

## Effect of Electromagnetic Field on Some Behaviour Modality of Honeybee Colonies (*Apis mellifera*) in Field Conditions

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**Abstract:** The object of this study was to determine some behaviour patterns regarding biological-rearing status of honeybee colonies situated at different distances from two mobile phone base stations in field conditions. Electric field strength measured at each location was: 1.0 V/m (location O); 0.027 V/m (location H); 0.065 V/m (location K), respectively and the frequency was the same for all locations at 937.5 MHz. During observation of experimental honeybee colonies, the following biological aspects were recorded: colony strength, presence of queen cells, aggressiveness and composure of adult bees on combs as behavioural parameters. Assigned mean values for observed parameters show that at beginning of experiment honeybees were distress and within time they moderated described behavioural modality.

**Key words:** Radio Frequency Electromagnetic Field (RF-EMF), mobile phone base station, honeybee colonies, behaviour, biological aspects, parameters

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### INTRODUCTION

Mobile phone base stations, known as tower antenna, emit 900 MHz microwave signal and pulsed at low frequencies-microwave radiation. This radiation is perceived as environmental pollution (Balmori, 2015). Although, the absorbed energy from radio frequency radiation at the operating frequency of mobile phones can not break chemical bounds, the results of many studies on different organisms have shown that exposure to it can cause oxidative stress and genotoxic effects (Tkalec *et al.*, 2013), disorders of the immune and neurological system (Stronati *et al.*, 2006; Huber *et al.*, 2002), increased amount of the stress proteins (Calabro *et al.*, 2012) and change the cellular metabolism (Mousavy *et al.*, 2009). Exposure to this radiation is highly bioactive and can induce significant alteration in the physiological functions of living organisms (Sivani and Sudarsanam, 2012). Different exposure scenarios were applied on honeybee colonies and a broad range of effects (Cucurachi *et al.*, 2013). Previous studies regarding effects of RF-EMF at frequencies from 900 MHz-2.4 GHz investigated mostly adult honey bees are still controversial because there are several studies that have not found biological effects after exposure (Ruediger, 2009; Verschaeve, 2009; Vijayalaxmi and Prihoda, 2012; Mall and Kumar, 2014). But for this important pollinator insects, researchers also reported the significant decline in colonies strength and in the egg laying rate of honeybee queen (Sharma and

Kumar, 2010), induction of “worker piping” which is associated with swarming (Favre, 2011) and the alteration of some biochemical parameters (Kumar *et al.*, 2013). By Vilic *et al.* (2017) found honeybee worker larvae significantly affected when exposed to modulated but not to non-modulated RF-EMF radiation, resulting in DNA damage.

Honeybees presents the valuable experimental animals to study effect of atmospheric environment electro pollution because in their abdomens they possess magnetite granules which helps them in flight navigation (Hsu *et al.*, 2007). Also, the results of some experiments suggest that radiation produced by mobile phone base station towers is actually frying the navigational skills of the foragers and preventing them from returning back to their hives (Rubin *et al.*, 2006) and this impaired behaviour affect homing ability (Carreck, 2014; Ferrari, 2014). There are some reports of significantly lower production of apian products with decreased winter survivorship (Kimmel *et al.*, 2007) or sudden unexplainable disappearance of adult honeybees from hives-syndrome called Colony Collapse Disorder (CCD) (Cane and Tepedino, 2001; Steinhauer *et al.*, 2018). In the light of this honeybee characteristics, aim of this study was to determine some behaviour modality regarding biological-rearing status as well as estimating the strength of honeybee colonies, situated at different distances from two mobile phone base stations and exposed to different electric field strength in field conditions.



Fig. 1: Distance between; a) Mobile phone base towers (A, B) and honeybee colonies location O and b) Locations of observed honeybee colonies (O, H, K) (<http://geoportals.dgu.hr/>)

### MATERIALS AND METHODS

The experiment was conducted at the apiary situated in Southern Croatia, NUTS 2-HR03 and LAU 1-HR035 (according: National classification space units for statistical needs). Fifteen homogenous honeybee colonies (*Apis mellifera*) were selected and situated at three locations: O ( $43^{\circ} 23' 7,20''$  N;  $17^{\circ} 13' 16,97''$  E; 534 m above-sea altitude) (n-5; 67.24 m and 159.76 m distance from mobile phone base tower, respectively) (Fig 1a); H ( $43^{\circ} 22' 43,55''$  N;  $17^{\circ} 13' 34,55''$  E; 450 m above-sea altitude) (n-5; 790 m and 700 m distance from mobile

phone base tower, respectively); K ( $43^{\circ} 23' 7,17''$  N;  $17^{\circ} 14' 30,05''$  E; 277 m above-sea altitude) (n-5; 1630 m and 1520 m distance from mobile phone base tower, respectively). Distances between three experimental apiaries (O, H, K) are presented on Fig 1b. Before transportation of hives with honeybee colonies to selected locations the average electric field strength and frequency were measured at each location using portable spectrum analyser NARDA SRM 3000 (NARDA, USA). During observation period (active beekeeping season 2014, April-September) five clinical inspections of honeybee colonies were conducted at monthly intervals

and the following biological aspects were recorded: colony strength, presence of queen cells and aggressiveness and composure of honeybees on combs as behavioural parameters. Statistical effect sizes between experimental honeybee colony groups (O, H, K) were calculated using Cohen's D effect size calculator.

## RESULTS AND DISCUSSION

Electric field level measured at each location was: O-1,0 V/m; H-0,027 V/m; K-0,065 V/m and the frequency was the same for all locations at 937.5 MHz. The most significant differences in honeybee colonies behaviour as well as in biological parameters was observed during first 2 months after start of hives exposure and significant changes were visible only for honeybee colonies situated at location O. In comparison with other two locations at this location where hives were situated nearest to mobile phone tower antenna and exposed to highest electric field level, the visible higher aggressiveness level and decreased composure of adult honeybees, appearance of new queen cells and slightly decline in colony strength were observed.

In particular in all hives were recorded sufficient pollen and nectar store which was enough to rear the honeybee brood. There was not observed significant difference in development of brood or in strength of colonies between locations but at location O in all colonies was observed presence of new queen cells or young queen successfully produced by workers as well as mating like in healthy colonies. This observation was similar to accidental observation of Mall and Kumar (2014) and different from study which demonstrate that RF-EMF exposure has significantly affected ontogenetic queen development with increased queen's mortality during pupation, under field conditions but under higher electric field level (Odemer and Odemer, 2019). At location H only one colony produced new queen and at location K disorders were not observed.

Assigned mean values for aggressiveness\* per honeybee colony were: O (2.2; 1.2; 2.2; 2.6;3.4), H (2.4; 3.0; 2.8; 3.8; 4.0), K (3.0; 3.8; 3.8; 4.0; 4.0) and for composure of adult bees on combs\*\* were: O (2.6; 1.8; 1.8; 3.8; 3.8), H (2.4; 3.2; 3.6; 3.8; 3.8), K (3.4; 3.8; 3.8; 4.0; 4.0). Calculated effect sizes between experimental groups were as follows: O-H  $d_{\text{cohen}} = 0.442$ , H-K  $d_{\text{cohen}} = 0.20$ , K-O  $d_{\text{cohen}} = 0.737$  for aggressiveness; O-H  $d_{\text{cohen}} = 0.221$ , H-K  $d_{\text{cohen}} = 1.347$  and K-O  $d_{\text{cohen}} = 0.898$  for adult bee's composure on waxcombs. (\*1-aggressive bees, fly, attack and sting; 2-less aggressive bees, fly, tray to attack and sting; 3-normal but discomfort behaviour of bees, do not attack or sting; 4-very gently bees, calm walking; \*\*1-fidgetily bees, leave

from combs; 2-fidgetily bees, several leave from combs; 3-normal behaviour of bees, walking toward honey storage; 4-very calm bees, walking on combs). Obtained results show that at beginning of experiment honeybee colonies situated at all locations (O, H, K) were distress and within time they moderated described behavioural parameters but at location O honeybees have been changed their behaviour whence they produced new queens. In research of Odemer and Odemer (2019) honeybee queens that survived the RF-EMF exposure treatment were also able to establish full functional colonies, demonstrating an immense recovering potential.

## CONCLUSION

It can be concluded that exposure of honeybee colonies in vicinity to mobile phone base stations in field conditions as unfavourable environmental factor, may induce temporarily alteration in the honeybee behaviour and biological activities, probably as consequence to adaptation process.

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