

The puzzle of honey bee losses: a brief review

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Abstract

The impact of pesticides on honey bees is an issue that has been studied for many years and is now being reconsidered because controversy still exists with the relationship of insecticides and Colony Collapse Disorder (CCD). It is insufficient to explain CCD with only bee pathology studies. Research must be conducted on a wider series of causes: i) in open field and agroecosystems, to understand the fate of pesticide blends, ii) in the hives, to determine ways to enhance honey bee defence to diseases and parasites. References regarding imidacloprid and CCD in the maize agroecosystems are critically reviewed. Pesticides and the techniques to rationally use them (in particular following the integrated pest management guidelines) represent one of the several puzzles regarding the mystery of CCD or honey bee vanishing. An appendix, i.e., a rejected letter to *Science* and relevant reply, is also reported.

Key words: pesticides, side-effects, sub-lethal, maize sowing, imidacloprid, honey bee.

Introduction

For many years a group of entomologists at Bologna University and the National Institute of Apiculture (now CRA-API) worked on honey bees and studied the possibility of adopting *Apis mellifera* L. as a bioindicator of environmental pollution in Italy (Celli *et al.*, 1985; Celli and Porrini, 1988; Porrini *et al.*, 2002; Celli and Macagnani, 2003). In agroecosystems, new and old active ingredients applied for pest control can kill many beneficial insects and the residues of such active ingredients can be found both in the bodies of dead adult honey bees, and in hive products (Porrini *et al.*, 2003).

Pesticides are applied in different environmental conditions, with different application technologies and concentrations. Moreover, pesticide use is regulated by laws specific to individual countries, the type of crop, period of year, and agroecosystem. Combined with other stress factors, agrochemicals are suspected to contribute to the recent honey bee 'mystery' known as 'honey bee vanishing' or Colony Collapse Disorder (CCD), as mainly indicated in North America.

Many hypotheses are available on the problem of declining bee populations and the related economic damage for beekeepers and agriculture. We believe that the problem is made worse by some in the media who sensationalize and report unsupported data and opinion. Such sensationalizing and the use of unsupported data are, unfortunately, not restricted to the media and can be made by scientists who report data that are not sufficiently verified, come from suspected sources, and/or fail to cite the relevant research. We feel that the latter is of special concern because in some published manuscripts neither the author(s), reviewer(s), and editor(s) were acquainted with competing literature.

The recent concern over honey bee losses is a poorly understood phenomenon. As recently as March 15, 2010 in *The Washington Post*, Jeffery S. Pettis (research leader for the USDA-ARS Honey Bee Laboratory in Beltsville) said: "I am very concerned about on what we have seen in California and other parts" of the United States. It is evident that as we enter the spring season,

CCD is still an unsolved problem. Unfortunately, CCD in several Italian localities continues and remains a very important global issue. The debates between beekeepers, farmers, pesticide producers, environmentalists, and researchers are ongoing.

Despite the fact that CCD is unanimously considered by scientists to depend on several causes, two camps are now in conflict. On the one side are the environmentalists/beekeepers and on the other pesticide companies and the scientists sponsored by them. It is impossible to 'demonstrate scientifically' the direct influence that the pesticide corporations, seed companies, and some farm lobbies, have on research teams that conduct research on honey bees – especially that related to CCD. There are several international and national projects investigating CCD, examples include COLOSS and APENET, respectively. Globally many other projects are being carried out, while some of these are sponsored by public funding, others are supported by the pesticide corporations. In the latter case, are the scientific results and hypothesis influenced?

The International Commission for Plant Bee Relationships (ICP-BR) - Bee Protection Group since 1980 has investigated on the hazards of pesticides to honey bees. The data on honey bees have stimulated the research to obtain information on other pollinators. We believe that gathering such data may be important for the enhancement of regulatory risk assessments designed at reducing the impact of pesticides on bees (Lewis *et al.*, 2007).

The purpose of this brief review is to comment, and stimulate discussion, on recent papers published by Nguyen *et al.* (2009), Chauzat *et al.* (2009), and Ratiieks and Carreck (2010). In response to the paper of Nguyen *et al.* (2009) we have submitted a critical manuscript to the *Journal of Apicultural Research* but, six months after the submission it was rejected by the senior editor Prof. Norman L. Carreck. Another submission of a short letter to *Science* was rejected too. We believe strongly that the proper use and evaluation of pesticides is one of the most important issues facing scientists, environmentalists, and farmers today. Therefore, we decided to publish here some opinions regarding pesticide

treatments that can seriously affect honey bee health, particularly in maize. At the end of this paper (appendix) we attach the letter sent by the first author to the journal *Science* and the reply relevant to the rejection is presented to our readers.

In Italy, the suspension of sowing dressed maize seeds provoked many reactions in the popular press and other media. We believe that papers published in scientific journals influence politicians and legislators preparing rules regarding prohibition and limitation of pesticide use. Scientific papers that indicate no hazard of pesticides and refuse to discuss data offering contrary opinions on the effect of pesticides on honey bees and other beneficial insects may cause an underestimation of the real damages that agrochemicals inflict on ecosystems.

Possible impact on honey bees of sowing dressed maize seeds

In a recently published article, Nguyen *et al.* (2009), the last two lines of the abstract, report: “Our results support the hypothesis that imidacloprid seed-treated maize has no negative impact on honey bees”. Verbatim this sentence is strong but based on a weak hypothesis, because it only concerns the Belgian conditions. Furthermore, should the readers of Nguyen *et al.* (2009) not study the text thoroughly; they might misunderstand the real hazard of this agronomic practice. Other studies have scientifically demonstrated the negative impact of imidacloprid-coated maize seeds on honey bees. Some of these results, not cited by Nguyen *et al.* (2009), were published in the *Bulletin of Insectology* 2003 (available online for free) in the ‘Proceedings 8th International Symposium of the ICP-BR Bee Protection Group – Hazards of Pesticides to Bees – Bologna, September 4-6, 2002’. A discussion of these controversial data was published too.

With regard to all the papers presented during the Symposium, Nguyen *et al.* (2009) only reported the reference of Maus *et al.* (2003) (i.e. Bayer researchers). The main conclusion of Maus *et al.* (2003) was: “crops grown from seeds dressed with imidacloprid do not pose any significant risks to honeybees under field conditions”. On the contrary, the paper of Greatti *et al.* (2003) and Greatti *et al.* (2006) (data related to northeastern Italy) indicated that, during maize sowing, pesticide dust is dispersed from the sowing machine, drifts to the wild vegetations and negatively impacts foraging bees. Based on the highly systemic properties of imidacloprid, the Belgian colleagues (Nguyen *et al.*, 2009) investigated in open fields on correlation between bee poisoning and the presence of dressed-seed maize areas. The experiments were designed to detect a possible summer intoxication caused by pollen collections from maize fields sowed during the spring. The aim of the Nguyen *et al.* (2009) paper was to study imidacloprid’s side-effects on honey bees later in the maize growing season. However, it was already suspected that side- and subsequently sub-lethal effects might be observed on honey bees after the overwintering period, when foragers collect pollen, nectar, honey dew, water, etc. on wild vegetation at the border of maize

fields. The poisoning, for instance, could be related not only to ingestion of insecticide-contaminated pollen produced by treated plants but also to the pesticide drift observed during the sowing of coated maize seeds.

In agreement with these findings are the latest observations made during the spring of 2008 in southern Germany (van Engelsdorp and Meixner, 2010). The weather conditions during, and just after, sowing and the type of drilling machine (i.e. pneumatic or not) are also important and must be considered in any pesticide evaluation. Laboratory data also suggest the possibility of honey bee poisoning due to the toxic guttation drops from maize plant grown up from imidacloprid-coated seeds (Girolami *et al.*, 2009). In Mediterranean areas, maize sowing starts earlier than in northern Europe, with periods of scattered rain and wind. These environmental factors must also be considered in any proper evaluation of pesticides. Thus, the reported differences in side-effects on coated seed on honey bees might very well depend upon circumstances (figure 1) (Porrini *et al.*, 2009).

Regarding sub-lethal effects, the paper of Nguyen *et al.* (2009) was probably submitted for publication before the paper of Yang *et al.* (2008), so the Belgian authors could not cite the latter study. Nevertheless, other data on the effects of low doses of imidacloprid on honey bees can easily be found in the literature. Kirchner (1999), for example, found that a dose above 20 ppb, “causes not only a reduction in the foraging activity of treated bees, but also induces trembling dances that discourage other worker bees from foraging. The waggle dance that communicates foraging direction becomes less precise”. However, the data of Schmuck *et al.* (2001) - Bayer researchers - indicate no damage at a feeding dose concentrations of 20 ppb. The papers of: Suchail *et al.* (2001a; 2001b), Pham-Delegue *et al.* (2002), Medrzycki *et al.* (2003), Bortolotti *et al.* (2003), Decourtye *et al.* (2004a), Bonmatin *et al.* (2005b) all demonstrated several negative side-effects of imidacloprid and also found residues in maize pollen that can be collected by foraging bees late in the season (Bonmatin *et al.*, 2005a). Concentrations as low as 6 ppb of imidacloprid and 2 ppb of fipronil have caused observed sub-

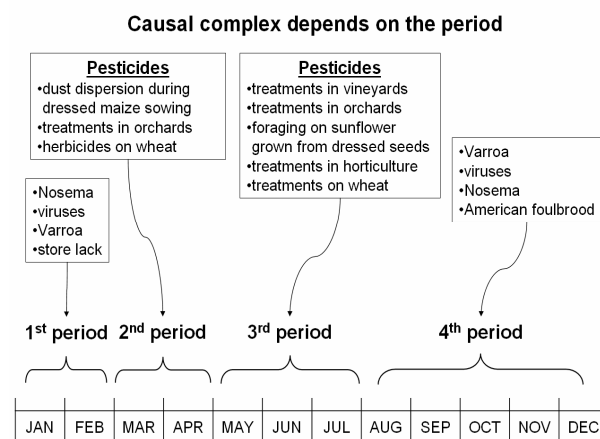


Figure 1. Main mortality factors affecting honey bees in northern Italy.

lethal effects (Colin *et al.*, 2004). Recently, Yang *et al.* (2008) clearly confirmed – again – these previous data. Particularly in open fields abnormal foraging behaviour of honey bees was observed. The effect on foragers indicated that: “... the normal foraging interval of honey bee workers was within 300 seconds. However, these honey bee workers delayed their return visit for > 300 seconds when they were treated orally with sugar water containing imidacloprid. This time delay in their return visit is concentration-dependent and the lowest effective concentration was found to be 50 µg/liter”.

Pesticide exposure and diseases affecting bees

In general the research on sub-lethal effects of pesticides is a complicated topic particularly in social insects (Desneux *et al.*, 2007).

Past examples of low levels of insecticides that are responsible for decreasing the number of honey bee colonies available for pollination and reducing the honey bees' effectiveness as pollinators are reported. Sub-lethal doses of deltamethrin disrupt the homing flight of honey bees (Vandame *et al.*, 1995). Parathion disrupts the communication dance of foragers (Schrickler and Stephen, 1970). Furthermore, sub-lethal exposure to permethrin retards learning as measured by the classical conditioning of proboscis extension response (PER) (Mamood and Waller, 1990; Taylor *et al.*, 1987; Decourtye and Pham-Delegue, 2002). Insecticides considered harmless to bees actually interfere with associative learning (Abramson *et al.*, 1999; Abramson *et al.*, 2004; Decourtye *et al.*, 2004b).

The concern about the chronic exposure to sub-lethal doses of insecticides (fipronil, acetamiprid and thiamethoxam) on honey bees was recently discussed by Aliouane *et al.* (2009).

Fungicides are usually considered safe for honey bees and beneficial insects. However, captan and the propiconazole (ergosterol biosynthesis inhibitor - EBI) can affect *Osmia lignaria* Say and *A. mellifera* (Ladurner *et al.*, 2005). Propiconazole and myclobutanil can be synergists for the insecticide cyhalotrin inducing negative side-effects on bees (Pilling and Jepson, 1993). Pesticide residues in hives positioned in apple orchards can affect honey bees (Smodiš Škerl *et al.*, 2009). In Slovenia these latter authors indicate: “... insecticide residues remain in pollen loads when using doses appropriate for crop protection purposes, and regularly contaminate the grass and undergrowth in orchards”. Mullin *et al.* (2010) indicates that: “frequent coincidence in pollen of high levels of the non-systemic fungicide chlorothalonil with lower levels of systemic pesticides including fungicides is another probable synergistic combination that needs further exploration concerning bee decline”.

The effect of pesticides may be studied not only on adults but also with the larvae. In bumble bees Mommmaerts *et al.* (2006) found that although no lethal effect could be detected on adults, the use of insecticides (IGR) has strong effects on colony growth and larval development. Pesticides considered harmless to *Osmia cornuta* (Latreille) adults can manifest a toxic impact on

larvae (Tesoriero *et al.*, 2003). Studies on honey bee larvae are reported by Davis *et al.* (1988), Desneux *et al.* (2007) and the in vitro rearing of artificial feeding to test side-effects of pesticides on different stages of larvae is described by Aupinel *et al.* (2005).

Sub-lethal effects were also reported in causing stress and may lower resistance to pathogens such as *Nosema* sp. (Alaux *et al.*, 2010). Diana Cox-Forster in Stokstad (2007) “suggests that the discovery of so many kinds of pathogens in the collapsed colonies indicates that the bees in them, for whatever reason, have suppressed immune systems”. Although many papers regarding bee diseases and parasite attacks are recently published, some references are much older e.g., 1906 Isle of Wight disease! See: Bowen-Walker and Gunn, 2001; Amdan *et al.*, 2004; Yang and Cox-Foster, 2007; Neumann and Carreck, 2010.

The recent supplemental issue of the *Journal of Invertebrate Pathology* emphasized pathogens and parasites that cause honey bee decline. Sponsored by 5 corporations, the Sponsorship Statement suggests the possibility that pesticides have negative side-effects on bees and states verbatim: “Unfortunately, honeybees, like all organisms are subject to diseases caused by pathogens, among these being various viruses, bacteria, and fungi. In addition, the use of chemical insecticides, especially when used improperly, can take a heavy toll on bee populations”. But can we be sure that even in the case of proper agrochemical use, no honey bee damage occurs? The paragraph about the ‘Non-disease factors influencing managed honey bee populations’ in the van Engelsdorp and Meixner (2010) historical review, indicate the presence of dangerous pesticide residues. Further, pesticide impacts differ between Germany and the United States. In all the other papers published in this supplemental issue, the focus seems to shift away from the effect of pesticides to other mortality factors. As but one example, consider Ratnieks and Carreck (2010) who stated: “consensus seems to be that pests and pathogens are the single most important cause of bee colony losses”.

In general it is possible to demonstrate the causes by symptoms (i.e. some typical honey bee adult dead or appearance of colony mortality in the hive), but in the case of CCD event is not. The hypothesis that CCD is linked to diseases and parasites is supported by the data. Other data, however, indicate that among these many factors, the relationship between agrochemicals, particularly imidacloprid applications and honey bee mortality, is scientifically sound and well demonstrated in particular areas. Since the late 1990s, for example, many peer reviewed journals have published papers on toxicity and poisoning of honey bees, wild bees and other pollinators (Tasei, 2002). Bumble bees are also affected by imidacloprid (Tasei *et al.*, 2000; Bortolotti *et al.*, 2002) and at more than one month after the treatment in greenhouses, pesticide residues may still be dangerous to these pollinators (Sterk and Benuzzi, 2004). Finally, imidacloprid metabolites are very toxic to arthropods and may be hazardous to other organisms. The study of imidacloprid metabolites is a particular important and seldom studied research area that can provide important new data (Suchail *et al.*, 2001b).

Is it possible to mitigate pesticide side-effects on the honey bee? Is the farm economy damaged by a reduced use of pesticides?

In the case of pesticide-coated maize seeds, we suggest to follow the Integrated Pest Management (IPM) techniques. Instead of merely preventing possible attack by pest insects, farmers must know when, and if, the pesticide seed dressing is really necessary. In this particular agroecosystem (maize is not a typical cash crop), we strongly believe that the available data suggests that the negative side-effects of pesticide-coated maize seeds are so dangerous to honey bees, other beneficial insects and to the environment, that it should not be used.

As a consequence of only relying upon insecticides, crop pests may actually increase. For instance, the European corn borer, *Ostrinia nubilalis* (Hubner) (Lepidoptera Crambidae), damage to maize appears to be favoured due to the reduction of predators following the use of imidacloprid seed treatment (Albajes *et al.*, 2003). Few data in the literature demonstrate the necessity of adopting insecticide-coated maize seeds to obtain an increase yield. In Spain, no benefit was observed (Albajes *et al.*, 2003). Similar data regarding northeastern Italy are also available. Monitoring by direct sampling or pheromone traps to forecast possible heavy damages by click beetles and other ground insect pests, is the typical way to rationally deal with good agronomical practices (Furlan, 2005). As an example, IPM can be adopted to reduce damage made by the new established pests in northern Italy, including the western corn rootworm, *Diabrotica virgifera virgifera* LeConte (Coleoptera Chrysomelidae). This pest is already resistant to several pesticides. Crop rotation together with monitoring using pheromone traps will be the best way to mitigate the insecticide resistance and rootworm invasion (Furlan *et al.*, 2006).

In crops other than maize, pesticide treatments must be regulated following IPM guidelines such as not allowing pesticide use during the blossom period. Farmers must be made aware that many active ingredients with long persistence can be hazardous to honey bees and beneficial insects. They must also be made aware that pesticide residues on honey bees can be easily detected as demonstrated by the huge research program carried out in the United States (Mullin *et al.*, 2010).

Despite many references and data reported in the literature, the French authors Chauzat *et al.* (2009) state: "To our knowledge, this study is the first attempt to quantify the effects of pesticide residues on honey bee colony health under field conditions". Nevertheless, the problem was studied by many authors even before 2009 (as example: Atkins *et al.*, 1981; Anderson and Glowka, 1984; Anderson and Wojtas, 1986; Sanford, 1993, Koch and Weisser, 1997; Schmidt *et al.*, 2003; Bonmatin *et al.*, 2005b) and it is important to stress that abnormal bee mortality is one of the symptoms of colony health's impairment. In Italy too, the effects of pesticides in open fields were examined (Celli and Gattavecchia, 1984; Celli *et al.*, 1985; Celli and Porrini, 1988; Giordani *et al.*, 1979; Porrini *et al.*, 2002; Greatti *et al.*, 2003). The statement of Chauzat *et al.* (2009) that: "no statistical relationship was found between colony mor-

tality and pesticide residues", appears very optimistic and differs in respect to previous French opinion and the latest findings by Bonmatin *et al.* (2005b), Rortais *et al.* (2005) and Halm *et al.* (2006) that indicate concentrations of imidacloprid found in the field are large enough to damage honey bees.

In the case of the insecticide use in the maize agroecosystem, any pesticide-coated seed application in our opinion represents a non-sustainable practice.

It is evident that farmers, beekeepers and society in general can obtain economic and environmental advantages by adopting IPM. No references about this aspect are reported in the Nguyen *et al.* (2009) paper. In some situations (particularly in Italy) since 2008 (the seasons 2009 and 2010 this practice was suspended by law) the choice to use pesticide-coated maize seeds, or not to use such seeds, was not an easy decision for the farmers to make because usually only pesticide-coated seeds were sold by seed companies. As reported before, this agronomical practice (i.e. sowing of insecticide-dressed maize seeds) is not cost effective for farmers and, at least in Italy, could provide hazard to honey bees and other beneficial insects. Recently, for example, some still unpublished field and laboratory trials indicated that the neonicotinoids have sub-lethal side-effects on the two-spot ladybird *Adalia bipunctata* (L.) (Lanzoni *et al.*, in press). In laboratory experiments, Papachristos and Milonas (2008) have demonstrated a detrimental effect at sub-lethal doses of two soil applied insecticides (imidacloprid and carbofuran) on development, survival and fecundity on the ladybird *Hippodamia undecimnotata* (Schneider).

Generally speaking there is no doubt that imidacloprid and other pesticides are dangerous at very low doses to beneficial insects. Oldroyd (2007) reports: "when insecticides are used, honey bee losses are common, and where bees are required for pollination, careful management is required to minimize bee losses" and further: "Insecticides must be applied in a manner that is non-hazardous to bees and other beneficial organisms". But as with all risk assessment, it is difficult to foresee all possible consequences of wide-spread usage of particular compounds. Perhaps some new insecticide-related phenomenon is now manifesting as CCD". Since 1988, Haynes (1988) indicates the importance of sub-lethal effects of neurotoxic insecticides on insect behaviour and reports: "The assumption that a colony of honeybees is healthy simply because no increase in mortality is noted immediately after exposure to an insecticide may not be valid". Thompson (2003) stressed the importance of considering the wide variety of sub-lethal effects of pesticides on bee behaviour, ranging "from effects on odour discrimination to loss of foraging bees from disruption of their homing behaviour. Many of the reported effects occurred at levels at or below those estimated as likely occur, in the short term, following field application".

The case of Italian maize sowing with imidacloprid coated seed can be one of the several that may occur in the field. The fact that in some apiaries, following this kind of treatment, bees are healthy as immediately detected, is not an indication of harmless effects on honey bees, as reported by Haynes (1988) and Medrzycki *et al.* (2009). The

concern about these agronomical practices discussed in the papers published by Italian researchers was important to forbid the use of coated maize seeds. The results of the Italian studies clearly suggest that one neglected area of cooperation between scientists and the agro industry is in the design of more efficient sowing machinery and a better preparation for seed insecticide coating that will reduce drift and hazards for beneficial insect (Maini, 2008). These findings may be useful to enhance bee protection if this method of pesticide application is again legalized.

Conclusion

The European Environmental Agency (EEA) discusses 12 lessons and the last is: “avoid paralysis by analysis” (Harremoës *et al.*, 2001). We believe that this fits the case of pesticide hazards to honey bees (Maxim and van der Sluijs, 2007). In fact, if scientists use more refined analytical detection tools (i.e. reducing LOD - level of detection) the problems remain with a classical ‘uncertainty’ and no decisions are made by decision-makers. The previous paper of Chauzat *et al.* (2009), just for imidacloprid in the pollen load, indicated a LOD of 0.2 ppb but in Mullin *et al.* (2010) the LOD is 2 ppb. Comparisons are not always easy to do between different laboratories and analytical methodologies (Suchail *et al.*, 2001a).

In field experiments, honey bees may show different ranges of susceptibility with high variability and controversial data are difficult to be statistically analysed. Stress, due to mixtures of pesticides or other toxic ingredients collected by honey bees in polluted areas, may induce diseases as shown in recent studies reported by Alaux *et al.* (2010). Recently, another possible stress factor induced by pesticides has been discovered. During the early spring, colonies may have difficulties in maintaining an optimum hive temperature (Medrzycki *et al.*, 2010) causing the rearing of low-fitness honey bees.

Another important issue is the use, in the hive, of the miticides to control the *Varroa destructor* (Anderson et Trueman). These miticides could be applied by beekeepers incorrectly affecting honey bee health (Lodevani *et al.*, 1992; Tremolada *et al.*, 2004).

The agrochemical industry stakeholders may contest this situation clearing the pesticide treatments in open fields for protection of honey bees to reduce mortality or CCD. So usually these long debates impact regulatory policy.

Goulson *et al.* (2008) reviewed the literature on the effects of sub-lethal pesticides on beneficial insects and reported data that support Mineau *et al.* (2008). In fact, the latter authors state: “Mounting evidence suggests that pollinators worldwide are experiencing dramatic population declines, and exposure to pesticides is one of the factors that can account for this”. So we need to suggest that farmers adopt a safer use of pesticides. Mineau *et al.* (2008) also report: “... application rates and oral or contact toxicity (but the latter especially) can be used to predict the likelihood that honey bee mortality will occur. Model predictions also suggest that some insecticides carry an extreme risk for bees, despite the lack of documented incidents”.

The criticisms discussed in this brief review must be considered as constructive. We hope to clarify (particularly in Italian agroecosystems) that weather conditions, kind of machinery used, timing of sowing and the active ingredient must be taken into account in order to reduce not only the damages caused by pests but also the hazard to honey bees and other beneficial insect populations. The wild bee populations also must be studied to predict any decline due to pesticide exposure and other factors. In Italy, for example, a survey was administered to locate various species and populations of wild bees. Results indicate a lower number of species than those listed in the Italian Checklist. As reported by Quaranta *et al.* (2004): “The specimens account for a total of 355 species (38% of the species listed in the Checklist of the Italian Fauna). The 74.6% (total No. 265) of these was found in the agroecosystems, and the 81.4% (total No. 289) in the seminatural landscapes”. Recently, Manino *et al.* (2010) indicate a possible decrease or shrinking in the *Bombus* sp. in the Susa Valley (Italy). Once again Mullin *et al.* (2010) reported: “The widespread occurrence of multiple residues, some at toxic levels for single compounds, and the lack of any scientific literature on the biological consequences of combinations of pesticides, argues strongly for urgent changes in regulatory policies regarding pesticide registration and monitoring procedures as they relate to pollinator safety. This further calls for emergency funding to address the myriad holes in our scientific understanding of pesticide consequences for pollinators”. The abstract of Mullin *et al.* (2010) concludes: “While exposure to many of these neurotoxicants elicits acute and sublethal reductions in honey bee fitness, the effects of these materials in combinations and their direct association with CCD or declining bee health remains to be determined”, so with this sentence are we continuing to follow the paralysis by analysis? As the last sarcastic EEA lesson points out.

We are conscious that the CCD puzzle will be very difficult to unravel. We strongly believe that the data show that pesticide involvement is a large piece. It is for posterity to judge and fit into place the last piece; to understand what happened to the honey bees during the last years of the second millennium and the first years of the third millennium.

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References

- ABRAMSON C. I., AQUINO I. S., RAMALHO F. S., PRICE J. M., 1999.- Effect of insecticides on learning in the Africanized honey bee (*Apis mellifera* L.).- *Archives of Environmental Contamination and Toxicology*, 37: 529-535.
- ABRAMSON C. I., SQUIRE J., SHERIDAN A., MULDER P. G., 2004.- The effect of insecticides considered harmless to honey bees (*Apis mellifera*): proboscis conditioning studies by using the insect growth regulators tebufenozide and diflubenzuron.- *Environmental Entomology*, 33 (2): 378-388.

- ALAUX C., BRUNET J-L., DUSSAUBAT C., MONDET F., TCHAMITCHAN S., BRILLARD J., BALDY A., BELZUNCES L. P., LE CONTE Y., 2010.- Interactions between *Nosema* microspores and a neonicotinoid weaken honeybees (*Apis mellifera*).- *Environmental Microbiology*, 12 (3): 774-782.
- ALBAJES R., LÓPEZ C., PONS X., 2003.- Predatory fauna in cornfields and response to imidacloprid seed treatment.- *Journal of Economic Entomology*, 96 (6): 1805-1813.
- ALIOUANE Y., EL HASSANI A. K., GARY V., ARMENGAUD C., LAMBIN M., GAUTHIER M., 2009.- Subchronic exposure of honeybees to sublethal doses of pesticides: effects on behavior.- *Environmental Toxicology and Chemistry*, 28 (1): 113-122.
- AMDAM G. V., HARFELDER K., OMHOLT S. W., 2004.- Altered physiology in worker bees (Hymenoptera: Apidae) infested with the mite *Varroa destructor* (Acari: Varroidae): a factor in colony loss during overwintering.- *Journal of Economic Entomology*, 97: 741-747.
- ANDERSON J. F., GLOWA W., 1984.- Insecticidal poisoning of honey bees in Connecticut.- *Environmental Entomology*, 13 (1): 70-74.
- ANDERSON J. F., WOJTAS M. A., 1984.- Honey bees (Hymenoptera: Apidae) contaminated with pesticides and polychlorinated biphenyls.- *Journal of Economic Entomology*, 79 (5): 1200-1205.
- ATKINS E. L. KELLUM D., ATKINS K. W., 1981.- *Reducing pesticide hazards to honey bees: mortality prediction techniques and integrated management strategies*.- Leaflet 2883, Division of Agriculture Sciences, University of California, Berkeley, USA.
- AUPINEL P., FORTINI D., DUFOUR H., TASEI J-N., MICHAUD B., ODOUX J-F., PHAM-DELEGUE M-H., 2005.- Improvement of artificial feeding in a standard in vitro method for rearing *Apis mellifera* larvae.- *Bulletin of Insectology*, 58 (2): 107-111.
- BONMATIN J. M., MARCHAND P. A., CHARVET R., MOINEAU I., BENGSCHE E. R., COLIN M. E., 2005a.- Quantification of imidacloprid uptake in maize crops.- *Journal of Agricultural and Food Chemistry*, 53: 5336-5341.
- BONMATIN J. M., MOINEAU I., CHARVET R., COLIN M. E., FLECHE C., BENGSCHE E. R., 2005b.- Behaviour of imidacloprid in fields. Toxicity for honey bees, pp. 483-494. In: *Environmental chemistry: green chemistry and pollutants in ecosystems* (LICHTFOUSE E., SCHWARZBAUER J., ROBERT D., Eds).- Springer-verlag, Berlin, Germany.
- BORTOLOTTI L., PORRINI C., SBRENNI G., 2002.- Effetti dell'imidacloprid nei confronti di *Bombus terrestris* (L.) Prove di laboratorio.- *Informatore Fitopatologico*, 52 (3): 66-71.
- BORTOLOTTI L., MONTANARI R., MARCELINO J., MEDRZYCKI P., MAINI S., PORRINI C., 2003.- Effects of sub-lethal imidacloprid doses on the homing rate and foraging activity of honey bees.- *Bulletin of Insectology*, 56 (1): 63-67.
- BOWEN-WALKE P. L., GUNN A., 2001.- The effect of the ectoparasitic mite, *Varroa destructor* on adult worker honey bee (*Apis mellifera*) emergence weights, water, protein, carbohydrate, and lipid levels.- *Entomologia Experimentalis et Applicata*, 101: 207-217.
- CELLI G., GATTAVECCHIA C., 1984.- Primi dati sulla tossicologia dell'alveare in Romagna.- *Bollettino dell'Istituto di Entomologia "Guido Grandi" della Università degli Studi di Bologna*, 38: 205-216.
- CELLI G., MACCAGNANI B., 2003.- Honey bees as bioindicators of environmental pollution.- *Bulletin of Insectology*, 56 (1): 137-139.
- CELLI G., PORRINI C., 1988.- Apicidi e residui di pesticidi nelle api e nell'alveare in Italia (1983-1986).- *Bollettino dell'Istituto di Entomologia "Guido Grandi" della Università degli Studi di Bologna*, 42: 75-86.
- CELLI G., PORRINI C., TIRAFERRI S., 1985.- Rapporti tra apicoltura e ambiente. L'ape come indicatore biologico dei pesticidi (con particolare riferimento alla provincia di Forlì). (Nota preventiva).- *Bollettino dell'Istituto di Entomologia "Guido Grandi" della Università degli Studi di Bologna*, 39: 231-241.
- CHAUZAT M-P., CARPENTIER P., MARTEL A-C., BOUGEARD S., COUGOULE N., PORTA P., LACHAIZE J., MADEC F., AUBERT M., FAUCON J-P., 2009.- Influence of pesticide residues on honey bee (Hymenoptera: Apidae) colony health in France.- *Environmental Entomology*, 38 (3): 514-523.
- COLIN M. E., BONMATIN J. M., MOINEAU I., GAIMON C., BRUN S., VENMANDERE J. P., 2004.- A method to quantify and analyze the foraging activity of honey bees: relevance to the sublethal effects induced by systemic pesticides.- *Archives of Environmental Contamination and Toxicology*, 47: 387-395.
- DAVIS A. R., SOLOMON K. R., SHUEL R. W., 1988.- Laboratory studies of honeybee larval growth and development as affected by systemic insecticides at adult-sublethal levels.- *Journal of Apicultural Research*, 27: 146-161.
- DECOURTYE A., PHAM-DELEGUE M-H., 2002.- The proboscis extension response: assessing the sublethal effects of insecticides on the honey bee, pp. 67-84. In: *Honey bees: estimating the environmental impact of chemicals* (DEVILLERS J., PHAM-DELEGUE M-H., Eds).- Taylor & Francis, London, UK.
- DECOURTYE A., DEVILLERS J., CLUZEAU S., CHARRETON M., PHAM-DELEGUE M-H., 2004a.- Effects of imidacloprid and deltamethrin on associative learning in honey bees under semi-field and laboratory conditions.- *Ecotoxicology and Environmental Safety*, 57 (3): 410-419.
- DECOURTYE A., ARMENGAUD C., RENOU M., DEVILLERS J., CLUZEAU S., GAUTHIER M., PHAM-DELEGUE M-H., 2004b.- Imidacloprid impairs memory and brain metabolism in the honeybee (*Apis mellifera* L.).- *Pesticide Biochemistry and Physiology*, 78: 83-92.
- DESNEUX N., DECOURTYE A., DELPUECH J. M., 2007.- The sublethal effects of pesticides on beneficial arthropods.- *Annual Review of Entomology*, 52: 81-106.
- FURLAN L., 2005.- An IPM approach targeted against wireworms: what has been done and what still has to be done.- *IOBC/wprs Bulletin*, 28 (2): 91-100.
- FURLAN L., CANZI S., DI BERNARDO A., EDWARDS C. R., 2006.- The ineffectiveness of insecticide seed coatings and planting-time soil insecticides as *Diabrotica virgifera virgifera* LeConte population-suppressors.- *Journal of Applied Entomology*, 130 (9-10): 485-490.
- GIORDANI G., SABATINI A. G., CELLI G., NARDI M., 1979.- Endosulfan e api. Ripercussioni dei trattamenti con endosulfan su *Apis mellifera* L. bottinante in campi di medica da seme in fiore.- *Bollettino dell'Istituto di Entomologia della Università degli Studi di Bologna*, 34: 125-143.
- GIROLAMI V., MAZZON M., SQUARTINI A., MORI N., MARZARO M., DI BERNARDO A., GREATTI M., GIORIO G., TAPPARO A., 2009.- Translocation of neonicotinoid insecticides from coated seeds to seedling guttation drops: a novel way of intoxication for bees.- *Journal of Economic Entomology*, 102 (5): 1808-1815.
- GOULSON D., LYE G. C., DARVILL B., 2008.- The decline and conservation of bumble bees.- *Annual Review of Entomology*, 53: 191-208.
- GREATTI M., SABATINI A. G., BARBATTINI R., ROSSI S., STRAVISI A., 2003.- Risk of environmental contamination by the active ingredient imidacloprid used for corn seed dressing. Preliminary results.- *Bulletin of Insectology*, 56 (1): 69-72.
- GREATTI M., BARBATTINI R., STRAVISI A., SABATINI A. G., ROSSI S., 2006.- Presence of the a.i. imidacloprid on vegetation near corn fields sown with Gaucho® dressed seeds.- *Bulletin of Insectology*, 59 (2): 99-103.
- HALM M. P., RORTAIS A., ARNOLD G., TASÉI J. N., RAULT S., 2006.- New risk assessment approach for systemic insecticides: the case of honey bees and imidacloprid (Gaucho).- *Environmental Science & Technology*, 40: 2448-2454.
- HARREMOËS P., GEE D., MACGARVIN M., STIRLING A., KEYS J., WYNNE B., GUEDES VAZ S., 2001.- *Late lessons from early warnings: The precautionary principle 1896-2000*.- Environmental issue report No 22, European Environment Agency (EEA), Copenhagen, Denmark.
- HAYNES K. F., 1988.- Sublethal effects of neurotoxic insecticides on insect behavior.- *Annual Review of Entomology*, 33: 149-168.

- KIRCHNER W. H., 1999.- Mad bee disease? Sublethal effects of imidacloprid (Gaucho) on the behavior of honey bees.- *Apidologie*, 30 (5): 421-422.
- KOCH H., WEISSER P., 1997.- Exposure of honey bee during pesticide application under field condition.- *Apidologie*, 28: 439-447.
- LADURNER E., BOSCH J., KEMP W. P., MAINI S., 2005.- Assessing delayed and acute toxicity of five formulated fungicides to *Osmia lignaria* Say and *Apis mellifera*.- *Apidologie*, 36 (3): 449-460.
- LANZONI A., SANGIORGI L., DE LUIGI V., CONSOLINI L., PASQUALINI E., BURGIO G., - Analisi della selettività di insetticidi verso *Adalia bipunctata* (Col.: Coccinellidae) mediante un approccio di tipo demografico: valutazione degli effetti cronici di alcuni insetticidi nei confronti dei coccinellidi.- *Notiziario sulla Protezione delle piante*, 23: (In press).
- LEWIS G., THOMPSON H., SMAGGHE G., 2007.- In focus: pesticides and honeybees – the work of the ICP-BR Bee Protection Group. Editorial.- *Pest Management Science*, 63 (11): 1047-1050.
- LODESANI M., PELLACANI A., BERGOMI S., CARPANA E., RABITTI T., LASAGNI P., 1992.- Residue determination for some products used against *Varroa* infestation in bees.- *Apidologie*, 23 (3): 257-272.
- MAINI S., 2008.- Diagnosi di esperti a confronto. Tempi difficili per le api? - *Rivista di Frutticoltura e di Ortofloricoltura*, 70: 66-67.
- MAMOOD A. N., WALLER G. D., 1990.- Recovery of learning responses by honeybees following a sublethal exposure to permethrin.- *Physiological Entomology*, 15: 55-60.
- MANINO A., PATETTA A., BOGLIETTI G., PORPORATO M., 2010.- Bumble bees – the work of the Susa Valley (Hymenoptera Apidae).- *Bulletin of Insectology*, 63 (1): 137-152.
- MAUS C., CURÉ G., SCHMUCK R., 2003.- Safety of imidacloprid seed dressings to honey bees: a comprehensive overview and compilation of the current state of knowledge.- *Bulletin of Insectology*, 56 (1): 51-57.
- MAXIM L., VAN DER SLUIJS J. P., 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 (1-3): 1-17.
- MEDRZYCKI P., MONTANARI R., BORTOLOTTI L., SABATINI A. G., MAINI S., PORRINI C., 2003.- Effects of imidacloprid administered in sub-lethal doses on honey bee behaviour. Laboratory tests.- *Bulletin of Insectology*, 56 (1): 59-62.
- MEDRZYCKI P., SGOLA STRA F., BORTOLOTTI L., BOGO G., TOSI S., PORRINI C., SABATINI A. G., 2009.- Can the brood rearing temperature affect adult bee fitness? A hypothesis explaining the time interval between bee loss and its primary causal factor, pp. 84-84. In: *APImondia 41st congress 2009*, Montpellier, France, 15-20 September, 2009.
- MEDRZYCKI P., SGOLA STRA F., BORTOLOTTI L., BOGO G., TOSI S., PADOVANI E., PORRINI C., SABATINI A. G., 2010.- Influence of brood rearing temperature on honey bee development and susceptibility to poisoning by pesticides.- *Journal of apicultural research*, 49 (1): 52-59.
- MINEAU P., HARDING K. M., WHITESIDE M., FLETCHER M. R., GARTHWAITE D., KNOPPER L. D., 2008.- Using reports of bee mortality in the field to calibrate laboratory-derived pesticide risk indices.- *Environmental Entomology*, 37 (3): 546-554.
- MOMMAERTS V., STERK G., SMAGGHE G., 2006.- Hazards and uptake of chitin synthesis inhibitors in bumblebees *Bombus terrestris*.- *Pest Management Science*, 62: 752-758.
- MULLIN C. A., FRAZIER M., FRAZIER J. L., ASHCRAFT S., SIMONDS R., VAN ENGELSDORP D., PETTIS J. S., 2010.- High levels of miticides and agrochemicals in North American apiaries: implications for honey bee health.- *PLoS ONE*, 5 (3): e9754. [doi:10.1371/journal.pone.0009754]
- NEUMANN P., CARRECK N. L., 2010.- Honey bee colony losses.- *Journal of Apiculture Research*, 49 (1): 1-6.
- NGUYEN B. K., SAEGERMAN C., PIRARD C., MIGNON J., WDART J., THIRIONET B., VERHEGGEN F. J., BERKEVENS D., DE PAUW E., HAUBRUGE E., 2009.- Does imidacloprid seed-treated maize have an impact on honey bee mortality? - *Journal of Economic Entomology*, 102 (2): 616-623.
- OLDROYD B., 2007.- What's killing american honey bees? - *PLoS Biology*, 5 (6): e168. [doi:10.1371/journal.pbio.0050168]
- PAPACHRISTOS D. P., MILONAS P. G., 2008.- Adverse effects of soil applied insecticides on the predatory coccinellid *Hippodamia undecimnotata* (Coleoptera: Coccinellidae).- *Biological Control*, 47: 77-81.
- PHAM-DELÈGUE M-H., DECOURTYE A., KAISR L., DEVILLERS J., 2002.- Behavioural methods to assess the effects of pesticides on honey bees.- *Apidologie*, 33: 425-432.
- PILLING E. D., JEPSON P. C., 1993.- Synergism between EBI fungicides and a pyrethroid insecticide in the honeybee (*Apis mellifera*).- *Pesticide Science*, 39 (4): 293-297.
- PORRINI C., GHINI S., GIROTTI S., SABATINI A. G., GATTA VECCHIA E., CELLI G., 2002.- Use of honey bees as bioindicators of environmental pollution in Italy, pp. 186-247. In: *Honey bees: estimating the environmental impact of chemicals* (Devillers J., Pham-Delègue M-H., Eds).- Taylor & Francis, London, UK.
- PORRINI C., SABATINI A. G., GIROTTI S., FINI F., MONACO L., CELLI G., BORTOLOTTI L., GHINI S., 2003.- The death of honey bees and environmental pollution by pesticides: the honey bees as biological indicators.- *Bulletin of Insectology*, 56 (1): 147-152.
- PORRINI C., SABATINI A. G., MUTINELLI F., ASTUTI M., LAVAZZA A., PIRO R., TESORIERO D., MEDRZYCKI P., SGOLA STRA F., BORTOLOTTI L., 2009.- Le segnalazioni degli spopolamenti e delle mortalità degli alveari in Italia: resoconto 2008.- *L'Apis*, 17 (1): 15-19.
- QUARANTA M., AMBROSELLI S., BARRO P., BELLA S., CARINI A., CELLI G., COGOI P., COMBA L., COMOLI R., FELICOLI A., FLORIS I., INTOPPA F., LONGO S., MAINI S., MANINO A., MAZZEO G., MEDRZYCKI P., NARDI E., NICCOLINI L., PALMIERI N., PATETTA A., PIATTI C., PIAZZA M. G., PINZAUTI M., PORPORATO M., PORRINI C., RICCIARDELLI D'ALBORE G., ROMAGNOLI F., RUIU L., SATTÀ A., ZANDIGIACOMO P., 2004.- Wild bees in agroecosystems and semi-natural landscapes. 1997-2000 collection period in Italy.- *Bulletin of Insectology*, 57 (1): 11-61.
- RATNIEKS F. L. W., CARRECK N. L., 2010.- Clarity on honey bee collapse? - *Science*, 327 (5962): 152-153.
- RORTAIS A., ARNOLD G., HALM M. P., TOUFFET-BRIENS F., 2005.- Modes of honeybees exposure to systemic insecticides: estimated amounts of contaminated pollen and nectar consumed by different categories of bees.- *Apidologie*, 36 (1): 71-83.
- SANFORD M. T., 1993.- Protecting honey bees from pesticides.- *University of Florida IFAS Extension Circular*, 534: 1-21.
- SCHMIDT H-W., BRASSE D., KÜNST C., MÜHLEN W., VON DER OHE W., TORNIER I., WALLNER K., 2003.- Introduction of indices for the evaluation of tent tests and field tests with honeybees.- *Bulletin of Insectology*, 56 (1): 111-117.
- SCHMUCK R., SCHONING R., STORK A., SCHRADEL O., 2001.- Risk posed to honeybees (*Apis mellifera*: Hymenoptera) by an imidacloprid seed dressing of sunflowers.- *Pest Management Science*, 57: 225-238.
- SCHRICKER B., STEPHEN W. P., 1970.- The effect of sublethal doses of parathion on honeybee behaviour. I. Oral administration and the communication dance.- *Journal of Apicultural Research*, 9: 141-153.
- SMODIŠ ŠKERL M. I., VELIKONJA BOLTA Š., BAŠA ČESNIK H., GREGORC A., 2009.- Residues of pesticides in honeybee (*Apis mellifera carnica*) bee bread and in pollen loads from treated apple orchards.- *Bulletin of Environmental Contamination and Toxicology*, 83 (3): 374-377.
- STERK G., BENUZZI M., 2004.- Nuovi fitofarmaci, prove di tossicità sui bombi in serra.- *Colture Protette*, 53 (1): 75-77.
- STOKSTAD E., 2007.- The case of the empty hives.- *Science*, 316 (5827): 970-972.
- SUCHAIL S., GUEZ D., BELZUNCES L. P., 2001a.- Toxicity of imidacloprid and its metabolites in *Apis mellifera*.- *Les Colloques de l'INRA*, 98: 121-126.
- SUCHAIL S., GUEZ D., BELZUNCES L. P., 2001b.- Discrepancy between acute and chronic toxicity induced by imidacloprid and its metabolites in *Apis mellifera*.- *Environmental Toxicology and Chemistry*, 20 (11): 2482-2486.

- TASEI J-N., 2002.- Impact of agrochemicals on non-*Apis* bees, pp. 101-126. In: *Honey bees: estimating the environmental impact of chemicals* (DEVILLERS J., PHAM-DELÈGUE M-H., Eds).- Taylor & Francis, London, UK.
- TASEI J-N., LERIN J., RIPPAULT G., 2000.- Sub-lethal effects of imidacloprid on bumblebees, *Bombus terrestris* (Hymenoptera: Apidae), during a laboratory feeding test.- *Pest Management Science*, 56 (9): 784-788.
- TAYLOR K. S., WALLER G. D., CROWDER L. A., 1987.- Impairment of a classical conditioning response of the honey bee (*Apis mellifera* L.) by sublethal doses of synthetic pyrethroid insecticides.- *Apidologie*, 18: 243-252.
- TESORIERO D., MACCAGNANI B., SANTI F., CELLI G., 2003.- Toxicity of three pesticides on larval instars of *Osmia cornuta*: preliminary results.- *Bulletin of Insectology*, 56 (1): 169-171.
- THOMPSON H. M., 2003.- Behavioural effects of pesticides in bees – their potential for use in risk assessment.- *Ecotoxicology*, 12: 317-330.
- TREMOLADA P., BERNARDINELLI I., COLOMBO M., SPREAFICO M., VIGHI M., 2004.- Coumaphos distribution in the hive ecosystem: case study for modeling applications.- *Ecotoxicology*, 13 (6): 589-601.
- VANDAME R., MELED M., COLIN M., BELZUNCES L. P., 1995.- Alteration of the homing-flight in the honey bee *Apis mellifera* L. exposed to sublethal doses of deltamethrin.- *Environmental toxicology and chemistry*, 14 (5): 855-860.
- VANENGELSDOR D., MEIXNER M. D., 2010.- A historical review of managed honey bee populations in Europe and the United States and the factors that may affect them.- *Journal of Invertebrate Pathology*, 103 (Supplement 1): S80-S95.
- YANG X., COX-FOSTER D., 2007.- Effects of parasitization by *Varroa destructor* on survivorship and physiological traits of *Apis mellifera* in correlation with viral incidence and microbial challenge.- *Parasitology*, 134 (3): 405-412.
- YANG E. C., CHUANG Y. C., CHEN Y. L., CHANG L. H., 2008.- Abnormal foraging behavior induced by sublethal dosage of imidacloprid in the honey bee (Hymenoptera: Apidae).- *Journal of Economic Entomology*, 101 (6): 1743-1748.
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Appendix to “The puzzle of honey bee losses: a brief review” by S. MAINI, P. MEDRZYCKI, C. PORRINI

Letter sent (February 22, 2010) by Stefano MAINI to *Science* and relevant reply (February 26, 2010)

Honey bee: Let's Talk about Colony Losses Puzzle

According to F.L.W. Ratnieks and N.L. Carreck (“Clarity on Honey bee collapse?” 8 January 2010, p.152) (1) the “consensus seems to be that pests and pathogens are the single most important cause of bee colony losses”. Actually, many other scientists are concerned about the inappropriate or even misuse of insecticides. So, not only the beekeepers are seriously affected by bee colony losses, but also farmers, seed companies and pesticide producers. The fact that they state the main cause of bee losses are “diseases” may give the false impression that insecticides can be sprayed without the attention that is needed. For example, Integrated Pest Management strategies rely on pest monitoring, and these IPM principles are being neglected in the case of sowing of seed coated with neonicotinoid imidacloprid for a simple reason: the insecticide has been applied even if the pest infestation is not present. According to (2) cited by (1) imidacloprid “seems unlikely responsible for the French bee deaths”. This appears to be a biased opinion and a conflict of interest in light of the fact that the author of (2) is a researcher employed by the producer of imidacloprid. The authors of the perspective (1) have neglected to cite other articles published in the same issue, which demonstrate the sub-lethal effects of imidacloprid on bees (3). Why were these results ignored? More recent articles have also confirmed the neonicotinoid side effects on bees (4). Regulatory guidelines in both the USA and in Europe aim at protecting bees by limiting the use of insecticides harmful to pollinating insects. Farmers and beekeepers should work together to find solutions which result in effective pest control while protecting bee health. Needless to say, healthy bees are less susceptible to diseases (5) and *vice versa*.

References

1. F.L.W. Ratnieks, N.L. Carreck, *Science* **327**, (2010)
2. C. Maus *et al.*, *Bull. Insectology* **56**, 51 (2003)
3. P. Medrzycki *et al.*, *Bull. Insectology*, **56**, 59 (2003)
4. E.C. Yang *et al.*, *J. Econ. Entomol.* **101**, 1743 (2008)
5. C. Alaux *et al.*, *Environ. Microbiol.* doi :10.1111/j.1462-2920.2009.02123.x

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Dear Dr. Maini,

Thank you for sending a Letter-to-the-Editor to *Science*. We have read over your contribution, but will not be able to publish it in the magazine. We are letting you know as a courtesy in case you wanted to seek another outlet for your letter.

Please do not reply to this email, as it will not be read by *Science*. Unfortunately the volume of submissions precludes specific discussions about individual submitted letters.

Sincerely,

The Editors

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