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RESEARCH ARTICLE

SURVIVAL AND LONGEVITY OF GAMMA IRRADIATED *Bactrocera invadens* (DIPTERA: TEPHRITIDAE)

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ABSTRACT

In sub-Sahara Africa, *Bactrocera invadens* is a major pest of fruits and vegetables and causes huge economic losses to fruit production. The Sterile Insect Technique (SIT) is a pest control strategy that is effective against tephritids and can be applied. Gamma radiation treatment has recently been reported to cause sterility in this fly, but information on the effect of sterilizing radiation doses on insect qualities such as survival or longevity is needed since these qualities are important for an effective SIT control programme. Therefore, pupae of *B. invadens* were exposed to gamma radiation doses of 25, 50 and 75 Gy, and it was found that their survivals were not significantly different from that of the non-irradiated control. The maximum longevities of the irradiated and non-irradiated flies were also similar and showed there was no statistically significant difference beetween them. The radiation doses applied in this study do not compromise adult survival of *B. invadens* and therefore can be considered for use in any future SIT programmes against this fly.

INTRODUCTION

Since its detection in various parts of sub-Sahara Africa, *Bactrocera invadens*, has established itself as a major pest of fruits and vegetables on the continent (Lux *et al*., 2003a; Mwatawala *et al*., 2004; Vayssieres *et al*., 2005; Billah *et al*., 2006). Production losses arising from the damage caused by this tephritid fruit fly pest on fruits, especially mangoes, in many countries in Africa is estimated to be beetween 10 and 57% (Lux *et al*., 2003b; Vayssieres *et al*., 2005). In addition to the damage inflicted on fruit production by *B. invadens*, its presence in the sub-Sahara African region also brings a barrier to free trade between countries within this region and other countries outside the region (Ravry, 2008; Guichard, 2009) as efforts are made to prevent the spread of this invasive and destructive pest.

The Sterile Insect Technique (SIT), is an environment-friendly and species-specific pest control strategy based on the use of sexually sterile males to reduce wild populations (Knipling, 1955; Hendrichs *et al*., 2002). Sterile males released en mass mate with wild females, resulting in infertile eggs and subsequently a decrease or total elimination of the wild pest population. Sterility is commonly achieved by exposure of insects to radiation (Benedict and Robinson, 2003). Though radiation induces sterility in many insects, the dose required to ensure complete sterility varies among different species (Bakri and Hendrichs, 2004). Increasing the radiation dose usually results in higher levels of sterility, but increase in radiation doses also lead to reduction in insect qualities such as longevity, survival, mating competitiveness, etc (Calkins and Parker, 2005). Males of *B. invadens* have been reported to be incapable of producing offspring following exposure to gamma radiation dose of 75 Gy (Ogaugwu *et al*., 2012), suggesting that SIT can be used for its control. However, effective control of wild populations using SIT would require that the sterilizing doses do not compromise quality of the sterilized insects. This study therefore assessed the survival and longevity of *B. invadens* treated with different doses of gamma radiation since these qualities, together with an acceptable level of sterility, will be important for the success of any potential SIT programme on this important pest.

MATERIALS AND METHODS

Source of *B. invadens* immature stages and adults

Mangoes were collected from mango trees in three study locations namely the Agricultural Research Station (ARS) Kpong, the Agricultural farm of the University of Ghana and the Botanical Gardens of the University of Ghana, Legon. The fruits were kept in plastic racks at ambient temperature in the laboratary to allow for the incubation of eggs and larvae in them as described by Utomi (2006). Pupae obtained following

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Table 1. Percentage adult eclosion from irradiated and non-irradiated pupae

Dose (Gy)	0Gy	25Gy	50Gy	75Gy
Mean adult eclosion ± SE (%)	79.3 ± 2.7	78 ± 7.2	79.3 ± 10.7	83.3 ± 6.4

SE is standard error of mean

Table 2: Effect of radiation on longevity of adults

Dose (Gy)	0Gy	25Gy	50Gy	75Gy
Mean maximum longevity ± SE (%)	74 ± 0.6 [a]	72 ± 1.5 [a]	74 ± 0.6 [a]	68 ± 5.8 [b]

[a] is not significantly different from [b]; SE is standard error of mean

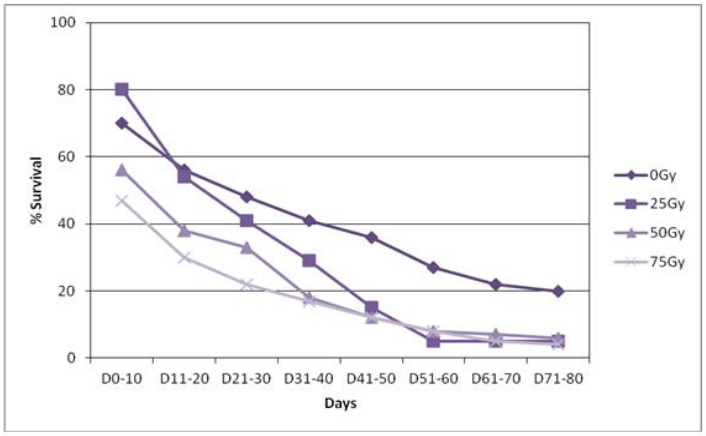

Fig. 1. Percentage survival of treated and untreated *B. invadens* adults

pupation of larvae that dropped from the fruits were kept in glass vials plugged with cotton wool.

Irradiation of pupae

Pupae were transported in glass vials plugged with cotton wool to the Radiation Technology Centre of the Ghana Atomic Energy Commision (GAEC). In this study, all pupae used were aged 6 days after pupation since this age was found to be most suitable for irradiation of *B. invadens* to obtain adult eclosion values higher than 50% (Ogaugwu *et al*., 2012). The pupae were exposed to radiation doses of 25, 50 and 75Gy at a dose rate of between 0.5208 and 0.5155 Grays per second (Gy/s), as earlier described by Ogaugwu *et al*. (2012). Fifty pupae were held in a glass vial, labelled appropriately and irradiated for each dose. Treatment for each respective dose was replicated trice. Another three glass vials containing fifty pupae each were not treated and kept as control (0Gy). After irradiation, the irradiated and non-irradiated pupae were taken back to the laboratory and kept in plastic cages labelled appropriately according to the dose of treatment for the emergence of adults. Percentage eclosion of adult flies from irradiated and non-irradiated pupae were determined.

Assessment of adult survival and longevity

Adult flies eclosing from pupae were fed on a diet composed of sugar and yeast (3:1 ratio). The temperature and humidity conditions at which the adult flies were kept were 28-34ºC and 61-93% relative humidity respectively. All the cages were checked daily, dead flies were removed and mortalities were recorded. Percentage survival of flies at any time interval was determined by dividing the number of flies alive at that point by the initial number of flies in the group. Survival curves for different treatments were plotted using the percentage survival. Longevity was determined by subtracting the date of eclosion of fliey from the date of its mortality. T-Test or Analysis of Variance (ANOVA) was used where necessary to compare different samples.

RESULTS

Adult eclosion from pupae

The numbers of adult flies recovered from irradiated and non-irradiated pupae were similar. Mean percentage adult eclosion from pupae irradiated at 25 Gy was slightly lower than that for the non-irradiated pupae, but the value obtained from pupae irradiated at 50Gy was the same as that of the non-irradiated pupae (Table 1). However, the mean percentage adult eclosion from pupae irradiated at 75Gy was found to be higher than that for non-irradiated pupae and other treatment groups (Table 1).

Survival of irradiated flies

As shown in Figure 1, both the control and treatment groups had survival curves with similar pattern, but the survivals of irradiated flies were generally lower than that for the non-irradiated control flies. However, single factor ANOVA on the samples showed that there was no significant difference between the percentage survival of the non-irradiated flies and those irradiated at 25, 50 and 75Gy ($F = 1.82$, $df = 3$, $P = 0.17$).

Longevity of irradiated adults

Study on the longevity of the flies was terminated on the 75th day after adult eclosion from pupae, though some flies were still alive in the cages for the different treatment doses (20 % in 0Gy, 5% in 25Gy, 5% in 50Gy and 4.8% in 75Gy). The longevity of the flies generally decreased as the dose of

radiation treatment increased and so did the maximum longevity of the flies. The mean maximum longevity for all treatment doses was above 70 days except for those treated at 75Gy (Table 2). T-Test analysis showed that there was no statistically significant difference existing between the maximum longevity of non-irradiated flies (0Gy) and those irradiated at different doses (Table 2).

DISCUSSION

The effect of gamma radiation on the survival and longevity of *B. invadens* in the laboratory was investigated in this study. This was necessary to ascertain if the radiation doses (25, 50 and 75Gy) reported to cause varying levels of sexual sterility in this fruit fly pest (Ogaugwu *et al*., 2012) would be suitable for use in future SIT programme in the case that adult survival is not highly compromised. Results from this study concurred with what had earlier been reported by Calkins and Parker (2005) by showing that increase in radiation doses causes a decrease in adult fly survival. Nevertheless, the differences observed between the survivals of the control and treated groups were found not be statistically significant. This implies that the radiation doses used in this study (25, 50 and 75Gy) do not compromise adult survival of *B. invadens* and therefore can be considered for use in any future SIT programmes against this fly. The result of this study was also in agreement with the finding of Opiyo (2001) who examined the survival of the tsetse fly, *Glossina pallidipes* irradiated as adults at 40 – 140Gy and found out that there was no significant difference in their survival. In addition to survival, we also investigated the longevity of *B. invadens* and found that they live for many months. The study was terminated 75 days after eclosion of adult flies from pupae and many flies were still alive at the time. Another fruit fly species, *B. dorsalis*, which is closely related to *B. invadens* had also been reported to live for many months (Steiner, 1957). Treatment of *B. invadens* pupae with the different radiation doses used in this studies had no statistically significant effect on maximum adult fly longevity.

The age of 6 day after pupation was found to be the suitable age for pupal irradiation to obtain high number of eclosing adults (more than 50%) in *B. invadens* (Ogaugwu *et al*., 2012) and this study also confirmed that. The percentage of adult flies eclosing from irradiated and non-irradiated pupae were all above 70% and showed that the irradiation doses applied had no adverse effect on the final recovery of adults from pupae. Though irradiation at adult stage should reduce negative effects of radiation on insect quality (Lance and McInnis, 2005), irradiation at pupal stage was chosen as transportation of adults is cumbersome and also because the amount of pupae to be irradiated can easily be controlled and maximized. Further studies are needed to determine an optimum radiation dose(s) that combines a high level of sterility and acceptable survival with a good level of mating competitiveness in adult males of *B. invadens* before any possible SIT can be initiated on this pest of high economic importance. For such studies, it would be better to use flies domesticated in the laboratory for some generations as these should be easier to manipulate than those reared out straight from fruits.

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