SHORT COMMUNICATION

Effects of gamma radiation on biological development of *Aedes Albopictus*

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Abstract:

Dengue is a mosquito-borne viral disease, that may spread across countries. There are two main causes of dengue transmission which are *Aedes aegypti* and *Aedes albopictus*. However, in Malaysia, *Aedes albopictus* overlap the distribution of *Aedes aegypti* and its population in the certain area showed more dominant than *Aedes aegypti*. The objective of this study was to investigate the effects of gamma radiation on the biological development, including the hatchability rate, development period, embryonation period and adult emergence of *Aedes albopictus.* Average total of 360 *Aedes albopictus* eggs were irradiated with gamma radiation of 5, 10, 15, 20 and 25 Gy. Based on the result, hatchability rate decreased significantly with increasing of gamma radiation doses (p= 0.011). The shortest embryonation period was at day 12; eggs that irradiated with the least gamma dose (5 Gy). For adult emergence, only eggs that irradiated with 5 Gy able to emerge into adult.

Keywords: *Aedes albopictus*; gamma irradiation; biological development

1. INTRODUCTION

Dengue infection can cause fever, severe joints and muscle pain. In Malaysia, dengue fever cases were reported as a leading cause of hospitalization and death from all states annually. As of May 2019, there were total of 49,521 dengue cases reported in just five months by the Ministry of Health Malaysia [1]. Many methods were done to control the spreading of dengue virus such as fogging and insecticidal treatment. However, these methods seem ineffective and become more challenging due to mushrooming of houses and growing construction [2].

Another alternative that can be used is “Sterile Insect Technique” (SIT). SIT by using gamma radiation is preferable to control the population of any pest or vector as it is more effective, more sustainable and more friendly to the environment. A previous finding found that SIT by using gamma radiation has been applied successfully in controlling the Mediterranian fruit fly, *Ceratitis capitata* and the screwworm, *Cochliomyia hominivorax* [3]. Other than that, gamma irradiation also had been used in pest control method to inactivate development of some species. In the present study, inactivation of fungal in the honeybee was done by exposing them to gamma radiation [4]. Prior to proceed with controlling the population of vector, effect of gamma radiation on its biological development and radiosensitivity should be understand first, or else, SIT is difficult and impossible to be done. This study was done to understand the effects of five discrete gamma radiation doses on the biological development, including the hatchability rate, development period, embryonation period and adult emergence of *Aedes albopictus*.

2. MATERIALS AND METHODS

The materials used for this experiment were *Aedes albopictus* strains, ^{60}Co gamma irradiator- GC 220 E model, plastics containers, chicken liver powder, 10% sucrose solution, vitamin B complex, Dino Lite, mosquito cage, filter paper and dechlorinated water.

2.1 Preparation of *Aedes Albopictus*

The *Aedes albopictus* eggs strains (F0) were obtained from Institute for Medical Research, Kuala Lumpur. The mosquitos were reared until second generation (F1) in the insectarium under controlled conditions at a temperature of 27±2 °C with 75% to 85% relative humidity and 10:14 hour light-dark regimen. We began the mass rearing process with the immersion of the laboratory strain eggs (F0) in a few plastic containers containing dechlorinated water. The eggs were left for days and daily monitored until the first emergence of 1st instar larvae. The larvae were fed daily with chicken liver powder for their growth and the water was maintained at optimum condition. When the larvae reached stage of pupae, they were separated from the rest of the larvae and placed into a container. Adults were fed with 10%

sucrose solution in a small bottle with a moist cotton wick. The males and females adult mosquitoes were allowed to mate and upon maturation, blood meal from restrained laboratory mice were given to the gravid females mosquitoes to supply protein from the blood to their eggs. For oviposition, a filter paper and a black plastic cup (6.0cm) filled with distilled water were placed inside the cage and observed daily. The laid eggs on the filter paper were collected within 24 hours and dried in room temperature. The collected eggs were kept for further experimental assays.

2.2 Irradiation Process of *Aedes Albopictus* Eggs

This study was performed in batches for five different doses which were 5 Gy, 10 Gy, 15 Gy, 20 Gy and 25 Gy and a control group. About 15-18 days aged eggs were irradiated by using Gamma Cell 220 Excel in a small cylinder cup along with moistened filter paper [5]. The eggs should be moistened before the irradiation procedure to avoid desiccation of the eggs. After exposed the eggs to gamma radiation, the irradiated eggs were kept for 24 hours in the insectarium. Then, profiles of every batch after being exposed with gamma radiation were captured under Dino Lite. After that, all the irradiated eggs and control with the filter paper were immersed in containers filled with dechlorinated water under controlled laboratory setting. The development period of the eggs from the first day of immersion until adult were observed daily and recorded.

3. RESULTS AND DISCUSSION

3.1 Effects of Gamma Radiation on Hatchability Rate of *Aedes albopictus* on Different Gamma Radiation Dose

Based on the hatchability rate, it was viewed that various level of hatchability effects was produced at different doses of gamma radiation (Table 1). Eggs that irradiated with the lowest dose (5 Gy) showed the highest mean hatchability rate of larvae which is 10.00 ± 5.00 percent. In contrary, the highest doses (20 Gy and 25 Gy) of gamma radiation contribute to the lowest mean hatching rate which is 3.33 ± 2.89 percent respectively.

Table 1: Comparison of mean hatchability percentage (%) on *Aedes albopictus* to different gamma dose

Dosage (Gy)	n	Mean hatchability percentage (SD)	p- value
Control	3	25.00 ± 13.23	
5	3	10.00 ± 5.00	
10	3	6.67 ± 2.89	0.011
15	3	5.00 ± 5.00	
20	3	3.33 ± 2.89	
25	3	3.33 ± 2.89	

Based on Table 1, ANOVA conducted was statistically significant in which it indicated that the hatching rate was influenced by gamma radiation dose, $F(5,12) = 4.93$, $p = 0.011$. There was a significant difference in hatchability rate among different gamma radiation dose at $p<0.05$. Post hoc analysis with Tukey's HSD test (using an α of 0.05) indicated that eggs irradiated with 10 Gy (M= 6.67, SD = 2.89) had significantly decreased the hatching rate followed by doses of 15 Gy (M= 5.00, SD = 5.00), 20 Gy (M= 3.33, SD = 2.89) and gamma radiation dose at 25 Gy (M= 3.33, SD = 2.89). The results showed that the gamma radiation doses were inversely proportional to the mean of hatching rate. Thus, as the gamma radiation doses increase, the hatching rate will decrease. Besides, in this study, the profile of eggs before and after being exposed to gamma radiation was captured under Dino lite. It showed that as the dose applied increased, the eggs experienced disruption of the structures and shapes might be due to the effect of gamma irradiation. From the obtained pictures, it revealed that only eggs that irradiated with the lowest dose (5 Gy) had no changes in their structure and shape. All eggs that irradiated at 10 Gy and above, at least one of the eggs had abnormal structure and shape [6]. Irradiation may induce dominant lethal mutations as a result of chromosomal damage. It was supported by other findings, whereby it stated that gamma doses used caused the development of eggs decreased might be due to vitellogenin synthesis inhibition [7].

3.2. Effects of Gamma Radiation on Development Trend of *Aedes Albopictus* on Different Gamma Radiation Dose

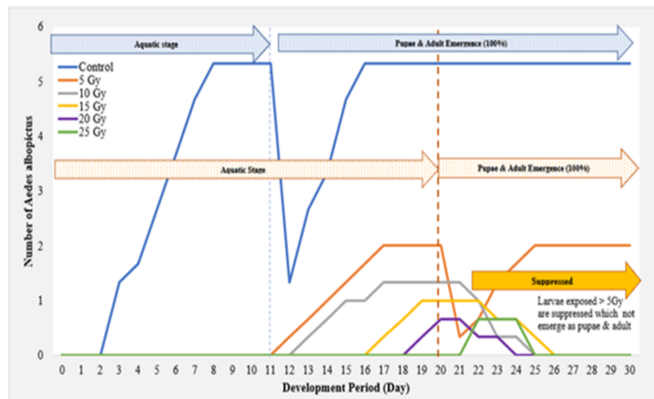

Figure 1: Average number of *Aedes albopictus* in aquatic stage until adult emergence after being irradiated with different gamma dose

The development trend data of *Aedes albopictus* was obtained from the first day of immersion until adult emergence. Figure 1 illustrates the average number of *Aedes albopictus* from the aquatic stage until adult emergence after being irradiated with five different gamma radiation doses which are 5 Gy, 10 Gy, 15 Gy, 20 Gy, and 25 Gy. The dotted line indicated that all hatched eggs had reached their 4^{th} instar and before pupae emergence. The embryonation period is defined as the first day of the larvae hatched. The results of this study showed the embryonation periods for eggs to become larvae were contrasted for each dose. It was observed that gamma radiation doses influenced the embryonation period. With the lowest dose, the time taken for the irradiated eggs to become larvae was shorter (at 12^{th} day) compared to other doses. The highest dose which at 25 Gy required 22 days for the eggs to hatch into larvae, thus it has prolonged embryonation period. In this study, gamma radiation did not affect the development periods of irradiated eggs of albopictus into adults. There was no difference in the development period for eggs to complete a development cycle until adult between the lowest dose (5 Gy) and unirradiated control. Both control and irradiated eggs at 5 Gy took 15 days to become adult and completed the cycle. Other than that, the result also showed that the hatched larvae were entirely suppressed during immature stages, and none of them undergo pupation when it was irradiated at dose 10 Gy and over. Only the hatched larvae from eggs that irradiated with the lowest dose (5 Gy) were able to emerge into viable adults.

4. CONCLUSION

In conclusion, the different biological parameters studied were affected by applying different doses of gamma radiation. The percentages of hatchability were significantly declined as the gamma radiation dose increased possibly due to vitellogenin synthesis inhibition and chromosome damage. Besides, a significant decrease in the embryonation period and adult emergence were obtained as the gamma radiation dose increased. Surprisingly, gamma radiation does not influence the development period of eggs to complete a cycle.

ACKNOWLEDGEMENTS

The authors would like to thank the staffs from the Centre of Environmental Health, Faculty of Health Sciences, Universiti Teknologi MARA for their assistance during the experimental study and staff from Faculty of Science, Universiti Kebangsaan Malaysia for facilitating the gamma irradiation.

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