Journal of Animal and Veterinary Advances 18 (2): 61-64, 2019
ISSN: 1680-5593

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

[1]Ivana Tlak Gajger, [1]Marinko Vilic, [1]Perica Tucak and [2]Kresimir Malaric
[1]Faculty of Veterinary Medicine, University of Zagreb, Heinzelova 55, 10000 Zagreb, Zagreb, Croatia
[2]Faculty of Electrical Engineering and Computing, University of Zagreb, 10000 Zagreb, Croatia

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

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.

Corresponding Author: Ivana Tlak Gajger, Department of Biology and Pathology of Fish and Bees, Faculty of Veterinary Medicine, University of Zagreb, Heinzelova 55, Zagreb, Croatia

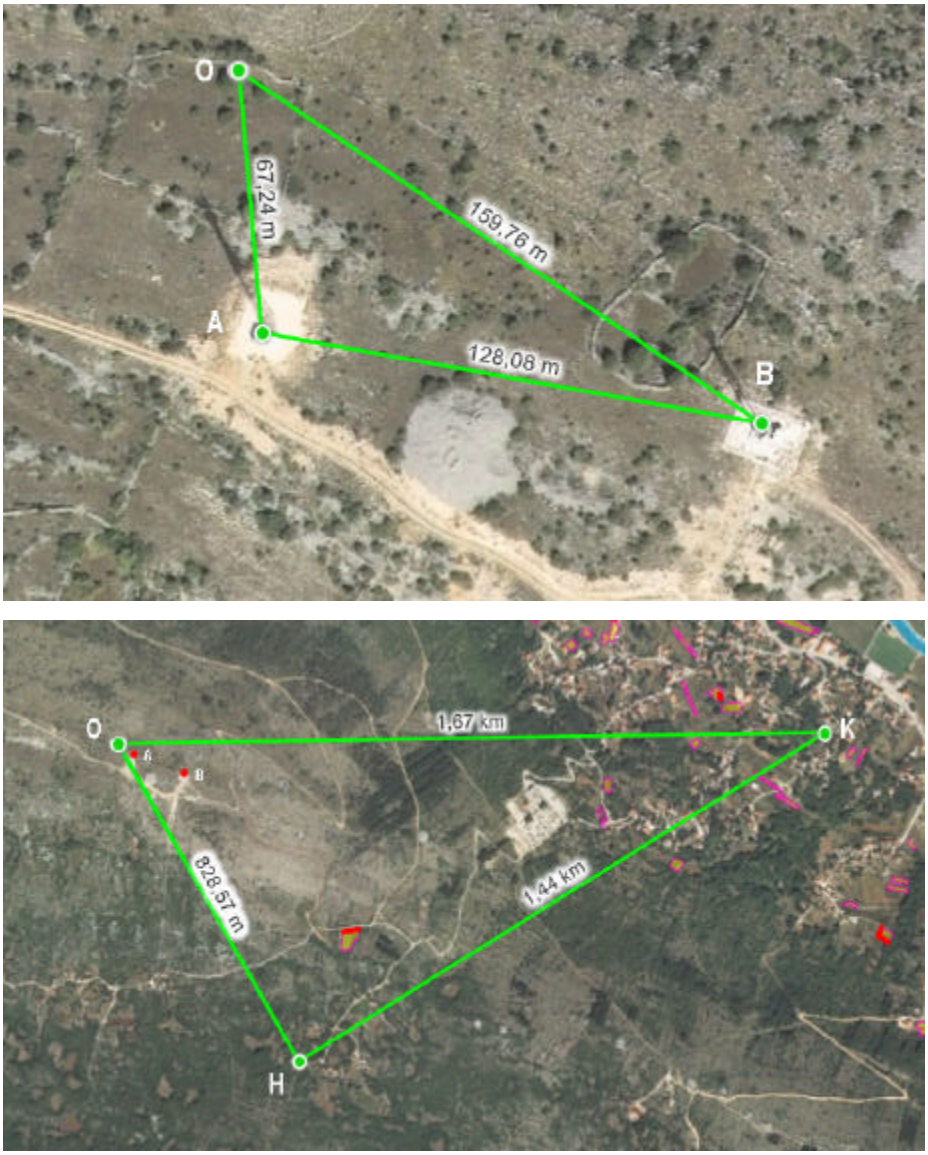

Fig. 1: Distance between; a) Mobile phone base towers (A, B) and honeybee colonies location O and b) Locations of observed honeybee colonies (O, H, K) (http://geoportal.dgu.hr/)

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° 23' 7,20" N; 17°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°22' 43,55" N; 17°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° 23' 7,17" N; 17° 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_{cohen} = 0.442, H-K d_{cohen} = 0.20, K-O d_{cohen} = 0.737 for aggressiveness; O-H d_{cohen} = 0.221, H-K d_{cohen} = 1.347 and K-O d_{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.

REFERENCES

Balmori, A., 2015. Anthropogenic radiofrequency electromagnetic fields as an emerging threat to wildlife orientation. Sci. Total Environ., 519: 58-60.

Calabro, E., S. Condello, M. Curro, N. Ferlazzo and D. Caccamo *et al*., 2012. Modulation of heat shock protein response in SH-SY5Y by mobile phone microwaves. World J. Biol. Chem., 3: 34-40.

Cane, J.H. and V.J. Tepedino, 2001. Causes and extent of declines among Native North American invertebrate pollinators detection evidence and consequences. Conserv. Ecol., 5: 1-1.

Carreck, N., 2014. Electromagnetic radiation and bees, again. Bee World, 91: 101-102.

Cucurachi, S., W.L. Tamis, M.G. Vijver, W.J. Peijnenburg and J.F. Bolte *et al*., 2013. A review of the ecological effects of Radio Frequency Electro Magnetic Fields (RF-EMF). Environ. Intl., 51: 116-140.

Favre, D., 2011. Mobile phone-induced honeybee worker piping. Apidologie, 42: 270-279.

Ferrari, T.E., 2014. Magnets, magnetic field fluctuations and geomagnetic disturbances impair the homing ability of honey bees (*Apis mellifera*). J. Apic. Res., 53: 452-465.

Hsu, C.Y., F.Y. Ko, C.W. Li, K. Fann and J.T. Lue, 2007. Magnetoreception system in honeybees (*Apis mellifera*). PloS One, 2: e395-e395.

Huber, R., V. Treyer, A.A. Borbely, J. Schuderer and J.M. Gottselig *et al*., 2002. Electromagnetic fields, such as those from mobile phones, alter regional cerebral blood flow and sleep and waking EEG. J. Sleep Res., 11: 289-295.

Kimmel, S., J. Kuhn, W. Harst and H. Stever, 2007. Effects of electromagnetic exposition on the behavior of the honeybee (*Apis mellifera*). Environ. Syst. Res., 8: 1-8.

Kumar, N.R., N. Rana and P. Kalia, 2013. Biochemical changes in haemolymph of *Apis mellifera* L. drone under the influence of cell phone radiations. J. Appl. Nat. Sci., 5: 139-141.

Mall, P. and Y. Kumar, 2014. Effect of electromagnetic radiations on brooding, honey production and foraging behavior of European honeybees (*Apis mellifera* L.). Afr. J. Agric. Res., 9: 1078-1085.

Mousavy, S.J., G.H. Riazi, M. Kamarei, H. Aliakbarian and N. Sattarahmady *et al*., 2009. Effects of mobile phone radiofrequency on the structure and function of the normal human hemoglobin. Intl. J. Biol. Macromol., 44: 278-285.

Odemer, R. and F. Odemer, 2019. Effects of Radio Frequency Electromagnetic Radiation (RF-EMF) on honey bee queen development and mating success. Sci. Total Environ., 661: 553-562.

Rubin, E.B., Y. Shemesh, M. Cohen, S. Elgavish and H.M. Robertson *et al*., 2006. Molecular and phylogenetic analyses reveal mammalian-like clockwork in the honey bee (*Apis mellifera*) and shed new light on the molecular evolution of the circadian clock. Genome Res., 16: 1352-1365.

Ruediger, H.W., 2009. Genotoxic effects of radiofrequency electromagnetic fields. Pathophysiology, 16: 89-102.

Sharma, V.P. and N.R. Kumar, 2010. Changes in honeybee behaviour and biology under the influence of cellphone radiations. Current Sci. Bangalore, 98: 1376-1378.

Sivani, S. and D. Sudarsanam, 2012. Impacts of Radio-Frequency Electromagnetic Field (RF-EMF) from cell phone towers and wireless devices on biosystem and ecosystem-a review. Biol. Med., 4: 202-216.

Steinhauer, N., K. Kulhanek, K. Antunez, H. Human and P. Chantawannakul *et al*., 2018. Drivers of colony losses. Curr. Opin. Insect Sci., 26: 142-148.

Stronati, L., A. Testa, J. Moquet, A. Edwards and E. Cordelli *et al*., 2006. 935 Mhz cellular phone radiation. An *in vitro* study of genotoxicity in human lymphocytes. Intl. J. Radiat. Biol., 82: 339-346.

Tkalec, M., A. Stambuk, M. Srut, K. Malaric and G.I. Klobucar, 2013. Oxidative and genotoxic effects of 900 MHz electromagnetic fields in the earthworm Eisenia fetida. Ecotoxicol. Environ. Saf., 90: 7-12.

Verschaeve, L., 2009. Genetic damage in subjects exposed to radiofrequency radiation. Rev. Mutat. Res., 681: 259-270.

Vijayalaxmi and T.J. Prihoda, 2012. Genetic damage in human cells exposed to non-ionizing radio frequency fields: A meta-analysis of the data from 88 publications (1990-2011). Mutat. Res. Genet. Toxicol. Environ. Mutagen., 749: 1-16.

Vilic, M., I. T. Gajger, P. Tucak, A. Stambuk and M. Srut *et al*., 2017. Effects of short-term exposure to mobile phone radiofrequency (900 MHz) on the oxidative response and genotoxicity in honey bee larvae. J. Apic. Res., 56: 430-438.