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Final report on ERDA Supported Research Project on

"Radiation Cytogenetics of the yellow-fever mosquito Aedes aegypti
and the plant genus Collinsia."

During April 1967 to September 1977.

Principal Investigator: Karamjit S. Rai, Professor of Biology, University
of Notre Dame.

Summary accomplishments: [Details provided earlier in Annual Reports]

A. Aedes aegypti: The major objectives of the project on A. aegypti, which is one of the most important disease vectors of man, were to study (a) the cytogenetic effects of radiation and certain chemical mutagens, (b) the genetics of radiation-induced chromosomal rearrangements with particular attention to reciprocal translocations and (c) the possibility of using translocations for genetic control of natural populations.

As a result of the work done during the years 1967-1977, these objectives have been mostly accomplished. The following accomplishments are particularly noteworthy:

1. The cytogenetics of A. aegypti has been established as a distinct and a formal discipline (1,2,3,6,33,34,38,39). Furthermore, these studies have served as a model which other investigators have followed with numerous other insect pest species including other mosquitoes, houseflies, sheep blow fly etc.

2. The genetic and cellular basis whereby a chemical mutagen (Apholate, an alkylating agent) induces sexual sterility was shown to result from its effect on chromosomes during gametogenesis (1,15,). It had observable effects on several tissues and cell types but somatic

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tissues underwent some sort of a repair mechanism (10). Chemically sterilized males produce fewer sperm (5) and the ones that are produced carry dominant lethal mutations (15). Ovarian transplantation experiments showed that the dominant lethal effect of the chemical did not result from interference with hormones essential for normal reproductive development but rather from direct and primary effect on chromosomes presumably during their replication causing irreparable and often gross aberrations (16). High resolution electron microscope studies were used to analyse the cellular damage at the ultrastructural level during oogenesis (40,41,43,44).

3. At a panel convened by the World Health Organization in Geneva in October 1967, to consider possible alternatives to the use of pesticides for insect control, the Principal investigator proposed the possibility of the use of genetic sterility associated with chromosomal translocations for this purpose (3). The proposal was based on the premise, that matings involving single and/or double translocation heterozygotes will produce certain frequencies of unbalanced zygotes and would thereby produce partial sterility (suppression) of wild populations. Moreover, such partial sterility will be expected to persist for several generations. This led to the isolation of several hundred radiation induced translocations in various laboratory and field populations (12, 21,47) and extensive work with them. These translocations were used to:

- a: study the effect of chromosome rearrangements on genetic recombination (11).
- b: correlate the three linkage groups with the three pairs of chromosomes (13).

- c: assess their population control potential using computer simulations (19,45).
- d: demonstrate for the first time that following field releases they can be incorporated in a field population and persist for several generations (29).
- e: double translocation heterozygotes with higher levels of sterility were synthesized (35,37)
- f: introduce high levels of sterility in natural populations (51).
- g: homozygous translocation stocks were synthesized (22) and field tested for population replacement (46).

Potential usefulness of the translocation method for genetic manipulation (17,18,20,21,26,35) was confirmed by the field work undertaken under the auspices of the World Health Organization in Delhi, India and U.S. A.I.D. in Mombasa, Kenya.

4. The cytogenetics of paracentric inversions was studied (25, 36). They showed interchromosomal effect on recombination and in one case produced excess of females (36). They are useful as tools for genetic manipulation purposes (4).

5. Radiation, when used to induce sexual sterility, is associated with undesirable somatic effects which reduce adult male competitiveness of sterilized males (9). However, this effect can be circumvented if males are irradiated in nitrogen (30).

6. More recent work using giemsa C-banding techniques (49) and DNA replication patterns (50) has shown the presence of two types of heterochromatin: constitutive and facultative. The latter is involved with genetic regulation of adult development.

7. The project was instrumental in training 6 Ph.D.'s (+2 in progress) and 11 post-doctoral scientists. In turn, these people are currently playing active and important teaching and/or research roles at several universities and research organizations, e.g. University of California, Berkeley and U.S.D.A.

8. The project permitted evaluation of a beneficial use of radiation in biological control (18,28).

B. Collinsia:

1. Abnormal types of chromosomal behavior (Desynapsis, excessive stickiness) resulting in high levels of sterility were shown to result from single gene mutations at the same locus (14,26).

2. Through an analysis of 13 radiation-induced translocations, the role of chromosome mechanics in determining random versus directed orientation of chromosomes in the interchange complex was demonstrated (23). This work also revealed the occurrence of floral chimeras ensuing from somatic crossing over (31) and of chromosomal chimeras in irradiated progeny (32).

3. One chromosome in the genome shows atypical cytogenetic behavior. This has been referred to as "Pseudosupernumerary". Its presence in the genome was experimentally demonstrated (48).

4. Two graduate students received their Ph.D. degrees and their training on this project.

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