

## Effects of Increasing Dosages of Gamma Irradiation on Wingbeat Frequencies of *Dacus dorsalis* Hendel Males and Females at Different Age Levels<sup>1</sup>

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The literature is rare concerning the effects of gamma irradiation on the wingbeat frequencies of insects; in fact, only two research groups recently have published such data: Shepard et al. (1968), reported that the wingbeat frequencies of male and female fall armyworm moths, *Spodoptera frugiperda* (J. E. Smith) irradiated with 40 kilorads (Kr) were significantly retarded and that females showed a consistently greater reduction than irradiated males. Also, Noblet et al. (1968), reported similar results with irradiated secondary screwworm flies, *Cochliomyia macellaria* Fabricius. They found that 2- and 10-day-old flies irradiated with 25 Kr had significantly reduced wingbeat frequencies compared with non-irradiated flies.

In view of the limited amount of research in this area, this study was conducted to determine whether increasing levels of gamma irradiation dosages significantly reduces the wingbeat frequencies of *Dacus dorsalis* Hendel males and females at different ages.

### PROCEDURES

Laboratory-reared *D. dorsalis* pupae were obtained from the USDA Hawaiian Fruit Flies Investigations Laboratory in Honolulu, Hawaii. Approximately 50 ml or 1,885 pupae in 4 separate batches each were irradiated 2 days before eclosion at dosage rates of 2.5, 5.0, 10.0, and 20.0 Kr of gamma radiation, respectively. In addition, a separate batch of 50 ml of pupae not irradiated were used as controls. Irradiation was done in a pool-type Cobalt-60 irradiator having a dose rate from 3.0 to 3.5 Kr/minute (Ohinata, personal communication).

Emerging adult flies of each treatment were provided the standard adult diet of sugar, water, and protein (Keiser and Schneider, 1969) and maintained in separate 30.5 cm<sup>3</sup> wooden cages inside an insectary having a mean low and high temperature and relative humidity of 23.5 ± 1.2 and

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$25.7 \pm 0.1^\circ\text{C}$  and  $74.5 \pm 0.4$  and  $78.4 \pm 0.2\%$ , respectively.

At adult ages of 1, 3, 5, 9, 17, and 33 days, non-irradiated and irradiated flies of both sexes were randomly selected from their cages and inactivated with low temperatures. While inactivated, each fly was harnessed with non-toxic neoprene rubber cement on its dorsal thorax region to an "L-shaped" wire. Subsequently, the free end of the wire harness was inserted into a stationary mounting, and after 2 minutes of sustained flight, the flies' wingbeat frequencies were recorded. Flies not remaining in sustained flight for the full 2 minutes were replaced.

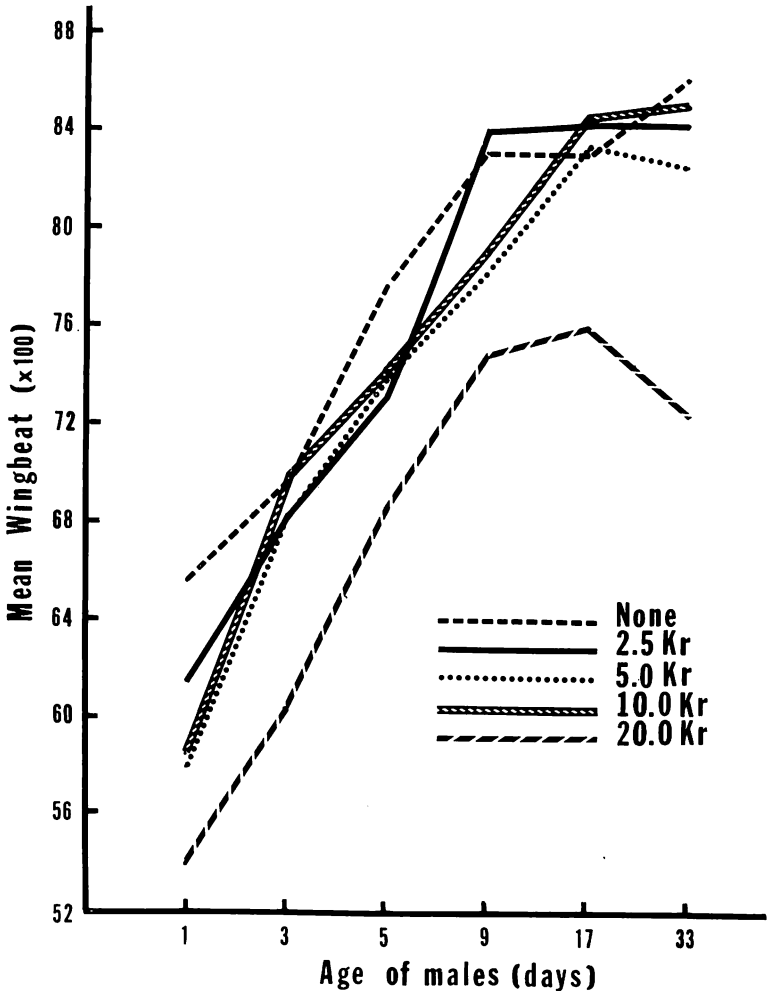


FIG. 1. Mean wingbeat frequencies (cycles/minute) of *D. dorsalis* males at different ages and gamma irradiation dosages.

Wingbeat frequency studies were performed using a General Radio Company Strobotac® Type 1531-AB having a flashing range rate from 110 to 25,000 flashes per minute and with an instrument accuracy of  $\pm 1\%$ . Wingbeat frequency studies were carried out in a darkened 10 ft<sup>3</sup> room, and hygro-thermographic readings taken inside the room showed the mean temperature and relative humidity to be  $25.2 \pm 0.4^\circ\text{C}$  and  $56.8 \pm 1.5\%$ , respectively.

### RESULTS

Regardless of treatments, both 1-day-old males and females recorded

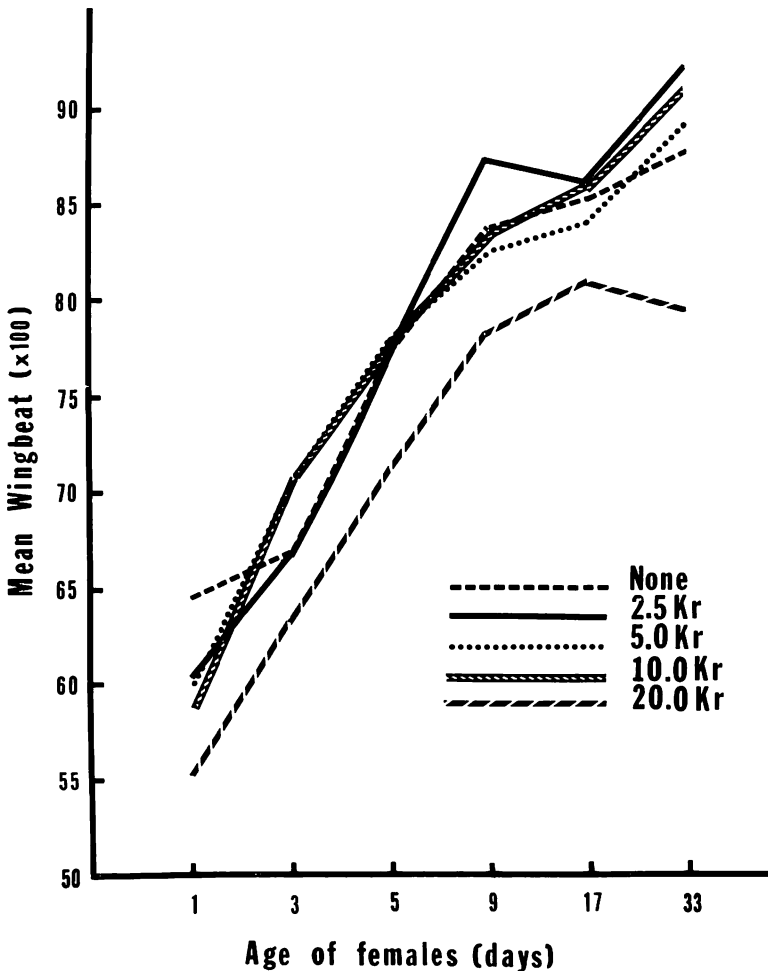


FIG. 2. Mean wingbeat frequencies (cycles/minute) of *D. dorsalis* females at different ages and gamma irradiation dosages.

TABLE 1. Comparison of treatment effects on *D. dorsalis* males and females: Non-significant (-) and significant (+) differences between treatments in mean wingbeat frequencies at the 5% level<sup>1</sup>.

| Treatment for both sexes | Age in Days |     |     |     |     |     |
|--------------------------|-------------|-----|-----|-----|-----|-----|
|                          | 1           | 3   | 5   | 9   | 17  | 33  |
| N × 2.5 Kr               | +/-         | -/- | +/- | -/- | -/- | -/- |
| N × 5.0 Kr               | +/-         | -/- | -/- | +/- | -/- | -/- |
| N × 10.0 Kr              | +/+         | -/- | -/- | -/- | -/- | -/- |
| N × 20.0 Kr              | +/+         | +/+ | +/+ | +/+ | +/+ | +/+ |
| 2.5 Kr × 5.0 Kr          | +/-         | -/+ | -/- | +/- | -/- | -/- |
| 2.5 Kr × 10.0 Kr         | +/-         | -/+ | -/- | +/- | -/- | -/- |
| 2.5 Kr × 20.0 Kr         | +/+         | +/+ | +/+ | +/+ | +/+ | +/+ |
| 5.0 Kr × 10.0 Kr         | -/-         | -/- | -/- | -/- | -/- | -/- |
| 5.0 Kr × 20.0 Kr         | +/+         | +/+ | +/+ | -/- | +/- | +/+ |
| 10.0 Kr × 20.0 Kr        | +/+         | +/+ | +/+ | -/- | +/+ | +/+ |

<sup>1</sup>♂♂/♀♀

the lowest mean wingbeat frequencies followed by increasing mean wingbeat frequencies to day 9 (Figs. 1 and 2). A t-test for significance of the difference between two sample means showed that high dosages of gamma radiation such as 20.0 Kr significantly reduced wingbeat frequencies of both sexes at all ages. Furthermore, significant differences were recorded at all ages between non-irradiated (N) and 20.0 Kr-irradiated males and females and also between 2.5 Kr- and 20.0 Kr-irradiated males and females (Table 1). High incidences of significance were also recorded for both sexes at most ages between 5.0 Kr- and 20.0 Kr-irradiated flies and also between 10.0 Kr- and 20.0 Kr-irradiated flies.

For both males and females the greatest range in mean wingbeat frequencies (cycles minute) occurred in flies irradiated with 10.0 Kr. However, for males only, the least range in mean wingbeat frequencies occurred in flies irradiated with 20.0 Kr, and the least range recorded by females occurred in non-irradiated flies. Furthermore, with the exception of 10.0 Kr-irradiated males at all ages, there was a general decrease in mean wingbeat frequencies with increasing radiation dosages; however, with females this trend was not apparent.

Females recorded higher mean wingbeat frequencies than males (except for 1-, 3-, and 5-day-old non-irradiated males and 1- and 3-day-old 2.5 Kr-irradiated males). For males the lowest mean wingbeat frequency was 5,395 recorded by 1-day-old males irradiated with 20.0 Kr; the highest mean wingbeat frequency was 8,600 recorded by 33-day-old non-irradiated males. Furthermore, for females, the lowest mean wingbeat frequency was 5,540 recorded by 1-day-old females irradiated with 20.0 Kr; the highest mean wingbeat frequency was 9,200 recorded by 33-day-old females irradiated with 2.5 Kr. Both 20.0 Kr-irradiated males and females at all ages recorded much lower mean wingbeat frequencies than any other treatments. The highest individual wingbeat frequencies

were 10,100 and 10,200 recorded by 9- and 33-day-old females, respectively, both irradiated with 2.5 Kr.

#### DISCUSSION

Sotavalta (1947), Chadwick (1951), and Pringle (1965) discussed the factors that commonly affected wingbeat frequencies in insects. They included in their discussions factors such as differences in age, sex, species, structural characteristics of muscles, rhythm of activity in the central nervous system, other internal factors such as fatigue, and environmental influences such as temperature. In essence they agreed that no single factor could be attributed to the differences observed in wingbeat frequencies. Also no one factor can account for the results obtained from this study on the wingbeat frequencies of irradiated flies, and only the most obvious factors are discussed.

Among the more important factors accounting for the differences in wingbeat frequencies of *D. dorsalis* males and females were the effects of aging and different irradiation dosages. Concerning aging effects, Keiser and Schneider (1969) reported that emerging *D. dorsalis* males and females had little or no stored energy resources and soon died if not provided sugar. Perhaps a lack or limited supply of available glycogen and other carbohydrates explains the low wingbeat frequencies recorded by these very young flies.

In addition to energy reserves, the condition of the flies' cuticle, flight muscles, and number and size of muscle sarcosomes after emergence might affect wingbeat frequencies, for according to Clark and Rockstein (1964), each species or strain of holometabolous insects possesses an obligatory period of postemergence maturation. This delayed maturation could be directly related to the flies' improved wingbeat frequencies because personal observations (handling the flies and periodically touching the flies' cuticle with forceps) indicated that the hardening of their cuticle was not completed until a few days after emergence. Surely these inherent physiological and behavioral differences accounted for some of the variations of the data.

Undoubtedly, however, the most important causes affecting wingbeat frequencies were the different levels of irradiation. High dosages are known to significantly reduce wingbeat frequencies of insects. This fact was demonstrated by Shepard et al., (1968), Noblet et al., (1968), and by results obtained from this study. Male and female *D. dorsalis* at all ages irradiated with 20.0 Kr showed a significant reduction in mean wingbeat frequencies over that of non-irradiated flies of both sexes. Perhaps such a high dose 2 days before adult eclosion severely damaged the developing muscle cells, and this damage together with other factors accounted for the significant reduction in wingbeat frequencies.

Another important factor to be considered is temperature. In Diptera there is a positive correlation of wingbeat frequencies with temperatures (Chadwick, 1951). However, in this study the temperatures only varied from 22.8 to 26.7°C and probably attributed very little to influencing the data obtained from this study.

#### SUMMARY

Regardless of irradiation dosages, both 1-day-old male and female *Dacus dorsalis* Hendel recorded the lowest mean wingbeat frequencies followed by increases to day 9. Also, high dosages of gamma irradiation such as 20.0 kilorads (Kr) significantly reduced the wingbeat frequencies of both sexes at ages 1, 3, 5, 9, 17, and 33 days. Finally, the wingbeat frequencies of males were more adversely affected by different dosages of gamma irradiation than were the wingbeat frequencies of females.

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