The Effect of EMF Radiation Emitted by Mobile Phone to Insect Population using *Drosophila melanogaster* as a Model Organism

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Abstract

Electromagnetic field (EMF) exposure has been reported produce a number of biological effects on biomolecules, cells, and up to the entire body of the organisms. Mobile phone devices, the most powerful EMF transmitters in the environment of human life, have become widely and increasingly used by the public. The exponential growth of mobile communications has been accompanied by a parallel increase in the density of EMF. Insects is one component of ecosystems that have various roles, both positive and negative, such as biological control and pests. In this study, the effect of EMF radiation emitted by mobile phone on insect over several generations were observed. *Drosophila melanogaster* was used as model organism and generation time, adult filial number, and sex ratio were observed in this study. As a result, a cell phone exposure significantly affected the generation time, whereas no significant effect on the adult filial number and sex ratios of *D. melanogaster*.

Keywords: Adult filial number; *Drosophila melanogaster*; EMF; generation time; mobile phone; sex ratio

1. Introduction

An electromagnetic field (EMF) is a physical field produced by electrically charged objects [1]. Human beings, like all living organisms, have alwasy been exposed to EMF that comes from numerous sources, both natural and artificial [2]. But, the increase of EMF's artificial sourcesin recent decades become one of the concerns that note in various forumstoday [3]. One artificial source of EMF is a mobile phone [2-4]. Related with the increase of EMF's artificial source, the existence and use of mobile phones has increased rapidly during the last few decades [5]. In 2015, there are more than 7 billion mobile phone subscriptions worldwide, up from less than 1 billion in 2000 [6]. With the increasing number of users, the opinions on the dangers of mobile phone radiation began to appear. Therefore, today, many researchers are conducting research to reveal the dangers of EMF radiation from cell phones, on humanor animal [7].

Insects is one component of ecosystems. As a component of the ecosystem, insects have an important role, both for the continuity of the ecosystem, as well as for human life [8-10]. Some of these roles, such as biological control and pests [9,10]. Associated with its role in the ecosystem, the loss of the entire population of an insect is a dangerous condition for the sustainability of an ecosystem, even if those insects has a negative role for human life.

In this study, the effects of EMF radiation emitted by mobile phone on insect populationover several generations were observed. *D. melanogaster* were chosen as a model organism in the study because *D. melanogaster* is the most significant model organism [11]. Furthermore, there are many technical advantasges of using *Drosophila* as a model organism, they are easy and inexpensive to culture in laboratory conditions and have a much shorter life cycle [12]. Our previous study revealed that the exposure of EMF from mobile phone affected the generation time of *D. melanogaster* N strain, although, the generation time then tends return to the normal time after several generations [13]. In this study, *ebony* strain was used and besides generation time, two other variables, adult filial number and sex ratio, were also observed.

Ecology is the scientific study of the interactions that determine the distrbution and abundancae of organisms [14]. By definition, ecology focuses on the higher organisational levels of populations, communities and ecosystems. But, it is plausible to link biological studies with ecological endpoints at the individual animal level to ecological interpretations at a higher organisation level [7]. Therefore, the results from this study can also be used as information related to the effect of mobile phones on the ecosystem.

2. Material and Methods

2.1. The organsim and environmental conditions

The *ebony* strain of *D. melanogaster* from Genetic Laboratory FMIPA UM was used in this study (Figure 1a;b). Flies were cultured in a 200 ml cylindrical glass bottle, with 7 cm diameter and 9 cm height, filled with 30 ml standard food (Figure 1c). The flies cultures were kept in a research room where the temperature was 25.5 ± 1° C.

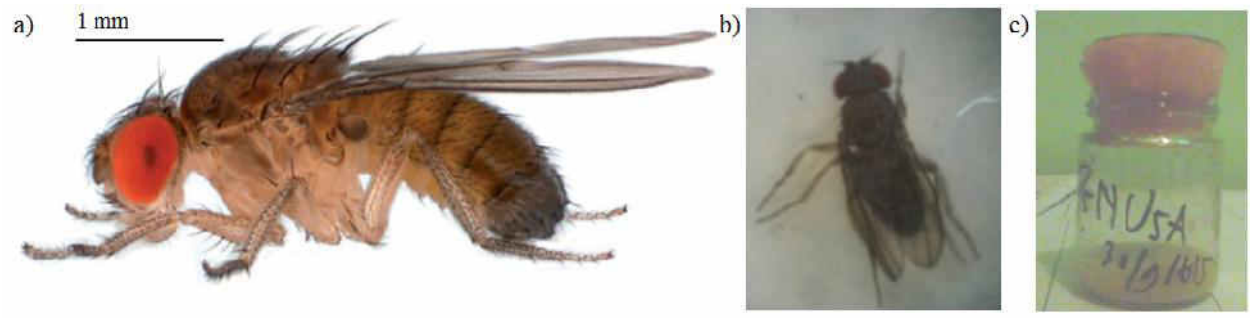

Figure1. a) *D. melanogaster* strain e [15]; b) *D. melanogaster* was used in this study; c) Flies bottle containing food

2.2. Food composition

The food consisted of ± 2500 ml water, 700 g banana (Raja Mala varieties), 200 g fermented cassava (tape singkong), and 100 g palm sugar. The mixture was boiled for over 45 minutes. This food quantitiy was enough for 35 cultured bottles.

2.3. Preparation of the control group

The control group was the flies were not exposed by mobile phone. Flies were cultured and crossed in research room which was free from mobile phones. Each cross consisting of one male and one female, both 1 X 24 hours after hatching from pupae. After 2 x 24 hours crossed, male fly was removed from the bottle.

2.4. Preparation of the treatment group: mobile phoneexposure

GSM mobile phone (Figure 2a) with provider that using frequencies at 900/1800 MHz (3G) and HSDPA 2100 (4G) was used as a source of EMF exposure. The position of the mobile phone and flies bottles during this study is illustrated in Figure 2b. Those bottles were place where flies were crossed. Each cross consisting of one male and one female, both 1 X 24 hours after hatching from pupae. After 2 x 24 hours crossed, male fly was removed from the bottle (same with control group). This study was conducted over three generations. As a note, flies have acclimatized for a generation.

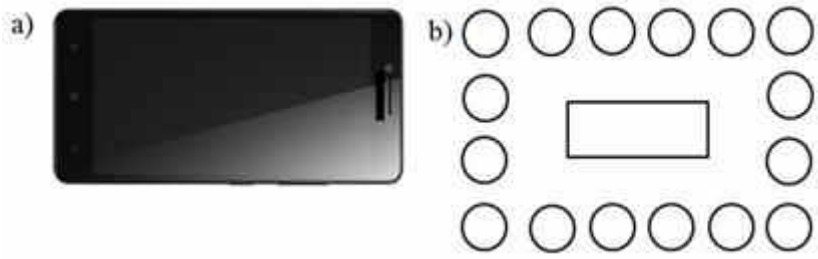

Figure2. a) The mobile phones used in this study; b) the position of the mobile phone (rectangle) and the flies bottles (circle), the distance between the mobile phone with the bottles is ± 20 cm

2.5. Determination of the generation time

The term of generation time in insect refers to the interval between production of eggs in one generation to the production of eggs in the next [16]. Due to the difficulty of observing the eggs production time in each generation, so in this study the eclosion time (when the adult fly emerged from the pupae) was used as a basis for determining the generation time.The data of generation time weresobtained by recording the period of time between parental eclosion and first filial adult eclosion in each generation. The statistical analysis of the results were carried out using the SPSS 22.0 programme. The generation time data from each group was calculated with one way ANOVA testat a significance level of 0.05. Furthermore, LSD test performed when the ANOVA test result was significant.

2.6. Determination of the adult filial number

The data ofadult filial numberwere obtained by recording the number of adult filial in each generation. The statistical analysis ot fhe result was carried out using the SPSS 22.0 programme. The number of filial from each generation were calculated with one way ANOVA testat a significance level of 0.05. Furthermore, LSD test performed when the ANOVA test result was significant.

2.7. Determination of the sex ratio

The data of sex ratio were obtained by recording the ratio of adult male to female filial in each generation. Then, the data were calculated using chi-square testat a significance level of 0.05.

3. Results and Discussion

3.1. The effect of mobile phone exposure onthe generation time of D. melanogaster

A cell phone exposure significantly affected the generation time of *D. melanogaster* (*p= 0.000*). Table 1 shows a comparison of generation time from each generation. The shortest generation time was in control group, whereas the longest generation time was in first generation from treatment group.

Table1. The effect of mobile phone exposure on the generation time of *D. melanogaster*

Group	Mean (hour)	Std. Deviation	Std. Error of Mean	LSD Notation
Control	229,9375	1.96188	0.98094	a
First generation	264,4167	1.50462	0.75231	d
Second generation	253,8333	2.71825	1.35913	c
Third generation	248,6625	4.38242	2.19121	b

3.2. The effect of mobile phone exposure on theadult filial number of D. melanogaster

A cell phone exposure did not affect the adult filial number of *D. melanogaster* significantly (*p=0.282*). Although did not significant, the data shows the change in the adult filial number of flies in the treatment group (depicted in graphic form in Figure 3). The filial decreased in the first generation of treatment groups, then increased in the second and third generations.

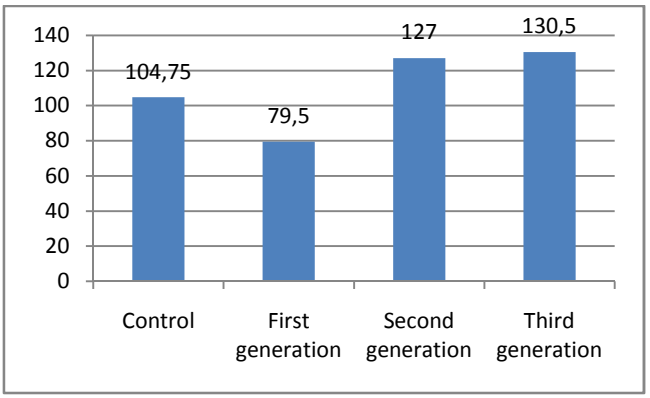

Figure3. The effect of mobile phone exposure on theadult filial number of *D. melanogaster*

3.3. The effect of mobile phone exposure on the sex ratio of D. melanogaster

A cell phone exposure did not affect the sex ratio of *D. melanogaster*. Table 2 shows the comparative data between the number of adult male to female filial in each generation with their chi square value.

Table 2. The effect of mobile phone exposure on thesex ratio of *D. melanogaster*

Group	Filial sex		χ^2
	♂	♀	
Control	192	227	2.92
First generation	164	154	0.31
Second generation	264	244	0.79
Third generation	261	261	0.00

note: χ^2 table = 3,84

Generation time is one aspect that greatly affects the population condition and the population dynamics [16-18]. The general trend shows the shorter generation time, the greater the populatioan of an insect [17-18]. In this study, a cell phone exposure significantly affected the generation time of *D. melanogaster.* As shown in Table 1, exposure of mobile phones caused the generation time becomes longer. However, in the treatment group, the generation timewere getting shortened and shortened in successive generations. This present results agreed with our previous study that observed the generation time of *D. melanogaster* strain N during four generations were exposed by mobile phones [13]. The generation time of the treatment group were longer than the control group may related to

the gonad development under the mobile phone exposure. It is based on the Panagopoulos's report that reported EMF emitted by mobile phone decreased the rate of cellular processes during gonad development in insects [19]. A side from the gonad development view, the change of generation time can also be seen from the development of hormones.

Ecdysteroids is hormones that regulates the growth of insects, including *D. melanogaster* [20-22]. During the development of the flies, the concentration of ecdysteroids initially increased followed by a decline to the very low concentrations wheneclosion occurs [21,22]. Related to this, Atli & Unlu argued EMF exposure may increased the proportion of ecdysteroid hormones because of stress condition casued by that field [23]. Therefore, the eclosion was arrested. The radiation as a stressful agent may also affect the juvenile hormone system. As a result oogenesis also arrested [24]. Therefore, the cellular processes during gonad development and the level of hormones related to molting and oogenesis may the reason why the generation time of treatment were longer than the control.

The adult filial number is another factor that affects population. There are two aspects associated with this variable, the fecundity and the survival of the filial before adult stage. In this study, a cell phone exposure did not affect the adult filial number of *D. melanogaster* significantly. There are various reports that provide a variety conclusions related to the effect of mobile phone exposure on *D. melanogaster* fecundity.If this variable is only viewed from the fecundity aspect, this present study argued with Kholy & Husseiny [25]. If this variable is viewed from the survival of the filial before adult stage, we can discuss it with the explanation that the non-thermal radiation from the GSM mobile phone can elevated stress proteins (hsps) level [26]. The role of these proteins is to maintain the structure and function of cellular proteins [26]. Because the function of cellular proteins is maintained, the overall function of the fly's body is still normal.

The last variable in this study is sex ratio. According to data analysis, a cell phone exposure did not affect the sex ratio of *D. melanogaster*. This present study argued with previous study that reported there were no significant difference on the effect of EMF exposure in males compared to females [27]. It shows that endurance between males and females against exposure to mobile phones is at the same level.

It is evident that mobile phone exposure affected the generation time of *D. melanogaster* and did not affect two other variables. Although this study has been completed, the research related to the effects of cell phone exposure to an organism still need to be done. One of the research topic that need to be addressed is the link between adaptation and mobile phone exposure. This is necessary because the generation time and the number of adult filial data in this study showed a tendency that leads to that.

4. Conclusion

A cell phone exposure significantly affected the generation time, whereas no significant effect on the adult filial number and sex ratios of *D. melanogaster*.

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