the larger the pollen harvest will be. This quantity varies in line with the brood size (and vice versa). Now, we have seen that one of the symptoms of the honey bee die-off is the gradual loss of foragers over the foraging season. The bees thus must cope more and more often with a lack of pollen or lower quality pollen, which helps to weaken them. The summer nectar flow is supposed to enable them to set aside stores to make it through the winter, but if the stored pollen is of poor quality, the entire colony's survival is threatened, as the bees' life expectancies fall. However, CARI does not consider the quality of the bees' food sources to be a cause of the die-off in Wallonia, as the FUSAGx team's pollen trap study showed that the pollen that was collected was sufficiently diversified (even if there were occasional gaps in the bees' harvests) (HAUBRUGE and NGUYEN, 12 September 2008). However, this hypothesis remains valid for other parts of the world.

Professor Jacobs of Ghent University (Belgium) has developed three scenarios linking the colony's state of development to its diet, as follows:

- The first scenario is an ideal scenario: Pollen is collected steadily throughout the season and the pollen is of good quality. The hive then develops normally: Eggs are laid daily and the young bees are fed enough and with good quality food. The colony's future is thus assured.

- In the second scenario, Jacobs envisions the consequences of the collection of good quality pollen that is interrupted, for various reasons. The interruptions will lead to temporary halts in laying. If the interruption is prolonged, one can observe acts of cannibalism within the brood (to avoid deficiencies and higher losses). If the interruption does not continue, the number of bees will drop (because of fewer births), but the bees that are born will be healthy. The colony's normal dynamics will then be restored after a while, if the break in foraging was not too lengthy.

- Finally, Jacobs envisions the case in which the bees collect pollen continuously, but it is of poor quality. As in the first scenario, the queen lays eggs without stopping, but the bees are going to be affected by more or less serious deficiencies that will lead to a general weakening of the hive. In addition, the bees' life spans will be greatly reduced. The hive's survival is thus in great jeopardy.

Jacobs developed these scenarios for pollen that was not contaminated by toxic residues, but one can easily imagine the same scenarios for pollen from plants that have been treated with pesticides or plant protection products (HAUBRUGE and NGUYEN et al., 2006; RESEAU BIODIVERSITE POUR LES ABEILLES, no date).

Another ongoing land use-related process is also regularly cited as causing the drop in food resources. It is urbanisation. In Spain, for example, the number of hives has risen although

the available acreage has fallen. The hive density per square kilometre in Spain is moreover twice that in France and well above the European average (4.6 hives/km² in Spain versus 2.11 in France and 0.25 in Europe as a whole) (LUQUE, 2008).

To combat this decline in nutrient resources for bees, BASF-Agro supported the creation of apicultural fallows in France. The idea was to provide refuge areas for bees in areas of extensive monocropping. The experiment showed that it was better to create small apicultural fallows that would form a network of spots rather than one big refuge area without any means of connecting areas to each other. In Belgium, proposals have been made to implement this type of initiative (*e.g.*, strips of grass and flowers) within the framework of agri-environmental measures (HOC and HUCORNE et al., June 2007).

Climate

Climatic conditions have a decisive influence on the colonies' fortunes, for they affect the colonies' lives both directly and indirectly. Late winters (which jeopardise the colony's dynamics) and extended droughts (which shorten the flowering period) have major impacts on bee mortality, just as humidity does (a factor in the development of certain diseases such as Nosema disease).

Other causes

Other possible causes of the die-off are often cited in the literature. They include genetic manipulations, which may have weakened the bees' resistance to certain diseases and/or environmental conditions, electromagnetic waves, poor beekeeping practices, and so on.

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So, it thus appears that the die-off can be explained by a myriad of factors: diseases, climatic conditions, intensive agriculture, loss of biodiversity, genetic engineering and selection, and so on. It would appear at first glance that these factors act through a cumulative effect, and that is what makes the problem complex and difficult to treat. Searching for a single cause may perhaps keep the controversy raging.

In the Walloon Region, the DGA (the regional department of agriculture) is in charge of the problem. It has commissioned a multifactor study of the problem from the FUSAGx team. As said above, no restrictive measure has been taken regarding the use of systemic insecticides for the time being, as beekeeping circles are pressing for, for the study's initial results failed to establish a formal link between these substances and the honey bee die-off. The Belgian public authorities' attitudes toward these pesticides diverge from those of the French authorities, which had suspended the use of the incriminated products even before getting the experts' opinions (principle of precaution). Another major player on the Belgian stage is CARI. It is an important source of information for Belgian beekeepers (and even abroad, especially in France), even though it is not unanimously supported by Wallonia's various beekeepers' associations and federations. The other main parties to the controversy obviously include the company Bayer CropScience (represented by its Development and Market Approval Manager, Hervé Tossen), the Belgian beekeepers' associations and federations, the non-profit association Inter-Environnement Wallonie (IEW – federation of environmental advocacy associations in the Walloon Region), which works in close cooperation with CARI, and the farmers' trade organization, Fédération Wallonne d'Agriculture (FWA) or "Walloon Agriculture Federation".

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PART TWO: APPROACH TO THE CONTROVERSY IN THE WALLOON REGION STARTING WITH THE SYSTEMIC INSECTICIDES DEBATE

Depending on the player, uncertainty hangs over different facets of the problem. No one can deny the die-off's existence, even though there are a few sceptics who are trying to relativise the phenomenon by asserting that it occurred before or it has already been around much longer than we think. Nevertheless, the majority view is that if die-offs occurred in the past, they never reached the magnitude that it has today. So, the uncertainty concerns more the causes of the problem ("potential danger") or the cause-and-effect relationship ("assumption") once the cause has been identified, depending on the case. Let us look at the Walloon controversy with regard to systemic insecticides and see which players are involved, the positions that they defend, and the resources that they mobilise to support their positions.

ARE SYSTEMIC INSECTICIDES RESPONSIBLE FOR THE WESTERN HONEY BEE DIE-OFF?

The pesticides used in Belgium are regulated on three levels: on the European level, first of all, by Directive 91/414/EC ("Council Directive of 15 July 1991 concerning the placing of plant protection products on the market"), transposed into Belgian law by the Ministerial Decree of 28 February 1994, which itself was modified by the Ministerial Decree of 8 December 1998. It is currently being revised and will ultimately become a Regulation. It should be stricter when it comes to assessing the risk, which will be closer to a hazard assessment, which, according to some analysts, might reduce the number of chemicals authorised until now. Next comes the federal level: Approving pesticides for sale on the Belgian market is under the jurisdiction of the Health Minister, who takes his/her decision on the basis of an opinion from the Approval Committee (Federal Public Service (Health, Food Chain Safety, and the Environment FPS) – DG4: "Animals, Plants, and Food", Pesticides & Fertilisers Office). Granting the market approval for the active ingredient is thus a European power, whilst granting the authorisation to sell the product is a national power. Finally, plant protection products (or pesticides) are also regulated on the regional level, since agriculture and the environment come under the region's jurisdiction in Belgium, but this time from the standpoint of their conditions of use (MAROT, DEVLEESCHOUWER et al. 2008).

So, the "systemic insecticides" problem thus involves the Belgian federal (Federal Public Service – Health Division) and regional authorities, as the DGA is in charge of beekeeping. Upstream, the European authorities are also involved, to wit, EFSA (European Food Safety Authority) (advice on risk management, modification of regulatory texts concerning plant protection products, and approval of the active ingredients) and EPPO (European and Mediterranean Plant Protection Organization), which establishes the procedures for assessing the risks linked to plant protection products. FUSAGx's team is also involved, with briefs from both the federal authorities (Federal Public Service - Health) and Walloon Region (DGA). At the end of 2005 the Federal Public Service's Health Hivision had set up a working group on bees to which the members of the Gembloux team belonged under a programme to cut pesticide and biocide use (Programme des Réductions des Pesticides et Biocides (PRPB)). This group, which the various parties commonly call the "bees group", finished its work in June 2007. The DGA, for its part, tasked this group with assessing the bee die-off risk factors in Wallonia and their implications for good agricultural practices under two contracts covering the periods stretching from 2004 to 2006 and from 2006 to 2008. CARI was also part of the "bees group" and was given two briefs by the authorities (2002-2003 and 2005) to gauge the magnitude of the phenomenon. Finally, the company that produces and markets the incriminated substance, namely, Bayer CropScience, is also quite naturally involved in the controversy. Still other parties are concerned by the problem, such as farmers and orchard farmers, but they do not play a direct role in it.

Before going any farther, we feel that it is important to consider the terms that are used to describe the problem and what they cover. First of all, the various parties do not envision mortality rates the same way. CARI and the individuals who rally to its point of view make a

clear distinction between two types of mortality. For them, the empty hive syndrome points to a type of mortality that is very different from the "usual mortalities", that is to say, deaths caused by conventional disease, poor weather conditions, or all other factors known to beekeepers. In their opinion, these "unexplained mortality rates" are what must be explored to understand the cause or causes of the die-off. In contrast, the FUSAGx team does not make this distinction and lumps all the deaths (conventional and unexplained) together. How does this create a difference? For FUSAGx's scientists, it means that the causes of the die-off are necessarily multifactorial: They keep track of deaths due to varroasis, the weather, food resources, in a word, all of the possible causes, without forgetting that there may be synergies amongst all these factors. It also means that if there are deaths linked to the systemic insecticides, they are "diluted" in the entire mortality pool, especially since the crosses between several variables makes it difficult to determine the predominant variable. In contrast, for CARI, one must indeed distinguish between the two types of mortality, even though they are added to yield a total, and not include the conventional causes of mortality in the explanation of the die-off observed over the past decade or so. According to CARI, the origin of the die-off is to be found in the hives' environments, that is to say, in the types of crop in the neighbourhood of each hive. To back up this hypothesis, the association's director, Etienne Bruneau, points to some field observations: Having noticed problems in some of their hives located near areas treated with systemic insecticides, some beekeepers moved a portion of their colonies to other (untreated) places. The colonies that remained in the original place died, whereas those that were moved showed no signs of a die-off phenomenon. According to Bruneau, everything thus seems to indicate that the hives' proximity to areas treated with systemic insecticides is a determinant factor in the development or non-development of the die-off phenomenon. This would also explain how the phenomenon could disappear completely from certain places from one year to the next and crop up in other places that had been spared until then. This last finding, which Bruneau illustrates by the "leopard skin's metaphor", invalidates, in his opinion, the hypothesis whereby disease is the explanatory factor, for this "leopard-spot" pattern does not correspond to the pattern of disease's spread. CARI thus does not reject the idea that multiple causes, such as disease and climate, are behind the bees' mortality, but asserts that the "conventional" causes can explain only a part of the deaths, and not the unexplained phenomena that have been observed in the field these past few years, such as the empty hives and behavioural disorders such as disorientation, bees "dragging themselves around" in front of the hive, etc[7]. According to the association, until there is proof to the contrary, systemic insecticides are the most probable cause of this unexplained die-off. The uncertainty thus concerns the link between the die-off and systemic insecticides.

Professor Haubruge's team (FUSAGx), for their part, give priority to disease as an explanatory factor, especially Varroa infestations, based on the results of their studies. Generally speaking, many scientists involved in the matter go down the pathogens path, with a special focus on *Nosema ceranae* (HIGES, MARTIN et al., 2006) and IAPV (Israeli Acute Paralysis Virus) (COX FOSTER, October 2007), for correlations – but not yet cause-and-effect relationships – have been established between their presence in the hives and hives affected by the die-off phenomenon. Still, the scientific community is not unanimously behind these results (ANDERSON and EAST, February 2008). This multiplication of the phenomenon's causes has the merit of keeping the issue open, but does not make its elucidation possible, as each party proposes its own hypothesis. This situation is advantageous for Bayer CropScience, moreover, which can mobilise other causes to cast the responsibility of its product in a more relative light. When it comes to uncertainty, here we are more in the potential hazard stage: For these players,

[7] When confronted with the first findings, many beekeepers wondered if they weren't responsible for the die-off (poor beekeeping practices), but after realising that the same beekeeper could have affected and unaffected hives, they concluded that mistakes on their part could not be the cause of the problem. FRENEY, J., D. HACKENBERG, et al. (2008). Témoignages d'apiculteurs confrontés aux mortalités d'abeilles. XXVII[e] Congrès National de l'Apiculture Française, Villefranche-sur-Saône, UNAF, Syndicat d'Apiculture du Rhône.

the problem is due to multiple factors and to date no one specific risk factor has been clearly identified.
When it comes to the Walloon case, however, Haubruge and his team rule out the possibility of systemic insecticides. Indeed, none of their studies succeeded in establishing links between these insecticides and the die-off phenomenon. To back up their hypothesis, they explain that they saw no systematic match between the areas treated with these products and the locations of the Walloon hives affected by die-off. Even better, they saw die-off phenomena in areas that were free from crops treated with systemic insecticides and showed that if they saw a significant link between the death rates and the presence of Gaucho® treated maize, this link was negative: The more Gaucho® treated maize there was, the fewer deaths there were. So, in their view, this substance was cleared of all suspicion (HAUBRUGE and NGUYEN, 12 September 2008).

Nor do the various parties mean the same thing when they talk about "die-off". During its first brief (2004-2006), the FUSAGx team took account of mortality and reduced honey production only in assessing the die-off phenomenon, these being the only objectively measurable data ("matter of fact" approach). They explained this choice at the time as follows:

> "[…] the notion of 'weakening' remains very vague and gives rise to some confusion. […] Behind the term 'weakening' there thus hides a host of symptoms left up to the observer's appreciation. […] So, in this review of the literature, we shall exclusively take colony mortality and honey production as quantifiable criteria for assessing the die-off of the Western honey bee" (HAUBRUGE and NGUYEN et al., 2006).

Bayer CropScience had adopted the same position in France when the company carried out field tests in 1995 to determine its product's responsibility for the collapse of colonies in sunflower fields treated with Gaucho®. The test findings were negative: The death rates were not higher in these fields than in the control fields (RIVIERE-WEKSTEIN, 2006). Moreover, the company's Belgian representative, Hervé Tossen, applies these study findings to the Belgian case without making any distinctions with regard to the French case. Whilst Bayer continues to stick to this position, that of Haubruge and his team has changed. Indeed, during their second research brief (from 2006 to 2008), they carried out tests to determine imidacloprid's influence on bees' behaviour. However, their conclusions remain rather evasive as, in their view, the findings are difficult to interpret (HAUBRUGE and NGUYEN, 12 September 2008). Taking account of the various influences on behaviour, they nevertheless have drawn closer to the position of CARI and the beekeepers who adopt a much broader definition of the phenomenon by taking account of not just (unexplained) mortality but also "weakened" hives and the bees' behavioural disorders (data that the FUSAGx team had considered too subjective during the first research brief). Several dimensions of the problem are considered ("matter of concern" approach), namely, economic (drop in honey production), ecological (the bee as an "environmental sentinel"), scientific and technical (plant protection product risk assessment), and health. How does this create a difference? It influences the way the studies of the systemic insecticides' roles in the *Apis mellifera* die-off are conducted and how their results are interpreted. If the die-off phenomenon is reduced to mortality only, this reduces the risk assessment to evaluating the substances' acute and chronic toxicities in bees[8]. There is no need to take account of their sublethal effects, that is to say, those that can affect the bee without killing it. So, there is no need to worry about determining whether these substances do or do not influence the bee's behaviour. Consequently,

[8] The indicator of a substance's acute toxicity is LD50 or the 50% lethal dose, that is to say, the amount of the substance necessary for half of the population exposed to it to die. The lower the value of LD50, the more toxic the substance. The acute toxicity of a substance is generally tested over 48 hours. Chronic toxicity, as its name indicates, engenders death in the wake of repeated exposure of a living thing to a substance. it is generally tested over a period of 10 days.

that also means that the tests set up to determine whether or not these products carry risks for bees limit the risk to that of death. All other influences on the bees will thus continue to be ignored. That is currently the reasoning that governs the procedure for assessing plant protection products' risks for bees, and that is also why this procedure is being revised.

Current procedures for assessing pesticides' effects on bees.

The studies are carried out in steps: laboratory study, cage/tunnel test, and then field tests.

A. Laboratory studies
- 213 Honeybees, Acute Oral Toxicity Test (Original Guideline, adopted 21st September 1998)
- 214 Honeybees, Acute Contact Toxicity Test (Original Guideline, adopted 21st September 1998

Principe
- Workers exposed by ingesting the substance dissolved in a sugar solution and by direct application to the thorax
- The bees are kept in climate-controlled cages (darkness, 25°C)
- Three replications on groups of 10 individuals; several doses tested.

-> Determination of LD50 (pesticide dose at which 50% of the bees are killed)

B. Brood toxicity test
Method for honeybee brood feeding tests with insect growth-regulating insecticides (Oomen P.A., *et al*., 1992)

Principe
- Hives fed with 1 L of a sugar solution containing the growth-regulating insecticide (insecticide that acts on the larval stages)
- Comparison of the effects with those of growth regulators (diflubenzuron or fenoxycarb).
- The colonies have access to natural sources of nectar
- Assessment of the brood's development stages
- Counting of the dead bees, larvae, and pupae in the pollen traps
- Intensity of flights, behaviour of the queen and colony

C. Cage and tunnel test
Directive for assessing the unintentional effects of pesticides for agricultural use on bees (EPPO, 1992)
Principe
- Small hives with a queen and at least 3 frames
- Exposure in cages of at least 40 m2
- Cages placed in a treated flowering crop that attracts bees: *Borago, Phacelia, Brassica, Sinapis*, cereals treated with a sugar-nectar solution
- Comparison of effects with 2 toxic insecticides (dimethoate or parathion)
- Mortality of the workers and impacts on the brood, foraging activity, and behaviour (possible repulsiveness)

D. Field test
Directive for assessing the unintentional effects of plant protection products on bees (EPPO, 1992)

Principe
- Hives with 10-12 frames placed near plots on the day they are treated (so as to increase the chances of visiting the plot)
- The product is applied at the maximum recommended dose
- The study is carried out on the test product, on a control, and on a reference product (toxic insecticide), preferably with replications. Three hives are used for each treatment.
- The plots are far from each other; care must also be taken to avoid having attractive fields nearby.
- The test lasts from 28 to 90 days.
- Assessment of mortality, the density of bees in the plot, behaviour, and pollen collection.
- Chemical analysis of the bees, pollen, wax, and honey.
- Evaluation of the state of the brood and the bee population

Behaviour change studies in the laboratory, tunnel, or field
Besides possible effects on bee mortality (both adults and larvae), it is also necessary to assess the possible effects of certain pesticides on the bees' behaviour. These include changes in their orientation processes or coordination of movements. A few study protocols that have not yet been validated internationally enable one to study these effects [*underlining added by the authors*].
Principle

- Feeding with sugar solutions containing the active substance or metabolites to test
- Single or repeated treatment
- NOEC for behavioural changes:
  - Frequentation of the feeder, various orientation dances and accuracy of orientation
  - Knockdown effect, motor coordination, proboscis extension reflex.

NOEC: No Observed Effect Concentration: Concentration of the active substance at which no effect is seen on the tested insect.

Source: Federal Public Service - Health, Food Chain Safety, and the Environment (Belgium) (excerpts)

Moreover, CARI, together with Inter-Environnement Wallonie (IEW) and some foreign beekeepers' unions, submitted to the International Committee for Plant-Bee Relationships (ICPBR), which is the body to which EPPO entrusted the job of drawing up risk assessment procedures related to bees, a protocol that takes account of the sublethal effects, too[9]. The ways that the various players envision the die-off also tell us how they envision the risk: either limited to mortality or extended to behavioural disorders. The various parties themselves wonder about the definition to give to the risk, for Directive 91/414/EC remains rather vague on this subject. Article 4(1)(b)(v) specifies that a plant protection product may be authorised by a Member State only *"…it has no unacceptable influence on the environment, having particular regard to the following considerations: … its impact on non-target species"* (Conseil des Communautés Européennes 1991). However, it does not specify what is meant by "unacceptable". Each party thus has its own interpretation.

Directive 91/414/EC is at the heart of the debate about systemic insecticides. It has generated highly technical discussions about the methodology to use to assess risk. It was effectively designed for sprayed products. Such products usually break down rather quickly and they are likely to affect bees through direct contact, at the time of spraying. That means assessing their acute toxicity. Now, CARI underlines the fact that the way that the bee is exposed to the systemic insecticides used to coat seeds is completely different and calls for a completely different approach to risk assessment. Here, exposure is indirect (it occurs through ingesting contaminated pollen and nectar), prolonged (it occurs throughout the flowering period), and can even be delayed (the pollen may be stored in the hive for several months before being eaten). What is more, the different categories of bee (foragers, workers inside the hive, etc.) are not exposed to these substances in identical ways. CARI also stresses the particular characteristics of *Apis mellifera*, namely, its low detoxification ability (compared with other arthropods), the way the colony functions like a super-organism ("studying an isolated individual makes no sense"), the

[9] EPPO is normally in charge of setting the risk assessment standards for plant protection products for Europe, but as it has no bee specialists in its ranks, it entrusted this task to ICPBR for the assessment scheme for bees. ICPBR is composed in part of members of agrochemical concerns. The working party tasked with revising the assessment scheme is chaired by Anne Alix of AFSSA (French Food Safety Agency). In the results of its multifactorial survey of the die-off phenomenon in France that was published in 2008 AFSSA was unable to show a link between the active substances found in the matrices that it tested and colony mortality. This report was strongly criticised by beekeepers.

complexity of its behaviours (the colony's equilibrium depends to a great extent on these behaviours), the existence of categories of individuals inside the hive, and differentiates the systemic insecticides from "conventional insecticides" on the basis of their physical chemical characteristics, namely, degree of toxicity, the substances' modes of action (neurotoxic), and breakdown and the characteristics of the metabolites resulting from this breakdown. For all these reasons, CARI feels that the current risk assessment procedure is inappropriate for judging the toxicities of these products in bees and calls for taking account of the risks of chronic and sublethal toxicity, which would make it possible to include the three components of the problem, to wit, mortality, weakening, and behavioural problems. That is why is it proposing a new risk assessment protocol. The association's chances of success depend on getting the key players, that is ICPBR, which was tasked by EPPO with reviewing the risk assessment protocol for active substances in connection with bees, interested in its proposal. If this protocol is accepted, a change in the assessment rules could be made on the European level, and consequently on the national level, but the chain of players who must be got on board is relatively long (CARI, IEW et al., 2007; BRUNEAU, 2008).

The stakes for Bayer CropScience are just the opposite: It is completely in the company's interest for the risk assessment protocol regarding bees to remain unchanged, since its product was authorised on this basis. Like Etienne Bruneau, Hervé Tossen distinguishes systemic insecticides from "conventional insecticides", but draws completely different conclusions from this distinction, because he underlines the advantages that the insects derive from not being exposed to the pesticides directly. He uses Directive 91/414/EC as a weighty argument to prove the innocuousness of his product (since it was authorised on this basis) and refers to the scientific studies that failed to establish a link between imidacloprid and bee mortality, especially that of the FUSAGx team (HAUBRUGE and NGUYEN, 12 Septembre 2008; HAUBRUGE AND NGUYEN et al., 2006). Tossen ignores the studies that point to the responsibility of his product (the same ones that Bruneau cites), for in his opinion they are based on data that cannot be measured objectively. In his opinion, one cannot assert with certainty that the observed behavioural disorders and weakening of the hives are linked to the presence of imidacloprid[10]. To support his position, he is shifting the debate toward other causes and mobilising the scientific studies that put other possible factors of the die-off first, such as Professor Jacobs's studies of bee nutrition (BASF 2004), studies of *Nosema ceranae* (HIGES, MARTIN et al., 2006) or IAPV (COX FOSTER, october 2007), but also the Saddier Report, which, like Professor Haubruge's team, favours the Varroa mite as the possible cause (SADDIER, October 2008).

Finally, the FUSAGx team has issued no opinion about the risk assessment procedure stipulated in Directive 91/414/EC, but as we saw above, its position has changed and today it is taking account of insecticides' sublethal effects on bees. We can thus assume that it will not be opposed to a revision of this procedure.

We thus see that the fact that the various parties approve or disapprove of the plant protection product approval procedure is in part linked to their definitions of the problem. To bolster their positions, Bruneau and Tossen make use of the same types of resource (scientific knowledge, leading figures, and objects such as Directive 91/414/EC and standardised protocols), but interpret them differently. We see the starting considerations: Tossen sticks to mortality and explores the possible causes of the phenomenon, whereas Bruneau also takes account of the weakened colonies and behavioural disorders and explores the links between these two phenomena and systemic insecticides. So, the way in which the problem is framed is also at stake in the debate. Deciding on a common framing of the matter seems indispensable for the

[10] For a detailed analysis of Bayer's position see the following article:
MAXIM, L. and J. P. VAN DER SLUIJS (2007). "Uncertainty: Cause or effect of stakeholders' debates? Analysis of a case study: The risk for honeybees of the insecticide Gaucho." Science of the Total Environment **376**: 1-17.

situation to move forward. What the beekeeping world shows is that the rules governing the approval procedure are flawed.

To conclude, let us simply stress that for the time being, the FPS- Health and DGA have not taken any decisions about systemic insecticides. Gaucho® treated maize therefore continues to be authorised in Belgium. Neither the federal nor regional authorities have taken any initiative to find an answer to this problem since the bees group completed its work in June 2007 and published its final report, which failed to produce a consensus on these products.

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AVENUES FOR THOUGHT

General teachings

- The *Apis mellifera* die-off is triggering discussion mainly on the technical front.
- The problem involves a heterogeneous set of players and knowledge. These players define the problem differently, with different criteria and means of measurement, which forces one to wonder what the "right diagnosis" is. In addition, the types of evidence that the various parties mobilise to justify their positions are different. This also forces one to wonder about "evidence-based science" in this situation.
- The Walloon case has also shown the importance of comparing the expert appraisals that have been conducted and their key elements. This triggers the question of what reliable information is and how to communicate clearly scientific information or information generated by other parties (the question of interpreting the data), but also reminds us of the need to ensure the traceability of the documents that support a given position.
- The die-off involves a number of spatial and temporal scales. The territorial dimension seems to play an important role in the problem ("leopard-skin die-off"), as do the time frames in which the various players place themselves (importance of the historical perspective as well). It can take several years, for example, to develop new molecules that will become the active substances of pesticides; orchards is thought out over periods of from 10 to 15 years; beekeeping can undergo huge annual variations; and so on. Finally, there is also the matter of the durations involved: delayed effects of systemic insecticides due to delayed consumption, persistence, 10-year market authorisations, and so on.
- The Walloon case also shows the regulatory authority's limits: The staff in charge of drawing up legislation and the civil servants in charge of analysing the approval applications alike are too short-handed to do the job, or time is lacking, or the authority lacks some powers.
- The knowledge mobilised to support positions comes from a rather diversified range of sources: scientific articles, press articles, investigative articles, press releases, reports commissioned by the Agriculture Ministry, reports published by the Health Ministry, the minutes of public hearings held in the Walloon Parliament, legislation (laws, directives, implementing orders, and so on), beekeeping websites, forums, blogs, (beekeeping and farming) trade journals, audiovisual materials, radio broadcasts, seminar and conference proceedings, interviews, and lectures.
- Finally, the matter of public opinion is never thought through: It is not known if it can help; no one mentions it.

Avenues of thought regarding the geographical dimension of the controversy (WP 4)

The arguments used by the parties to the controversy include some spatial elements.

Beekeepers were the first to show, backed up by experimental findings, that the hive's environment (that is to say, in their vocabulary, the types of crop present near the hives) was a determining factor of the die-off. Some of them deliberately moved part of their hives from an environment that was free from systemic insecticide-treated crops to an environment where such crops existed and found that the hives that had remained in the initial environment remained healthy whilst the hives that had been moved died (see the testimony of Hubert Guerriat, president of the Hainaut Province beekeepers' federation, in the transcript of the public hearing held in the Walloon Parliament in February 2004, as well as the testimonies of several speakers at the national apiculture congress held by UNAF at Villefranche-sur-Saône (France) in October 2008). Backing up this first argument, CARI showed that no signs of the die-off phenomenon were seen in urban areas: The Brussels hives were doing well, just like those in Paris and Berlin. In contrast, the association was able to show a significant correlation between *Apis mellifera* die-off and agricultural areas, especially in the major field crop and maize growing areas. These first two arguments support the hypothesis of the "systemic insecticides" factor as the cause of the die-off.

CARI's Etienne Bruneau has mobilised another spatial argument, but this time to invalidate a hypothesis that is often put forward, that of disease. He shows that the die-off can be seen in the form of a "leopard's skin", that is to say, that it occurs in the form of spots scattered haphazardly over the entire territory of Wallonia, with huge variations between regions and from one year to the next. In his view, this invalidates the hypothesis of a disease as being the explanatory factor of the die-off, for this leopard-spot pattern does not correspond at all to the conventional pattern of a disease's spread. Otherwise, how can one explain the fact that it appears and then disappears from a region in the space of a year? How does one explain that it doesn't spread gradually over the entire territory, in a ripple effect, but crops up in "dibs and dabs" here and there? And other questions follow. However, Professor Haubruge's team (FUSAGx) and Hervé Tossen (Bayer CropScience) counter these arguments with other arguments likewise grounded in spatial considerations.

The FUSAGx team showed that the areas where the die-off phenomena occurred did not coincide systematically with the areas of crops treated with systemic insecticides. They even established an inverse relationship between Gaucho® treated maize and bee mortality: The more treated maize there was, the lower the mortality figures. What is more, they ascertained the existence of mortality phenomena outside systemic insecticide-treated areas. According to the FUSAGx team and Hervé Tossen, who used their studies to his advantage, this invalidates the hypothesis that systemic insecticides are the cause of the die-off.

The beekeepers and CARI retorted by including a temporal dimension in their arguments, to wit: One must take account first of all of the possibility that the neurotoxic chemicals have a delayed effect on the bees, since the pollen can be stored for months before being eaten. Secondly, one cannot rule out persistence of the systemic insecticides in the soil, which might explain why the die-off phenomenon appears in areas where it should not appear, if the hypothesised role of the systemic insecticides is correct.

Remark: Let's not forget that CARI and the beekeepers on the one hand and Haubruge's team and Hervé Tossen on the other hand are not talking about the same things when they talk about mortality and die-off. This obviously is extremely important to bear in mind in the present case.

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Collaboration with the Munich team's Risk-Cartography Platform (WP2)

This exploration of the *Apis mellifera* die-off case study has enabled us to circumscribe better the stakes riding on the positions of certain key players in the die-off problem in Belgium. How can this be made visible on the Internet? One proposal put forward is to take advantage of the experience acquired by the Munich University team (Cordulla Cropp, Simon Meissner, and Gerald Beck) in developing their risk mapping platform (http://www.risk-cartography.org/en_project.html). A session devoted to the bee die-off controversy was kindly put at our disposal. We are currently testing the platform using our own data (those concerning CARI and IEW). The aim is to see to what extent this platform could serve (as a module within the MACOSPOL platform) as a resource for our own programme of experiments (WP6). Given the platform's current state, which is marked by its "stasis" (researchers have yet to create the database and links between its elements), its use will require a special stakeholders' agreement. Our work can serve, in the first stage, as a go-between between the platform and these stakeholders and launch thinking about how the various protagonists position themselves publicly on a map involving the three vital dimensions of "protagonist", "object", and "disputed fact". The work that we are currently doing in the Munich platform would enable us to prepare a version that would make the various protagonists in a controversy able to contribute to the database on their own. An experimental version of this platform can be viewed at the URL :
http://riskcart2.wzu.uni-augsburg.de/index.php?Lang=ENGLISH&PHPSESSID=a69e9cbdaa0647d788e91bd2727fd5c6

Given the current state of our thinking, we feel that testing the future platform (WP6) solely with the stakeholders would be chancy. The proposal that we should like to make and support most strongly is to test the platform with protagonists that might find it worthwhile to consult and/or interact with the platform as well as the stakeholders. Here we have journalists, teachers, the personnel of the regional environmental initiation centres (CRIEs), and so on in mind, that is, people who would serve as relays for communicating with the public at large. The reason for this seems obvious: It is necessary for the public dimension or public pressure to be present or exerted in order to motivate the stakeholders or make them capable of such involvement (Lippman, 2008). They must feel that the outcome of their interactions with the platform will be expected and evaluated by others. This is an intermediate pathway by means of which the social and political relevance of the platform can be tested. Without mobilising public opinion directly, such an arrangement will ensure that the various segments of the public will be present through the demands relayed by these communicators. For example, bee specialists from academia will have to couch their findings in terms that a broader public can understand, whilst apiculture, industrial, and agricultural organizations will have to set their sights on making their positions clear to their members, clients, or even consumers.

The participants approached for the testing:

Stakeholders: 1 representative of IEW;
1 representative of BAYERCropScience;
2 -3 representatives of the beekeeping community:
- head of a beekeeping federation;
- a "tester" beekeeper;
- head of CARI;

1-2 representatives of the scientific community:
- a member of FUSAGx's entomology department;
- a member of another entomology department (ULB or Ghent);

1 representative de la Walloon Agricultural Federation (FWA);
1 representative of the Walloon Region (Farm Ministry);

1 representative of AFSCA (Federal Agency for Food Chain Safety);
1 representative of the Ministry of Commodities or Federal Public Service – Health Division (FPS);
1 MEP in charge of the honey bee die-off issue.

For the users:

2 journalists (national press ad local media);
2 teachers (secondary schools and CRIE);
1-2 museum curators (federal and/or university);
1 blogger/moderator of an Internet chat forum.

Of course, these two panels will also have to voice their opinions about the other functionalities/modules presented within the platform.

We are in the process of finalizing the protocol for the testing, and are planning three meetings with the two panels before the end of June.

ANNEXES

Chronology of the die-off in Wallonia

1998-1999: First die-off findings (reported)

2001: The Pesticides Approval Committee of the FPS-Health (Federal Public Service - Health Division) re-assessed the risk of using Gaucho® treated maize (since this is a pollen-producing plant, it is possible that the risk for bees may be been underestimated in the first assessment). It concluded, however, that the product was innocuous for bees.

2002: CARI was commissioned to examine the problem within the framework of a project of the Commodities Fund (managed by the Federal Public Service - Health, Food Chain Safety, and the Environment).
"The main «objectives of this project were to determine the magnitude of the death rates and weakening of bee colonies in Wallonia, to take stock of the situation in the field in as great detail as possible, and to document the causes." (CARI 2003)

2003: In June, CARI published its final report under the above-mentioned brief, entitled *Suivi sanitaire d'urgence des ruchers présentant des symptômes de dépérissement* (Emergency Health Monitoring of Hives Showing Symptoms of Die-off). Its conclusions include the following: *"New symptoms have been observed in the areas of field crops and maize in Wallonia. …The observations made in the hives in Wallonia and information from other countries prompt us to favour several avenues that subtend chronic poisoning by neurotoxic pesticides recently used in agriculture. The new generations of these products might act as triggers, either alone or in conjunction with other pesticides, acaricides, or as yet unidentified products. This phenomenon might reinforce other sources of mortality that have been known for many years."* (CARI, 2003)

2004: CARI continued monitoring the situation in the field under an agreement with the region's Directorate-General for Natural Resources and the Environment (DGRNE). This time it was commissioned to carry out a more in-depth qualitative survey (monitoring of 15 Walloon beekeepers).
In 2004, the Walloon Region's Farm Ministry signed an agreement with Professor Haubruge's team at FUSAGx for a multifactor study of the *Apis mellifera* die-off.
On 12 February 2004, the Environment, Natural Resources, Agriculture, and Rural Affairs Committee of the Walloon Parliament held a public hearing during which the following took the floor: Etienne Bruneau (CARI), Eric Haubruge (FUSAGx), Hervé Tossen (Bayer CropScience Belgium), and representatives of various beekeeping and agricultural organizations and political parties. (COMMISSION DE L'ENVIRONNEMENT DES RESSOURCES NATURELLES DE L'AGRICULTURE ET DE LA RURALITE, 2004)

2005: As required by its agreement with DGRNE, CARI published its final report, entitled *Etat des lieux du phénomène de dépérissement des ruchers en Région Wallonne* (State of Affairs of the hive die-off phenomenon in the Walloon Region).
In an article in the magazine *Abeilles&Cie* summarising this report one can read the following: *"…the absence of differences between the agricultural areas, despite their great contrasts in terms of land use and agricultural activities, leads one to believe that we are faced with a problem whose cause or causes are widely present in the agricultural environment. The hive die-off seems to be linked to the areas of field crops, orchards, and/or the presence of maize fields."* (BRUNEAU, 2005)
At the end of 2005 the Federal Public Service's Health Division set up a joint working party under the Pesticide and Biocide Reduction Programme (PRPB) to examine the matter of bees and health policy and the problem of bees and pesticides. The oft-mentioned players who participated in this working party include Etienne Bruneau (CARI), Eric Haubruge and Bach

Kim Nguyen (FUSAGx), Edwin De Pauw and Joëlle Widart (CART – Trace Residue Analysis Centre, ULg, working with Haubruge's team), Hervé Tossens (Bayer CropScience Belgium), Pierre Hucorne and Edith Hoc from the FPS (from the "pesticides and fertilisers" and "animal and plant health policy" departments, respectively, and Janine Kievits (IEW).

2006: Creation of a "Varroa mite control strategy" group in parallel with the bees group. Its members include Etienne Bruneau (CARI), Eric Haubruge and Bach Kim Nguyen (FUSAGx), Frans Jacobs (UGhent), and H. Ramon (UVCB vzw).
2006 also marked the end of the first contract between Haubruge's team and the Walloon Region. A second agreement, however, extended its brief until 2008. In their review of the literature published in 2006, the authors recalled, *"…it is easier to incriminate a single cause, in this case pesticide use, than to listen to the environment and continually challenge oneself".* They stressed the presence of parasites and encouraged people not to minimise the importance of the weakening that they could produce (increasing sensitivity to other environmental factors, including to pesticides). Finally, they called upon the public authorities to help organize beekeeping and the development of apicultural science. (HAUBRUGE and NGUYEN et al., 2006)

2007: In June, the Federal Public Service's Health Division published the bees group's final report. In their conclusions, the authors underlined the following:
"When it comes to the pesticides strand, the group feels that a great deal of information concerning the hypothesis of poisoning due to the pesticides applied in seed coatings or to the soil was exchanged, but no consensus could be reached as to the impacts of these same products on the die-off phenomenon." (HOC and HUCORNE et al., June 2007)
Since then, the FPS - Health has taken no initiatives regarding the pesticides/bees problem. No decision came out of this group's work.

2008: In September, the FUSAGx team issued their research findings under their second agreement with the Walloon Region. They concluded that imidacloprid was not responsible for the die-off of *Apis mellifera* in Wallonia. (HAUBRUGE and NGUYEN, 12 September 2008)
Since, then, nothing has changed, the public authorities have not taken any decision, and the situation seems to be something of a stalemate.

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List of abbreviations

AFSCA: Agence Fédérale pour la Sécurité de la Chaîne Alimentaire (Federal Agency for the Safety of the Food Chain) (Belgium)

AFSSA: Agence Française de Sécurité Sanitaire des Aliments (French Food Safety Agency)

CAP: Common Agricultural Policy

CARI: Centre Apicole de Recherche et d'Information (Apiculture Research and Information Centre) (Belgium)

CCD: Colony Collapse Disorder

DGA: Direction Générale de l'Agriculture (Directorate-General for Agriculture) (Walloon Region, Belgium)

DGRNE: Direction Générale des Ressources Naturelles et de l'Environnement (Directorate-General for Natural Resources and the Environment) (Walloon Region, Belgium)

EFSA: European Food Safety Authority

EPPO: European and Mediterranean Plant Protection Organization

FNOSAD: Fédération Nationale des Organisations Sanitaires Apicoles Départementales (National Federation of Departmental Apicultural Health Organizations) (France)

FPS: "Federal Public Service"– See SPF

FUSAGx: Faculté Universitaire des Sciences Agronomiques de Gembloux (Gembloux Agricultural College) (Belgium)

FWA: Fédération Wallonne d'Agriculture (Walloon Federation of Agriculture)

IAPV: Israeli Acute Paralysis Virus

ICPBR: International Committee for Plant-Bee Relationships

IEW: Inter-Environnement Wallonie (Walloon federation of environment groups)

LD50: Lethal dose 50

PRPB: Programme des Réductions des Pesticides et Biocides (Pesticide and Biocide Reduction Programme)

SPF: *Service Public Fédéral, i.e.*, Federal departments tasked by ministries to conduct investigations on topics of interests) (Belgium)

SPF-SP: Service Public Fédéral Santé Publique, Sécurité de la Chaîne Alimentaire, Environnement (Federal Public Service - Health Division, Food Chain Safety, and the Environment) (Belgium)

UAA: Useable Agricultural Area

UFAWB: Union des Fédérations Apicoles de Wallonie et de Bruxelles (Union of Beekeeping Federations of Wallonia and Brussels)

URRW: Union Royale des Ruchers Wallons (Royal Union of Walloon Apiaries)

Glossary

Apis cerana: Latin name of the Eastern (Asian) honey bee.

***Apis mellifera*:** Latin name of the Western (European) honey bee.

Brood: The eggs, larvae and pupae of a beehive.

Depopulation: See "empty hive syndrome".

LD50 (Lethal dose 50): The indicator of a substance's acute toxicity is the LD50 or 50% lethal dose, that is to say, the amount of the substance necessary for half of the target population to die when exposed to the substance. The lower the LD50, the more toxic the substance. A substance's acute toxicity is generally tested over a 48-hour period.

Fipronil: Active substance of Regent®. It is a powerful neurotoxic of the phenylpyrazol family.

Systemic insecticides: They are called "systemic" because they spread through the plant's tissues throughout its growth cycle. They are thus found in the flower organs and, consequently, in nectar and pollen.

Imidacloprid: Active substance of Gaucho®. It is a powerful neurotoxic of the neonicotinoid family.

Metabolite: Intermediate product resulting from the metabolic breakdown of a substance.

Nosema disease: Disease caused by the microsporidia *Nosema apis* and *Nosema ceranae*. It is a sort of fungus that attacks the tissues of the bee's digestive tract.

PEC (Predicted Environmental Concentration): Predicted exposure concentration. It is used with the PNEC (PEC to PNEC ratio) to estimate the risk that a substance carries for a living thing that is exposed to it. There is a risk when the PEC is greater than the PNEC.

PNEC (Predicted No Effect Concentration): Predicted concentration at which there is no effect on living things in the environment (see "PEC").

Empty hive syndrome: Term used by beekeepers to describe a hive that contains almost no bees aside from a small handful around the queen and in which one finds no corpses, as if the bees had simply vanished.

Acute toxicity: See LD50.

Chronic toxicity: As the term indicates, this is the dose at which a substance causes the death of a living thing when it is exposed to the substance repeatedly. Chronic toxicity tests are generally carried out over a period of ten days.

Sublethal toxicity: As the term indicates, this is the dose at which a substance does not cause death, but can nevertheless affect the living thing that is exposed to it, causing, amongst other things, behavioural changes.

Varroasis: Disease caused by the mite *Varroa destructor,* which attacks the beehive's brood. Also called "varroatosis" and "varrosis".

List of useful links

GENERAL INFORMATION

- ApiWIKI: encyclopaedia on apiculture. Its contributors include beekeepers, amongst others. (In French only)
  http://www.apiwiki.eu/ver2/index.php?title=Accueil

- Wikipedia: see the article on the Western honey bee (species, life cycle, hive organization, and beekeeping):
  http://en.wikipedia.org/wiki/Western_honey_bee

- Lexique apicole de l'Union Royale des Ruchers Wallons (URRW) (beekeeping glossary – in French only)
  http://www.apiculture-urrw.be/apiculture/lexique.htm

- Encyclopédie universelle: See the article "abeille" (anatomy and history of humankind's relationship with the bee) (In French only)
  http://www.encyclopedie-universelle.com/abeille1/abeille-menu.html

- World apiculture directory
  http://www.beehoo.com/f_the.php?theme=Generalites

ABOUT THE CONTROVERSY

- ActuSciences: Brussels Free University (ULB) seminar exploring controversial subjects. The "Happy culture ? Api-rupture !" section is devoted to the "bee problem". (In French only)
  http://www.ulb.ac.be/inforsciences/actusciences/dossiers/sec/index.html

- Sciences et démocratie: A participatory site on societal debates on the influence of science and technology. There is a section devoted to the "bee problem". (In French only)
  http://www.sciences-et-democratie.net/

- Coordination gegen Bayer-Gefahren (platform against Bayer's misdeeds)
  http://www.cbgnetwork.org/

- « Menace chimique »: Belgian site challenging systemic insecticides. Audiovisual and radio excerpts about the "chemical threat". (In French only)
  http://www.menacechimique.be/

- Site of Gil Rivière-Wekstein's controversial book, « Abeilles: l'imposture écologique. L'affaire des insecticides maudits ». (In French only)
  http://www.affaire-gaucho-regent.com/index.html

- Gil Rivière-Wekstein's blog on the bee problem. (In French only)
  http://blogabeilles.affaire-gaucho-regent.com/

- « Agriculture & environnement »: Information bulletin from the economic, environmental, and strategy consulting firm founded by Gil Rivière-Wekstein. One can read here the authors (polemical and militant) positions on subjects related to agriculture and the environment, including the die-off of the Western honey bee. (In French only)
  http://www.agriculture-environnement.fr/spip.php?page=sommaire

- Inter-Environnement Wallonie (IEW): Federation of environmental defence associations of the Walloon Region. One can find a series of publications about the "bee problem" and more specifically systemic insecticides on this site. (In French only)
  http://www.iewonline.be/

- Chronology of the Gaucho® affair in France. (In French only)
  http://www.apicolturaonline.it/gaucho347.htm

BEEKEEPERS' ASSOCIATIONS

- Apimondia: International Federation of Beekeepers' Associations
  http://www.apimondia.org/

- Apiservices: Site giving a series of general information about beekeeping in many countries and beekeeping organizations.
  http://www.beekeeping.com/

  See also Apiservices's forum (Mainly in French):
  http://www.apiservices.com/cgi-local/Ultimate.cgi?action=intro&BypassCookie=true

- Syndicat des Producteurs de Miel de France (SPMF): This is the trade union of French professional beekeepers. (In French only)
  http://www.spmf.fr/

- Union Nationale de l'Apiculture Française (UNAF): This national union represents part of France's amateur beekeepers. (Mainly in French)
  http://www.unaf-apiculture.info/

- Syndicat National d'Apiculture (SNA): With UNAF, this is the other major French union of amateur beekeepers. (In French only)
  http://www.apiservices.com/sna/index.htm

- Centre Apicole de Recherche et d'Information (CARI) (Belgium). In connection with the *Apis mellifera* die-off problem, this association is strongly involved in setting up a new pesticide risk assessment procedure. (In French only)
  http://www.cari.be

- Union Royale des Ruchers Wallons (URRW). (In French only)
  http://www.urrw.be/

- Union des Fédérations Apicoles de Wallonie et de Bruxelles (UFAWB). (In French only)
  http://www.apimonde.com/

BELGIAN INSTITUTIONS

- Service Public Fédéral (SPF) Santé Publique (Belgian Federal Public Health Ministry)
  https://portal.health.fgov.be/portal/page?_pageid=56,512460&_dad=portal&_schema=PORTAL

- AFSCA: site of Belgium's Federal Agency for Food Chain Safety – "Beekeeping report" (legal framework in particular). (In French and Dutch only)
  http://www.afsca.be/sp/pa/prod-api-1_fr.asp

- *Moniteur belge/Belgisch Staatsblad*: Complete collection of Belgian legislation. (in French and Dutch only).
  http://www.ejustice.just.fgov.be/cgi/welcome.pl

- Fytoweb: site listing all the plant protection products approved in Belgium complete with their characteristics. (In French or Dutch)
  http://www.fytoweb.fgov.be/indexFr.asp

- Walloon agriculture portal. (In French only)
  http://agriculture.wallonie.be/apps/spip_wolwin/

EUROPEAN INSTITUTIONS

- EUR-lex: access to laws of the European Union
  http://eur-lex.europa.eu/fr/index.htm

- EPPO: European and Mediterranean Plant Protection Organization
  http://www.eppo.org/

- EFSA: European Food Safety Authority
  http://www.efsa.europa.eu/

OTHER LINKS

- Agriculture, biodiversité et abeilles – la biodiversité, c'est l'affaire de tous: The agriculture, biodiversity, and bees network site on apicultural fallows (a BASF Agro initiative) in France. (In French only)
  http://www.jacheres-apicoles.fr/

Documents available on line

- AFSCA, *Arrêté royal fixant les modalités des agréments, des autorisations et des enregistrements préalables délivrés par l'Agence fédérale pour la Sécurité de la Chaîne alimentaire*, AFSCA, Editor. 16 January 2006. (In French, Dutch and German)

  Available on the site of the *Moniteur belge/Belgisch Staatsblad*
  http://www.ejustice.just.fgov.be/cgi/welcome.pl

- AFSSA, *Enquête prospective multifactorielle: influence des agents microbiens et parasitaires, et des résidus de pesticides sur le devenir des colonies d'abeilles domestiques en conditions naturelles*. 2008. (In French only)

  Available at the following address:
  http://www.afssa.fr/Documents/LABO-Ra-EnqueteAbeilles.pdf

- ANDERSON, D. and I.J. EAST, *The Latest Buzz About Colony Collapse Disorder*. Science, February 2008. **319**: pp. 724-725.

  Available at the following address:
  http://www.sciencemag.org/cgi/reprint/319/5864/724c.pdf

- CARI, *Suivi sanitaire d'urgence de ruchers présentant des symptômes de dépérissement: Projet FF 02/15 (414) du Fonds Budgétaire des Matières Premières avec la participation de la Région Wallonne (équipe PRIME) et du programme européen 1221/97 "Miel". Rapport final*. 2003, CARI: Louvain-la-Neuve. (In French only)

  Available at the following address:
  ftp://ftp2.menacechimique.be/menacech/RAP_FINAL2_MAI_2003.pdf

- COMMISSION DE L'ENVIRONNEMENT DES RESSOURCES NATURELLES DE L'AGRICULTURE ET DE LA RURALITE, *Problématique de la disparition des abeilles. Compte rendu analytique*. 2004, Parlement Wallon: Namur. (In French only)

  Available at the following address:
  http://www.fsagx.ac.be/zg/Sujets_d_actualit%C3%A9/Abeilles/Compte-rendu%20Parlement%20Wallon%202004%20(1%C3%A8re%20partie).pdf

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  Available at the following address:
  http://www.sciencemag.org/cgi/reprint/318/5848/283.pdf

- COMITE SCIENTIFIQUE ET TECHNIQUE DE L'ETUDE MULTIFACTORIELLE DES TROUBLES DES ABEILLES, *Imidaclopride utilisé en enrobage de semences (Gaucho) et troubles des abeilles. Rapport final.* September 2003. (In French only)

  Available at the following address:
  http://agriculture.gouv.fr/IMG/pdf/rapportfin.pdf

- COUNCIL OF THE EUROPEAN COMMUNITIES (1991). Council Directive of 15 July 1991 concerning the placing of plant protection products on the market (91/414/EEC). European Union. Luxembourg, Office of Publications.

  French version:
  http://eur-lex.europa.eu/LexUriServ/site/fr/consleg/1991/L/01991L0414-20051201-fr.pdf

  English version:
  http://eur-lex.europa.eu/LexUriServ/site/en/consleg/1991/L/01991L0414-20051201-en.pdf

- HAUBRUGE, E., et al., *Le dépérissement de l'abeille domestique,* Apis mellifera *L., 1758 (*Hymenoptera: Apidae*): faits et causes probables.* Notes fauniques de Gembloux, 2006(59 (1)): p. 3-21. (in French only)

  Available at the following address:
  http://www.fsagx.ac.be/zg/Personnel/Cv/pdf%20zoologie/1551-1600/1585.pdf

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  Available at the following address:
  http://www.fsagx.ac.be/zg/Sujets_d_actualit%C3%A9/Abeilles/Bilan/Presentation12%20septembre2008.pdf

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