EFFECTS OF MICROWAVES ON GERM CELLS OF YOUNG AND OLD PUPAE IN *DROSOPHILA MELANOGASTER* AND AN ANALYSIS OF THE EFFECTS[1)]

YASUKO TONOMURA

(Received November 30, 1993)

While the remarkable progress in the application of electromagnetic waves has improved our lives, it is feared that the pollution caused by invisible electromagnetic waves may have adverse effects on humans, animals and plants.

The author and her associate researchers (Shima* in 1986; Ohno and Shima in 1988; Shima, Suzuki and Kishi in 1990; Shima and Kimura in 1992)** have conducted a study for the eight years since 1985 on the effects of electromagnetic waves. The study has used *Drosophila melanogaster* on which cytological, embryological, and genetic data have been collected by researchers in many countries, and a commercially available microwave range (2.45 GHz, with outputs of 200 W, 500 W and 550 W). The study has revealed various effects: the generation of mutants in wings, the induction of puffs on salivary gland chromosome arms of somatic cells, somatic mutagenesis due to microwaves and ganglion chromosomes in somatic cells of larvae, polyploidy of chromosomes and a change in protein synthesis from the electrophoresis of sibling adults. Some of these effects have been found to be attributable to microwave exposure.

Further studies have shown that the effects of microwave exposure include juvenile cataracts, temporary aspermia, and an unidentified clinical syndrome. In 1993, the present author proceeded to conduct a microwave exposure experiment to observe mutants using larvae and pupae of *Drosophila melanogaster*. At the same time, Kimura made an analysis of the protein synthesis of sibling flies (Tonomura and Kimura in 1993). The studies showed that the meiosis in spermatogenesis is completed during the pupation period. Thus, only pupae in the pupation period were used in the current study.

Young and old pupae fed with ordinary feed were removed from their bottles and placed in a styrofoam cage. They were then divided

[1)] Supported by a grant to Y. Tonomura from Center for Women's Studies, Tokyo Woman's Christian University.

* Dedicated to Dr. Shima, who wanted to live and work with us forever.

** We displayed our analysis by poster on 18th August of 1993 at the Seventeenth International Congress of Genetics in Birmingham, United Kingdom.

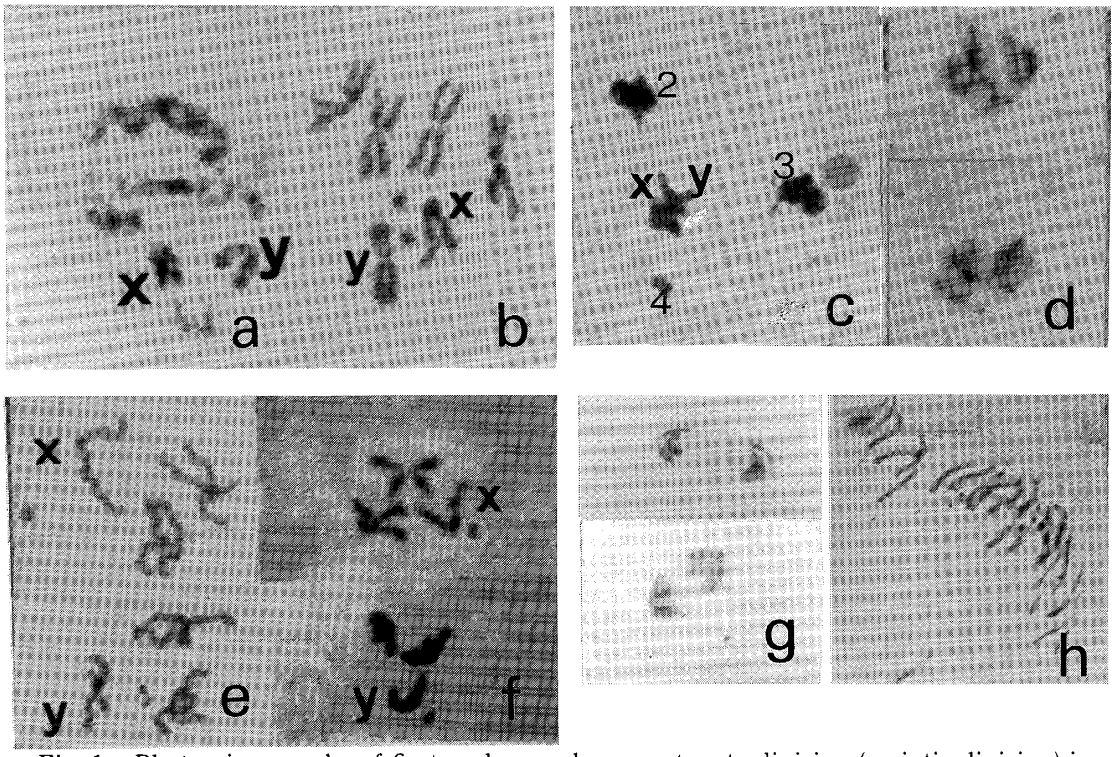

Fig. 1. Photomicrographs of first and second spermatocyte division (meiotic division) in *Drosophila melanogaster* (Control).

a–b: Spermatogonia. a: Promtaphase. b: Metaphase. c–d: First spermatocyte division. c: Metaphase. 2, 3, 4 and X–Y Chromosomes of bivalent configurations. d: Anaphase. e–g: Second spermatocyte division. e: Prometphase. f: Metaphase. g: Anaphase. h: Sperm packet.

into groups of 100 pupae each, and each group was exposed to microwaves for five seconds, 10 seconds, 30 seconds, 60 seconds and 90 seconds in a household microwave range with output powers of 200 W and 500 W. After the exposure, the germ cells of the male adult flies were taken out under a stereomicroscope to prepare a specimen using the air-dry method developed by Matsuda *et al.* (1983). The germ-cell specimens were observed for chromosome aberration. Abnormal chromosome or cells were compared with those of controls using a CCD camera printer or photomicrography, the details of which are shown in the figure 1–4. Abnormal germ cells were observed on adult flies regardless of the length of time pupae were exposed to microwaves: the times of exposure rayed from a short period of five seconds to a long period of 90 seconds. This finding is different from the results of an X-ray experiment. The wave lengths of the microwaves (1 mm to 1 m) are between those of infrared rays and the ultra-shortwaves used in telecommunications. They are sometimes called polarized waves. The present author believes that the experiment has shown the characteristics of micro-

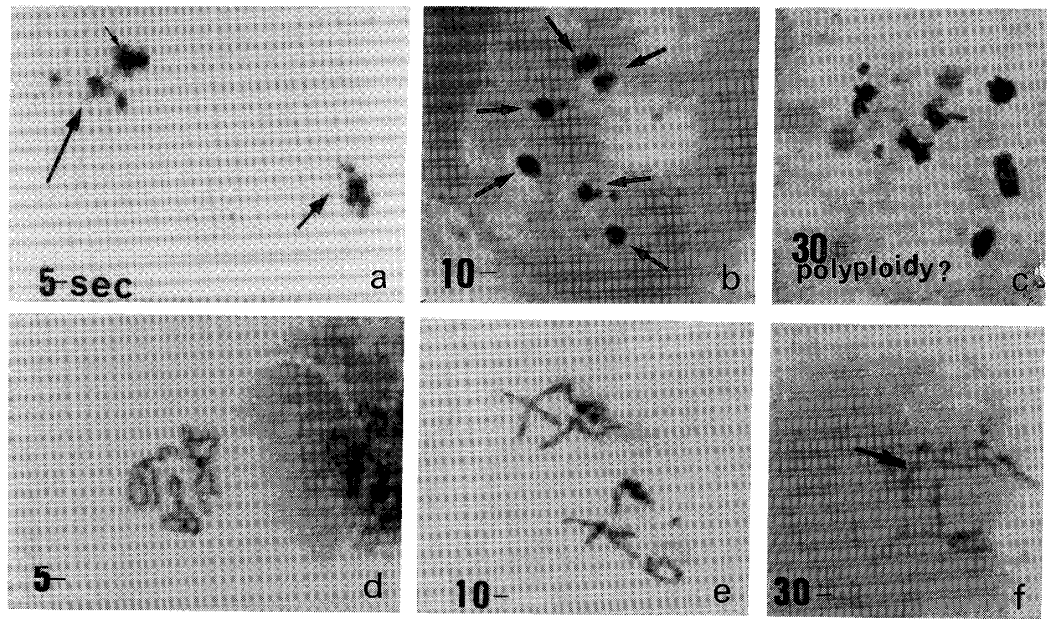

Fig. 2. Photomicrographs of the meiotic division of young pupae which were exposed with microwaves (2.45 GHZ) at output power of 200 W.

a–c: First spermatocyte division. Metaphase. 2, 3, 4 and X–Y Chromosomes of bivalent configurations. a: 5-second. b: 10-second. c-30-second (polyploidy?). d–f: Second spermatpcyte. d: 5-second. e: 10-second. f: 30-second. (Arrows indicate chromosomal aberations).

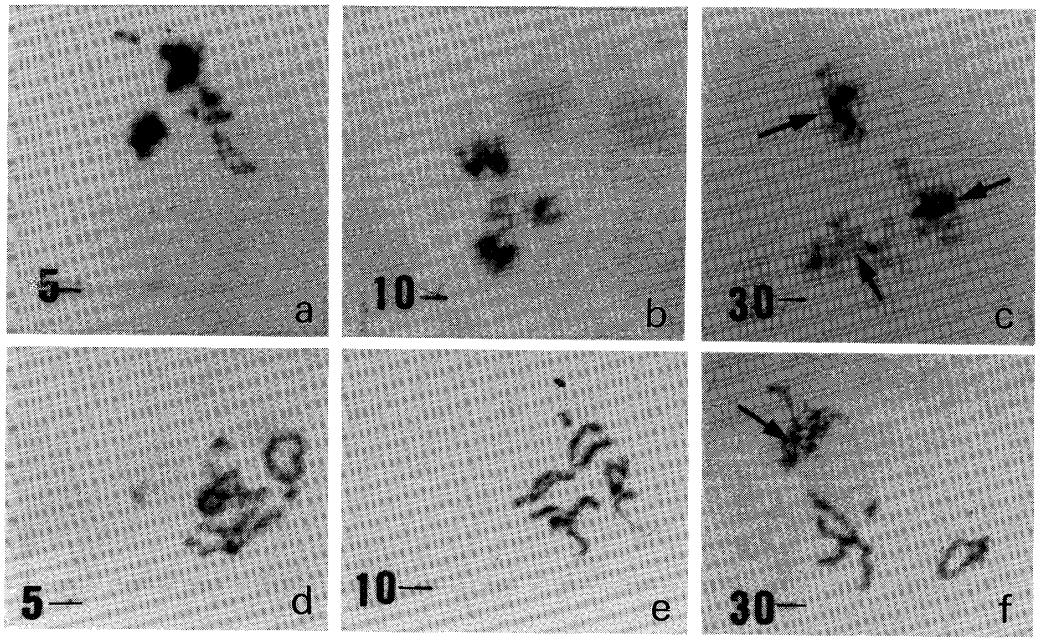

Fig. 3. Photomicrographs of the meiotic division of old pupae which were exposed with microwaves (2.45 GHZ) at output power of 200 W.

a–c: First spermatocyte division. Metaphase. a: 5-second. b: 10-second. c: 30-second. d–f: Second spermatocyte. d: 5-second. e: 10-second. f: 30-second. (Arrows indicate chromosomal aberations).

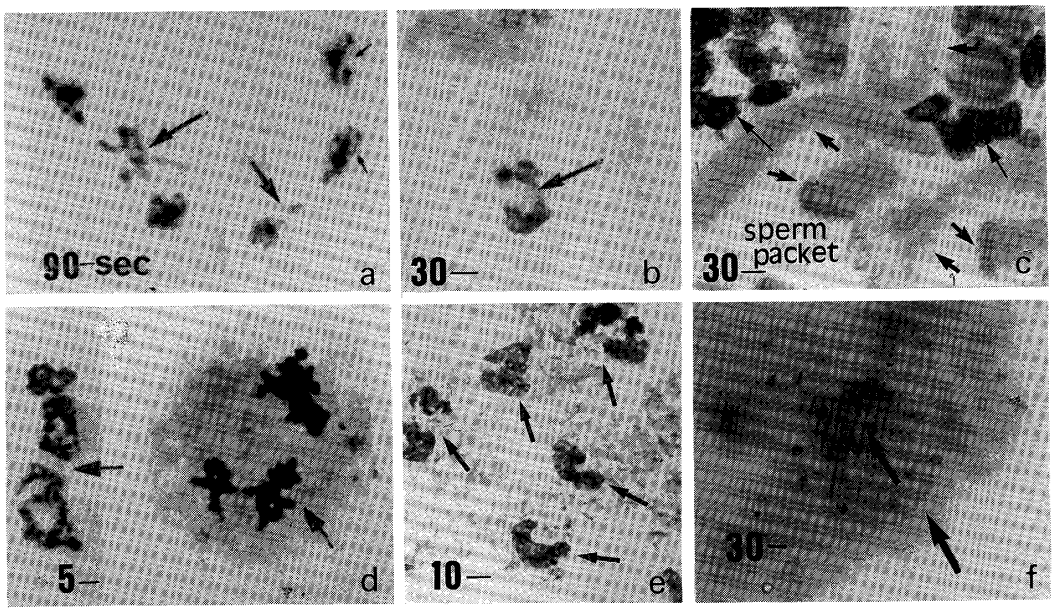

Fig. 4. Photomicrographs of the meiotic division of young and old pupae which were exposed with microwaves at output power of 200 W and 500 W.

a: 90-second exposure of first spermatocyte of young pupae, Metaphase. b: 30-second, Anaphase? c: 30-second, Abnormal cells and sperm packet of young pupae. d–f: Breakdown of cells which were exposed with microwaves at outpnt power of 500 W. d: 5-second, Abnormal configuration of chromosomes. e: 10-second, Old pupa. f: 30-second, Old pupa. (a, b, c, d, e and f: Arrows indicate abnormal chromosomes and cells).

waves. Pupae that received the full energy of the microwaves may develop abnormal cells and chromosomes even when the energy is weak. This would not happen in an X-ray-exposure test.

In 1994, Professor Kamiguchi of the Medical Department of Asahikawa University will expose a human sperm cell cultured *in vitro* to microwaves to observe the effects of microwaves on the sperm's activity and the semen's temperature using a microsensor.

The exposure time will be set at five seconds and then extended until the activity of the sperm significantly slows down.

Ashburner *et al.* (1976) has performed a cytologic experiment to analyze the function and structure of a gene of *Drosophila melanogaster*. They reported that exposing larvae to a heat shock (e.g., 40 minutes at 37 degrees C as opposed to the standard culture temperature of 25 degrees C) created puffs on the arms of the salivary gland chromosomes. They decided that this was due to heat-shocked genes. The present author observed, in a microwave-exposure test conducted in 1990, that the puffs induced on the arms of salivary gland chromosomes were different from the specific puffs Ashburner *et al.* found in 1976. She then planned to conduct the following experiment because she believed that microwaves

have unique characteristics other than heat generation. The author places a feeding bottle containing young and old adult flies in a water bath maintained at 37 degrees C. A portable water-proof thermometer is placed in the feeding bottle to monitor the temperature. The salivary gland chromosomes of the third-instar larvae are then taken out and made into a specimen using a method developed by Kayano (1987) to see it puffs are induced on the arms of chromosomes. If the results of the above simple heat-treatment test are different from those of Ashburner's experiment using microwaves, we will have some means to identify microwaves' inherent characteristics other than heat generation.

While microwaves' adverse effects on animals and plants have been studied by many scientists in the former Soviet Union and U.S.A. for the past 20 years, no definite conclusion has been presented showing whether or not they are harmful. Neverthless, we have learned that the U.S.A. and Japan had a plan to transmit microwave power from a solar power-generation satellite. We do not know how the microwave power from the satellite will affect the global environment (forests, humans, animals and plants). We believe that our basic experiments are vital and appropriate for assessing possible environmental pollution.

Acknowledgements

The author wishes to express her cordial thanks to Miss M. Nakagawa, Miss N. Shimazu and A. Sugimura, who are currently students at this university, for their kind assistance in carrying out this project by assembling data and some other tasks. I also whish to thank Dr. Clare L. Colegrove Prof. to Tokyo Woman's Christian University, for checking this English manuscript.

References

Kayano, H. and Kayano, A. 1987. Establishment of sex-limited inheritance due to a reciprocal translocation between the X-chromosome and an autosomal chronosome in *Drosophila*, Bulletin of the Faculty of Liberal Arts, Nagasaki University, Natural Science, 27: 1–17.

Matsuda, M., Imai, H. T. and Y. N. Tobari 1983. Cytogenetic analysis of recombination in male of *Drosophila ananassae*. *Chromosoma* 88: 286–292.

Tonomura, Y. and Shima, T. 1986. A preliminary report of the biological effect of microwave irradiation in *Drosophila melanogaster*. Science reports of Tokyo Woman's Christian University 36: 859–872.

Ohno, K., Shima, T. and Tonomura, Y. 1988. The biological effect of microwave irradiation on *Drasophila*. Science Reports of Tokyo Woman's Christian University 38: 933–941.

Tonomura, Y., Shima, T., Suzuki, K. and Kishi, M. 1990. Effects of microwaves and magnetic fields on *Drosophila*. Science Reports of Tokyo Woman's Christian University 40: 1031–1049.

Tonomura, Y., Shima, T. and Kimura, K. 1992. Effects of microwave on *Drosophila*, Part II. Science Reports of Tokyo Woman's Christian University 42: 1159–1175.

Tonomura, Y. and Kimura, K. 1993. Effects of Microwaves on Gem Cells of *Dnosophila melaogaster*. Science Reports of Tokyo Woman's Christian University 43: 1199–1204.