

Full Length Research Paper

# Effect of electromagnetic radiations on brooding, honey production and foraging behavior of European honeybees (*Apis mellifera* L.)

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The present investigation was carried out at HREC, Dhakrani, Dehradun during August-December, 2010. For the experiment three treatments, i) Colonies below the tower, ii) Colonies equipped with cell phone and iii) Colonies without cell phone were taken into consideration. To quantify the effect of electromagnetic radiation (EMR), all the treatments having different radiation level were maintained. It was observed that maximum brood area was found in control colonies (560.36 cm<sup>2</sup>) followed by the colonies kept near the tower 537.85 cm<sup>2</sup> and lowest brood area (534.81 cm<sup>2</sup>) was observed in the colonies equipped with cell phone. The average honey production was found to be highest (14.43 kg/hives) in the colonies placed near the tower followed by cell phone equipped colonies (13.76 kg/hive), while control colonies produced 12.80 kg/hive honey in first harvesting. There was no remarkable change in the nectar and pollen gathering behaviour of foragers and sufficient pollen and nectar stored in the colonies during the course of study. Therefore, in the light of above findings conclusion can be drawn that there is no apparent effect of EMR on brooding, honey production and foraging behaviour of *Apis mellifera* colonies.

**Key words:** Electromagnetic radiations, GSM 900 cell phone, behaviour, brood, *Apis mellifera*.

## INTRODUCTION

Honeybees have become essential component for the success of high tech agriculture. The economical role of honeybees in worldwide pollination has been statistically valued to be around 153 billion Euros in the year 2005 (Gallai et al., 2009). Bee losses have been recorded for more than a century (Hart, 1893; Aikin, 1897; Beuhne, 1910; Wilson and Menapace, 1979). Scientists suspect many factors to be responsible for the impairing and

death of the bees viz., varroa mite, pesticides, viruses, unscientific farming practices, monoculture, un-hygiene condition in the hive and dramatic change in climatic factors are the most widely cited possibilities. Radio frequency, electromagnetic radiation (EMR) has been reported to produce a number of inimical biological effects on biomolecules cells ultimately impairing the entire biological structure and functions of whole

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organisms (Bawin et al., 1975, 1978; Blackman et al., 1980, 1989; Dutta et al., 1984; Goodman et al., 1995; Kwee and Raskmark, 1998; Lin-Liu and Adey, 1982; Penafiel et al., 1997; Velizarov et al., 1999; Xenos and Margas, 2003). Honeybees possess magnetite crystals in their fat body cells and they present magnetic remanence (Gould et al., 1978; Keim et al., 2002). These magnetite structures are active parts of the magneto-reception system in honeybees (Hsu and Li, 1994; Hsu et al., 2007). Honeybees can be trained to respond to very small changes in the constant local geomagnetic field intensity (Walker and Bitterman, 1989a). They can also communicate through chemical and acoustical means (Winston, 1991; Tautz, 2008). A pervasive media report asserted that cellular phones were a possible cause of honey bee colony collapse disorder in April, 2007 (Good Morning America, 2007; Lean and Shawcross, 2007). An investigation of this report revealed that the media misinterpreted the findings of a study conducted by Kimmel et al. (2007) at Koblenz-Landau University in Germany. The study made no reference to Colony Collapse Disorder (CCD) and did not look at the effects of cellular phone radiation on honeybees.

In the US, disappearance of bees was observed several years back and was associated with the rising network of electromagnetic pollution. When honeybees cannot find their way back to the hive as a result of consistent electromagnetic background noise that seems to disrupt intercellular communication within individual bees, this is known as CCD. As per the literature available, CCD has spread to Germany, Switzerland, Spain, Portugal, Italy, Greece,

Scotland, Wales and North-west England. In England, the bee population depleted 54% between 1985 and 2005 as compared to an average of 20% across Europe. Recently, a sharp decline has also been noticed in commercial bee population in Kerala posing a serious threat to beekeepers, hitting apiculture. The State has the highest density of mobile towers. Similar cases have been observed in Bihar, Punjab, Nepal and other parts of India and have been attributed to increasing electromagnetic pollution in the environment (Girish, 2010).

The behavioural pattern of bees alters when they are in close proximity to mobile phones and towers. The vanished bees are never found, but thought to die alone far from home. Bee keepers told that several hives have been abruptly abandoned. If towers and mobile phones increase, the honeybees might be wiped out within 10 years. According to Aday (1975), the radiation of 900 MHz is highly bioactive, causing significant alternation in the physiological function of living organisms.

As far as research on electromagnetic pollution is concerned, no systematic studies have been conducted on potential effect of EMR from mobile phones on honeybee behaviour in India. Here, we present results from corresponding original experiments we have carried out with honeybee populations exposed to active mobile

phone radiation. The goal of these experiments was to identify potential effects of mobile phone communications on honeybee behaviour.

## MATERIALS AND METHODS

The present investigation on effect of EMRs of mobile tower and cell phone on behaviour of *Apis mellifera* L. was carried out at HREC, Dhakrani, Dehradun. The observations were recorded from last week of August to first week of December, 2010. Total of 15 colonies having the bee strength of 7 to 9 frames were selected for the experiment. For the above experiment, total three treatments each having 5 colonies were considered as replication viz. i) Colonies just below the tower, ii) Colonies placed at 2 km far from tower equipped with cell phone and iii) Control colonies maintained 2 km away from tower and without cell phone were designed. Out of 15 colonies, 5 colonies were shifted just near the tower and 5 colonies were provided with cell phone instrument of GSM 900 MHz frequency, cell phone were placed at the bottom of the hive (Plates 1 and 2). Rest of the 5 colonies were left in the apiary and treated as control. The frequent calls continuously for 10 min were made to ring the mobile instruments at 3 h interval every day. For measuring radiation, Radio frequency meter (RF meter) was used. With the help of RF meter, Electric field (E) m V/m<sup>2</sup>, Magnetic field (M)  $\mu$  A/m<sup>2</sup> and Power density (P) m W/m<sup>2</sup> was measured. The observation on brood area was recorded in cm<sup>2</sup> at weekly intervals in all the 15 colonies. The observation on honey production was recorded on 15<sup>th</sup> December, 2010 at the time of honey harvesting. The procured data was subjected to two-factorial randomized block design (RBD).

## RESULTS AND DISCUSSION

### Brood area

Data recorded (Table 1) at weekly interval clearly implies that brood area was found maximum (636.00 cm<sup>2</sup>) in the colonies maintained with cell phone on 10<sup>th</sup> September, 2010, whereas in control colonies the brood area was 600.00 cm<sup>2</sup> which is not much lower as compared to maximum brood. As far as the brood areas in respect of date of observation is concerned, the maximum mean brood area 595.26 cm<sup>2</sup> was found on 10<sup>th</sup> September, 2010 and minimum brood area 495.73 cm<sup>2</sup> was observed on 15<sup>th</sup> October, 2010, while brood areas pertaining to various treatments, the maximum 560.36 cm<sup>2</sup> was noticed in control colonies followed by the colonies kept near the tower where average brood area was 537.85 cm<sup>2</sup>. The lowest brood area 534.81 cm<sup>2</sup> was observed in the colonies equipped with cell phone (Figure 1). However, according to the statistical analysis, none of the treatment was found to be significant. On the contrary, Sharma and Kumar (2010) reported the significant decline in colonies strength and in the egg laying rate of the queen due to EMRs.

### Honey production

The experiment was started in dearth period in the end of



Plates 1a and b. Honeybees colonies with cell phone of GSM 900 MHz frequency.

August, 2010 and continued till the beginning of December. The honey stored in frames was extracted on 15<sup>th</sup> December, 2010 (Table 2). The average honey production of colonies near the tower was 14.43 kg/hives, while honey production in treatment with cell phone was

13.76 kg/hive. The control colonies produced minimum honey which was 12.80 kg/hive, while Sharma and Kumar (2010) reported in the same paper that there was neither honey nor pollen, brood and bees sustained in the colonies resulting in complete loss of the colony.



Plates 2a and b. Honeybees colonies kept near the electromagnetic radiation mobile tower.

### Behavioral observation

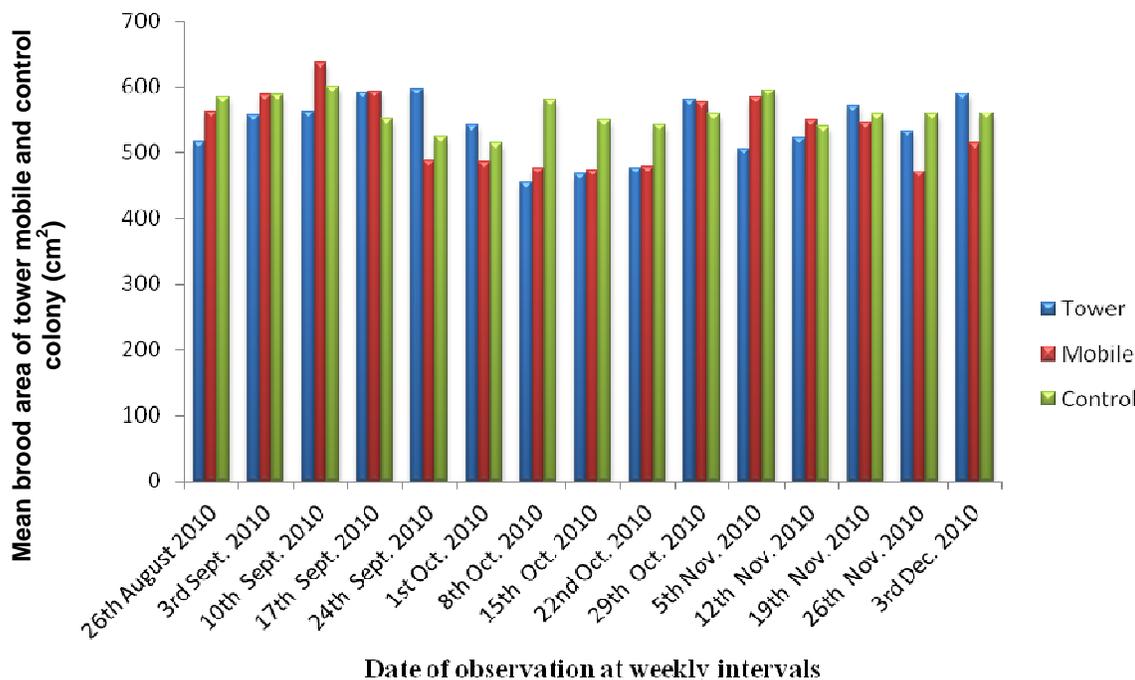
It was observed that there was no change in the nectar and pollen gathering foragers and therefore sufficient pollen and nectar store were recorded which was suffice to rear the brood in the colonies. Bees were critically observed during ringing of cell phone and it was noticed that bees working in the frames are not paying attention towards the instrument. The colonies beneath the tower (Table 3 and Figure 2) having maximum average electric field (E) 345.40 (m V/m), while in case of cell phone equipped colonies the average range was 57.70 (V/m) and in control colonies it was very low 07.90 (m V/m) as compared to tower colonies. Whereas average magnetic field (M) observed near the tower colonies was 670.63 ( $\mu$  A/m) and in mobile colonies it was measured 100.78 (m A/m). Power density (P) was also measured and it was

found that honeybees colonies near the tower encountering highest average power density 260.08 ( $\mu$  W/m<sup>2</sup>) and lowest 0.10 ( $\mu$  W/m<sup>2</sup>) in control colonies.

Remarkably, one of the Queens in the hive near the tower was accidentally killed during the shifting of the hive and the workers started to reform the new Queen in the hive. The queen was successfully produced by the worker and mating was also successfully performed as healthy colony. This again clearly corroborate that there was no apparent effect of EMR on behaviour and reproduction of Queen or drone. Similar type of result observed by Mixson et al. (2009) in the final series of experiments that no effect of GSM radiation exposure was found on aggression of honey bees. They also concluded that GSM cellular phone radiation emissions do not inhibit the foraging behaviours or navigational ability of honeybees, and are thus unlikely to affect

**Table 1.** Effect of electromagnetic radiation of cell phone on behaviour of *Apis mellifera*.

Date of observation	Mean brood area of colony (cm <sup>2</sup> ) at weekly intervals			
	Tower	Mobile	Control	Mean
26/08/2010	516.20	562.40	583.60	554.06
03/09/2010	556.80	587.80	587.80	577.46
10/09/2010	561.20	636.60	600.00	599.26
17/09/2010	592.00	592.80	551.80	578.86
24/09/2010	597.00	486.80	523.40	535.73
01/10/2010	542.80	486.20	514.00	514.33
08/10/2010	455.40	477.40	580.60	504.46
15/10/2010	467.20	473.20	548.80	495.73
22/10/2010	476.40	478.00	542.00	534.13
29/10/2010	580.40	576.40	559.00	537.26
05/11/ 2010	505.80	583.20	595.40	561.46
12/11/ 2010	522.80	548.80	540.60	537.40
19/11/ 2010	571.60	546.20	558.60	558.80
26/11/ 2010	533.40	471.20	559.20	521.26
03/12/ 2010	588.80	515.20	560.60	554.86
Gm	537.85	534.81	560.36	544.34
Sem =	sem1 = 14.434	sem2 = 32.276	sem3 = 55.903	
Cd at 5% =	cd1 = 40.28689 <sup>ns</sup>	cd2 at 90.084 <sup>ns</sup>	cd3 at 156.030 <sup>ns</sup>	



**Figure 1.** Effect of electromagnetic radiations on mean brood area of tower, mobile and control colonies of *A. mellifera* L.

colony health. Similarly, Kimmel et al. (2007) reported overall, 482 (63%) bees of the CG (non-exposed), 203 (56.4%) bees of the EG2 (radiation shielded down) and

365 (54.1%) bees of the EG1 (fully electromagnetic exposure) returned to their hive. These differences between the groups were not significant. Moreover, many

**Table 2.** Average honey production at first harvesting on 15 December, 2010.

Treatment	Control colonies (kg/hive)
Tower	14.43
Mobile	13.76
Control	12.80

**Table 3.** Average EMR frequency on *Apis mellifera* colonies during the observation period.

EMR Measurement	Tower	Mobile	Control
Electric field (E)	345.40 (m V/m)	57.70 (V/m)	07.90 (m V/m)
Magnetic field (M)	670.63 ( $\mu$ A/m)	100.78 (m A/m)	18.72 ( $\mu$ A/m)
Power density (P)	260.08 ( $\mu$ W/m <sup>2</sup> )	10.60 ( $\mu$ W/m <sup>2</sup> )	0.10 ( $\mu$ W/m <sup>2</sup> )

recent studies have also demonstrated that various tissues, cellular activities, memory, and learning in humans, rats, and mice are not affected when subjected to GSM or GSM-like microwave radiation (Cobb et al., 2004; Dasdag et al., 2003, 2004, 2008; Dubreuil et al., 2002, 2003; Forgacs et al., 2006; Joubert et al., 2007; Kumlin et al., 2007; Sienkiewicz et al., 2000; Smith et al., 2007; Thorlin et al., 2006; Tillmann et al., 2007). Nevertheless, these findings should not downplay the potential health hazards involved with the use of cellular phones.

Negative results are never appealing; however, no uniform consensus on the effects of microwave radiation on biological processes has been demonstrated in the existing literature. Contrary to the general belief, Mixson et al. (2009) reported that the 900 and 1800 MHz frequencies utilized by GSM technology are not a likely cause of, or a contributing factor in, colony collapse disorder. Other possible causes of CCD and factors contributing to honeybee population declines including biological pathogens (Cox-Foster et al., 2007), agrochemicals, climate change, and genetically modified crops must continue to be investigated. Moreover, the copious disagreement among published findings pertaining to the effects of cellular phone radiation on humans and other animals necessitates that researchers continue to investigate the biophysical interactions between microwave radiation and biological systems for the welfare of entire human community on this planet.

Though many reports published in different journal, books and newspaper revealed the insignificant effect of EMR on the humans and animals. Schneider and Lewis (2004) observed the induction of honeybee worker piping by the electromagnetic fields of mobile phones might have dramatic consequences in terms of colony losses due to unexpected swarming. The active mobile phone handsets in beehives noticeably induce the rate of worker piping. However, no evidence for piping of the laying

queen was observed, whereas in earlier report Walker and Bitterman (1989b) observed magnetic corollary at even 26 nanoTesla (nT) for changes in the foraging behaviour of bees. On the other hand Dimitris et al. (2004) reported Pulsed radio frequency, EMR from common GSM mobile phones, with a carrier frequency at 900 MHz, "modulated" by human voice, decreases the reproductive capacity of *Drosophila melanogaster* by 50 to 60%, whereas the corresponding "non-modulated" field decreases the reproductive capacity by 15 to 20%. A national survey performed in the United States (Bee Alert Technology, 2007), reported that implication regarding a direct correlation between erratic honeybee behaviour and mobile phone-generated electromagnetic fields would substantiate one more explanation for the "disappearance" of bee colonies around the world. This phenomenon accounts for 43% of all bee losses, apart from overwintering (39%), mite disease, (15%) and pesticides (3%). Recently, Sahib (2009) suggested that cell phones and cell phone towers near beehives interfere with honeybee navigation. He found that when a mobile phone was kept near a beehive it resulted in collapse of the colony in 5 to 10 days, with the worker bees failing to return home, leaving the hives with just queens, eggs and hive-bound immature bees. Daniel (2010) described the potential effects of electromagnetic waves originating from mobile phones on honeybee behaviour. Active mobile phone handsets have a dramatic impact on the behaviour of the bees, by inducing the worker piping signal.

## Conclusion

Several findings reported that sharp declines and potential health hazards in honeybee populations due to cellular phones and GSM radiation could considerably weaken the infrastructure of food webs across the globe.

Some countries have sought to limit the proliferation of mobile towers with strict rules. But in India no such rules have been formulated or implemented. Given the proliferation of mobile phone towers and their vital role in communications, solutions to the problem will not be as simple as eliminating the towers. As per the present investigation, all the treated colonies either with cell phone or tower radiation had perform well as normal colony and none of the colonies were perished during the experiment. Besides the fulfilling the requirement of growing offspring all the colonies had sufficient store of pollen and nectar which was harvested in the December, 2010 after accomplishment of the experiment. Indeed, the EMRs may harm the health of living creature in long run however; the immediate and direct impact is yet need intensive research to draw a firm conclusion.

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## Conflict of Interest

The author(s) have not declared any conflict of interests.

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