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Perspective

Is electromagnetism one of the causes of the CCD? A work plan for testing this hypothesis

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Abstract

The decline of domestic bees all over the world is an important problem still not well understood by scientists and beekeepers, and far from being solved. Its reasons are numerous: among others, the use of pesticides and insecticides, the decrease of plant diversity, and bee's parasites. Besides these threats, there is a potential adverse factor little considered: manmade electromagnetism. The production of electromagnetic waves by human settlements, cellphones relay and power lines largely increases nowadays. Bees are very sensitive to this electromagnetism. The present paper suggests two simple experimental protocols for bringing to the fore the potential adverse effect of electromagnetism on bees and to act consequently. The first one is the observation of bees' avoidance of a wireless apparatus; the second one is the assessment of colonies' strength and of the intensity of the electromagnetism field (EMF) surrounding them. If bees avoid a wireless apparatus, if hives in bad health are located in EMF of a rather high intensity, it can be presumed that bees are affected by manmade electromagnetism. This should enable searching for palliative measures.

INTRODUCTION

The nowadays nearly world-wide decline of domestic bees (*Apis mellifera* Linnaeus, 1758), known as the colony collapse disorder (CCD) [1,2], has not begun with the use of insecticides and pesticides but later on, and did not decrease (on the contrary!) when the use of such products has been controlled and limited. Of course, such substances imperil the bees, but they may not be the only cause of the CCD. Indeed, in presence of insecticides or pesticides, bees die and are found dead all around their hive. However, in numerous other cases, no dead bee can be seen either inside the hive or all around, while the number of bees remaining inside the hive obviously drastically drops [3]. Another cause of the CCD could be the decrease of plant biodiversity and thus of available adequate flowers [4]. There are also local causes, such as the presence of parasites (i.e. *Varroa destructor* Anderson & Truema, 2000), fungi and predators (i.e. *Vespa velutina* Lepeletier, 1836) [5]. All these factors cannot by their own explain the drastic collapse of so many bee colonies all over the world. So far, no scientific theory prevails for explaining the progressing collapse of bees. A further possible factor may be an event which started at the same time as the CCD, and the extent of which increases days after days in every country: the use of manmade electromagnetism. The wireless technology appeared just sometime before humans became conscious of the CCD; this technology progressed continuously and is still increasing, just like the CCD [5].

There are several elements in favor of an adverse effect of manmade waves on health and behavior. Electromagnetism affects all living organisms: unicellular ones, insects, amphibians, birds, and mammals among others. Plants too are affected by electromagnetic fields (EMF) [6,7,8,9]. There exist several reviews on the subject [e.g. 10,11,12]. Among animals, the insects are very sensitive to EMF. Working on the ant *Myrmica sabuleti* Meinert, 1861, we discovered that under EMF, their workers eat far less, collect nearly no food, recruit no longer nestmates, present locomotion problems, can no longer find their nest entrance, and can no longer come onto the food site. They presented a decrease of cognitive abilities. Indeed, they respond less to their pheromones (alarm pheromone: orientation value of 64.7° instead of 44.4°; trail pheromone: 3 walked arcs of 10° instead of 19; area marking pheromone: 1.79 ants coming onto the area instead of 3.78). In the same way, they cannot acquire as usually visual as well as olfactory conditioning, and have thus no longer any memory (score of conditioning: 47.5% instead of 75% – 85%). Moreover, the development of their larvae and nymphs is severely impacted [13,14]. Finally, using the protozoa *Paramecium caudatum* as a model, we discovered that EMF affects the cellular membrane [15], a result that was later on found and then explained by other researchers [16]. Since the cellular membrane is damaged by some frequencies of electromagnetic waves, the nervous system functioning also becomes perturbed [17,18,19]. This could explain the ethological and physiological abnormalities observed on ants under EMF. This could also

explain their perturbed larval and nymphal development since these phenomena are controlled and induced by secretions of the pars intercerebralis of the brain. If ants are severely impacted by electromagne tism, other insects should also be affected. Indeed, impact of EMF on insects, including bees, has been observed and studied by many researchers [20,21,22,23,24 and references therein, 25]. Before the invention of the wireless technology, plenty of active insects fled on crops, flowers, fruits, where they ate, drunk, collected nectar, and numerous dead insects were found crushed on cars. Nowadays, all this no longer occurs at such an extent [2]. Bees may be particularly affected by manmade electromagnetism [21,22,23]. They have magnetite in their brain, a compound which reacts to magnetism. While flying, they can cross electromagnetic fields of high intensity generated by relay antenna and power lines. When crossing such electromagnetic fields, bees may no longer remember their way, may no longer fly in the correct direction, and may become unable to go back to their hive. Alone, a bee cannot live; it dies in about two days, far from its hive. Note that birds are also affected by EMF [26]. Since moreover most of them eat insects, at least during a part of the year, the actual decrease of their numbers finds here a plausible explanation.

In various countries, present legislation tempts to limit the use of pesticides and insecticides, and to preserve the biodiversity of flowering plants. However, few are done for decreasing the exposition of people, animals and plants to manmade waves, and for protecting the bees. Generally, electromagnetism is not considered as being an element imperiling the living organisms, and among them the bees. The main reasons for this lack of interest could be the way of life in modern societies. People intensely use the wireless technology in their daily life. They use numerous devices relying on that technology e.g. to communicate, to share information. In some cases, they are even quite dependent on them, for working, having recreational activities or simply comfortably living. A lot of people earn their money, have a professional situation, and can efficiently work only using wireless technology. The presence of this technology in our daily life becomes so necessary that nearly nobody can now imagine an unconnected, wireless world. However, it still remains major concerns about this technology: may it imperil nature, and consequently be harmful to humanity? The objective of the present paper is to estimate to which extent bees are affected by electromagnetism and, as the case may be, to adopt palliative solutions.

We propose two easy experimental protocols for examining to which extent bees are impacted by EMF. Any beekeeper or anyone knowing a beekeeper is invited to make either the first or the second, or the two experiments proposed in the present paper and to send us the results. We intend to build a synthesis of them and to divulgate it in the most appropriate way, in a paper and in the media. This might lead beekeepers to act consequently, for example, to set hives in a secure place.

MATERIALS AND METHODS

First, we propose that each beekeeper makes, at his (her) convenience, a simple experiment in front of one or a few hives, using a GSM or any wireless apparatus (e.g. Wi-Fi-box). Secondly, we recommend any beekeeper (or anyone knowing a beekeeper) to collect information on the hives' strength and on the intensity of the surrounding EMF. We ask any participant to send us their assessments, so that we can examine the bees' avoidance of electromagnetism, and the relationship between bees' health and EMF intensity. Of course, the used hives must not be infected by parasites.

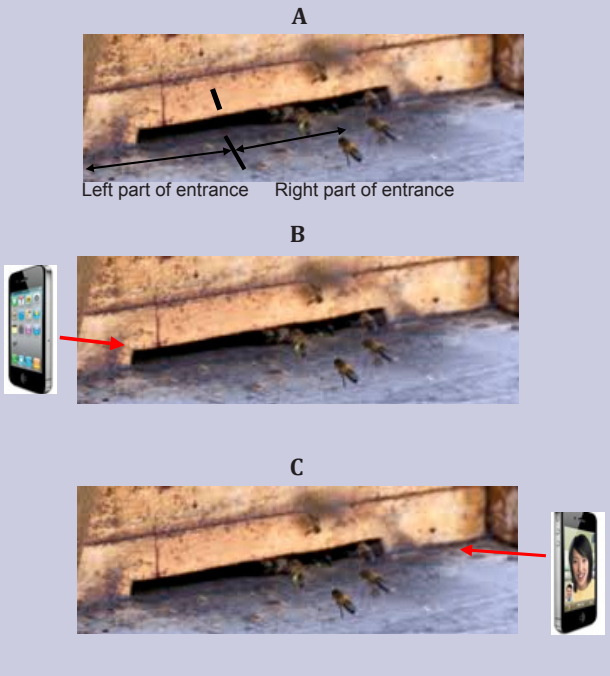
A simple experiment on bees

The experimental process is schematized in Figure 1. It consists in counting the bees coming into and out of the hive, moving either on the left part or on the right part of the hive entrance. The middle of that entrance must thus be marked (e.g. with a pencil or a pen), and if the entrance is very narrow, a larger artificial one should be built and tied to the initial entrance. The counting must be made during a given time period (see below) at the same time for the left and the right part of the entrance. Two persons can of course work together for obtaining these counts. The counting time must be determined according to the traffic of the bees: a minimum of 10 bees (more if possible, ideally 30) should be seen entering or leaving the hive, through the left or the right part of the entrance. If the traffic is important, the counting time period could be short (e.g. a few minutes); if the traffic is weak, the counting should be appropriately longer (e.g. 10, 15, or 20 minutes). The counting must be performed at least three times, exactly in the same way, during the same time period (for comparative purpose). First, a control counting must be made in a usual situation, i.e. without any wireless apparatus in front of the entrance. This provides the control numbers of bees' traffic. Then a second counting, experimental this time, is proposed. A just switched on and activated mobile phone (thus in the process of a phone call or of a phone reception) must be set on the left of the hive entrance, and a counting session must be realized in the same way as the control was done. The investigator must note the model of the Wi-Fi or cellphone device and note also the indicated power of emission (indicated by the selling company in the user manual). After that, a third, again experimental, counting should be made. The mobile phone previously used must be again just switched on and activated, but must be set this time on the right of the hive entrance, and a counting must again be done at that moment, in the same manner it has been done with the phone set on the left of the hive entrance. Later on, after the bees' recovery, a fourth and a fifth counting should ideally be made, in the same way as previously, with the mobile phone set on the left (fourth counting), then on the right (fifth counting) of the entrance, but after the phone had been deprived of its battery. Indeed, a switched off phone is still active, less than when switched on, but still operational (it can receive messages, for instance). To be inert, a mobile phone must be opened and its battery removed. These fourth and fifth counting will allow determining if the presence of an inert object at the hive entrance affects the bees.

Information on the EMF intensity and the hives' strength

This information should be collected, written then sent to us as briefly shown in Table 1. It takes only a few minutes to do so. First, assess the intensity of the electromagnetic field surrounding

Figure 1. Planning of a proposed experiment allowing revealing bees' avoidance of EMF. Details are given in the text. You are invited to send your results to the author.



Conditions	Left part of the entrance	Right part of the entrance
without cellphone with cellphone on with cellphone inert	first, third, fifth counting second counting fourth counting	first, second, fourth counting third counting fifth counting

A. Mark the middle of the entrance; if the entrance is narrow, add a broader one to it. **First counting (= control):** Count during a given time period the bees entering and leaving the hive through the left part and the right part of the entrance. You obtain two control numbers, one for the left and one for the right.

B. Second counting – GSM on the left: Set a just switched on GSM on the left of the entrance, the bottom of the GSM turned towards the entrance. Count the bees entering and leaving the hive through the left and the right parts of the entrance, exactly as you did for the control. You obtain two experimental numbers, one for the left with a telephone on, one for the right without telephone.

C. Third counting – GSM on the right: Set a just switched on GSM on the right of the entrance, the bottom of the GSM turned towards the entrance. Count the bees entering and leaving the hive through the left and the right parts of the entrance, exactly as you did for the control. You obtained two other experimental numbers, one for the left without telephone, one for the right with a telephone on.

If possible, do a fourth and a fifth counting with the GSM deprived of its battery (switch off the GSM, open it and remove its battery). You will obtain numbers for the left with a telephone inert and the right without telephone, as well as for the left without telephone and the right with a telephone inert.

D. Results can be presented in a table similar to the here above one, but this is not necessary. The numbers obtained without cellphone will be compared to those obtained with cellphone on (to evaluate cellphone effects), and with cellphone inert (to evaluate effects of an inert object).

the hives. You can either use an adequate apparatus (a magnetometer), or ask to a qualified person or organism (as an example, the French organism: http://www.robindestoits.org/) to make the required assessment. The intensity of the electromagnetic field can be exactly assessed (if stable, if an exact measure can easily be done, in V/m or W/m^2 or mW/cm^2), or can be evaluated (if the intensity varies between low and high values). In the latter case, you estimate that the intensity of the EMF equals 1, 2, 3, 4, and 5 when its value varies between 2 and 40, 41 and 100, 101 and 300, 301 and 1,000, 1,001 and 3,000 mW/cm^2, respectively. The result of this measure or evaluation should be written in the first column of a table. In the second column, please provide information on the hive's strength. Write an index, equaling respectively 5, 4, 3, 2, or 1 when the bees' health or the strength of the hives located in the measured electromagnetic field is excellent with no abnormal decrease of bee numbers or any abnormal behavior (5), good with only some slight decrease of the population or only a few bees with abnormal behavior (4), not very good with an obvious decrease of the population or numerous bees with abnormal behavior (3), rather bad with a large decrease of the population or widespread abnormal behavior (2), and catastrophic if nearly all, or all the population has disappeared or was collapsed (1). Moreover, if you can, estimate also the strength of one, or a few bee colonies using a method derived from that described in the Bee Book (www.coloss.org/beebook). Simply make a visual estimation of the number of combs occupied by honey and pollen stored, by brood and by workers, and precise the kind of hive used. If you refer, estimate the proportion of occupied area, i.e. the proportion of the combs surface covered with honey, pollen, brood or workers.

Table 1: Proposed inventory of the bees' health and of their surrounding electromagnetic field. Two assessments should be done, one of the EMF intensity (an exact measure or an estimation of it), the other one of the bees' health (an evaluation). You are invited to send your assessments to the author.

Relation between the EMF intensity and the general state of the bees' health
Measure or estimate the intensity of the electromagnetic field around and/or in the vicinity of the hives (where bees are accustomed to fly, and define at which distance from the hive). Give a precise measure in EM units, or estimate the intensity: **1** = very low (2 – 40), **2** = low (41 – 100), **3** = moderate (101 – 300), **4** = rather high (301 – 1,000), **5** = very high (1,001 – 3,000).

Evaluate the bees' health, the hives' strength: **5** = excellent (= no abnormal decrease of bees), **4** = good (some slight decrease of the population), **3** = not very good (obvious decrease of the population), **2** = rather bad (large decrease of the population), **1** = catastrophic (nearly entire vanishing of the population). If possible, estimate also the proportion of the comb surface covered by bees, pollen or honey.

Write your two assessments or evaluations in a table such as the below one, but this is not mandatory.

Intensity of EMF where bees usually fly, in EM units or evaluated from 1 to 5	Bees' health evaluated from 5 to 1; hives' strength given in % of comb surface occupied

Past and potential future results

Sharma and Kumar [21] have placed mobile phones in hives and measured several parameters assessing the colonies

strength. They observed a significant decline of bees' health, brood, returning to the hive ability, eggs lying, honey stores, and pollen stores. Favre [22] has set mobile phones in hives and has then recorded a typical piping sound produced by the bees, signifying the presence of a danger and the advice to nestmates to move away. Grölle et al. [23] made an experimental work using Dect phones for irradiating the bees. They observed that irradiated bees were far less able to come back to their hives in due time. All this is in favor of an impact of electromagnetism on bees' health and colony strength, but is not sufficient for affirming that the actual manmade electromagnetism is one of the factors causing the bees' CCD. To go a step further, the bees' avoidance of such an electromagnetism as well as the concordance between electromagnetism of high intensity and decline of colony strength must be examined, not by one researcher but by many ones and/or beekeepers. It is the reason why we here propose two simple experiments, hoping some participation from readers.

You are invited to send us the recorded numbers of bees entering and leaving the hive during each counting session, through the left and the right parts of the hive entrance, without phone, or with a phone turned on, or with a phone inert. Write your recorded numbers ideally, but not necessarily, in a table as shown in Figure 1. We shall pull the results, and compare the different recorded numbers.

You are also invited to send us your assessment of the electromagnetic field intensity and of the colony strength, by mail, ideally but not necessarily in a table (as shown in Table 1). The collected information will allow examining the correlation (= the strength of the relationship) between the intensity of the electromagnetic field surrounding the bees' hives and the state of these bees' health.

After having collected enough information for making a valuable analysis, we shall give a follow-up to your work: we intend to relate the results in a short paper and/or in the media.

DISCUSSION AND CONCLUSION

Bees are very important not only for humans (they produce honey, allow having seeds, vegetables, fruits, etc…), but also for nature. This is well explained for instance in the link ftp://ftp.fao.org/docrep/fao/012/i0842e/i0842e04.pdf. However, since about 20 years, they spectacularly and increasingly decline, this event having been labeled the bees' CCD. Among the numerous causes of this CCD (see the introduction section), there is one scarcely taken into account: manmade electromagnetism. Contrary to pesticides, insecticides, decrease of flower diversity, parasites, predators and so on, the effects of electromagnetism are not often evoked. A probable reason is that numerous devices used by humans depend on that technology and have now become tremendously widespread in our daily life. They are even essential in our daily life for working efficiently and having recreational activities. However, this useful technology may imperil the nature, and may consequently have adverse effects on humanity. Bees' CCD reveals a global situation, reflects what is actually occurring to the nature, all over the world. If you take attention to the wild and compare its state with that existing 20 years ago, you cannot but admit some decrease or bad health of flying insects, for instance. If such a situation persists, pollinators will cease to be numerous enough for assuring efficient pollination.

The objective of the present paper is to estimate to which extent domestic bees are affected by electromagnetism. Two experimental protocols are proposed: one aiming to examine the bees' avoidance of a wireless apparatus, the other tempting to relate bees' health to the intensity of their surrounding EMF. Through these proposed protocols and thanks to the collaboration of numerous beekeepers, we hope defining the potential harmful effect of EMF on bees. If the impact of electromagnetism on bees' health is demonstrated, then, beekeepers could take this impact into account and look for protective measures for their hives. For example, the hives could be located in places where the electromagnetism has a very low intensity, and/or the hives could be set inside a kind of Faraday cage or enclosure. This may help to put a brake on the bees' CCD.

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DISCLOSURE

The author declares having no conflicts of interst.

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About the Corresponding Author

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Summary of background:
I work on ants since 1969, studying essentially their ethology and their physiology. I have examined their communication, recruitment strategies, areas marking, navigation systems, visual perception, conditioning abilities, among others. I have also studied the ontogenesis of some of their cognitive capabilities. More recently, I used ants as biological models for examining the effects of substances (drugs, food additives …) consumed by humans. Until now, I could reveal the adverse effects of 21 such substances. Even if making pharmaceutical works, I go on studying the ants at an ethological and a physiological point of view.

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Current research focus:

- Effects of substances consumed by humans. The first studied are statins; the following ones will be the new natural drug used for caring of persons suffering from hypercholesterolemia, as well as the new largely used analgesic.
- The ants' potential ability in learning, by operant conditioning, to perform initially unknown tasks. Three experimental protocols are planned and will be conducted on Myrmica ruginodis.
- The ants' potential instinctive perception of what is good or harmful to their health.
- The impact on aquatic invertebrates of hormones nowadays present in natural water (using chironomes as models).

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