Inherited Semisterility for Control of Harmful Insects. V. Translocations in *Culex tritaenio-rhynchus*

Already in 1940 SEREBROVSKY[1] and recently LAVEN[2] and CURTIS[3] suggested inherited semisterility due to translocations or pericentric inversions as a possible means for control or eradication of pest insects. Experiments have therefore been undertaken to induce chromosomal aberrations in mosquitoes by ionizing irradiation *Culex pipiens*[4,5], *Aedes aegypti*[6], *Aedes albopictus*[5], *Culex tritaeniorhynchus*[5,7]). Basic data about the production and the degree of semisterility due to different types of translocations are reported for *Culex pipiens* in the first two papers of this series[8,9].

Culex tritaeniorhynchus, the main vector of Japanese encephalitis, was selected for further studies about X-ray induced chromosomal aberrations. Several 1–2-day-old males of this mosquito species were irradiated with dosages of 3500 R, 4000 R, 5000 R and 5500 R, and immediately mated with normal females. The irradiated males are more or less sterile. The degree of sterility depends on the applied dosages. This is expressed in non-hatching eggs most of which show no signs of embryonic development. The lethality values obtained in our irradiation experiments with *Culex tritaeniorhynchus* are comparable with the corresponding parts of the dosage-response curves of other mosquito species (*Culex pipiens*[5], *Anopheles pharoensis*[10]).

About half of the still hatching larvae develop normally and the resulting F_1 adults show normal vitality. They were outcrossed to normal individuals with the intention to isolate lines with reduced F_2 offspring. This semisterility is due to a reciprocal translocation or to a pericentric inversion. Translocations predominate in the experiments with *Culex pipiens*[9] and *Culex tritaeniorhynchus*[7].

Application of 3500 R gave in one experiment 125 F_2 offsprings (Figure 1), 25 of them with a sterility between 30% and 60% (group a), 9 others with a sterility between 20% and 30% (group b) and 7 between 10% and 20% (group c). The remaining 84 F_2 offsprings were normal.

In the following generation 21 of the F_2 offsprings of group a and group b were outcrossed to determine the type of translocation involved in the semisterility, i.e. whether they were sex-linked or autosomal. Group c animals were not tested for reasons of their low lethality. The following results were obtained: In 9 lines semisterility was inherited only through the males whereas all sister females were normal. This means that an exchange had occurred between the chromosome which carries the sex determining factor M for maleness and 1 of the 2 autosomes (this type of translocation is called TM).

In 6 other lines semisterility was inherited through both sexes, indicating translocations between the 2 autosomes (this type of translocation is called Ta).

All these 15 translocation lines were maintained for 16 generations in heterozygous condition. Viability was as good as in the normal strain, the degree of sterility and its variability was constant from generation to generation. The Table shows the average degree and the variability of lethality for each of these lines. There is an obvious accumulation of sterility percentages around 50% in contrast to the variation of sterility percentages in *Culex pipiens*[9]. That is to be expected if during meiosis I in translocation heterozygotes only 2 of the 3 segregation patterns were to occur, i.e. the alternate distribution and the non-homologous adjacent distribution. Whether this is characteristic for *Culex tritaeniorhynchus* cannot yet be asserted. F_2 offsprings with a lethality somewhat below 40% can also belong to a line with an average sterility around 50%, because the semisterility values within one line vary with $\pm$ 10–15%. Figure 2 presents the degree and the variability of lethality in 2 lines (TM 14 and TM 69). The observed sterility values show a normal distribution around a means which was constant in all generations. The remaining 13 lines gave comparable results.

Out of the 21 F_2 offsprings tested 15 revealed by the mode of inheritance of the semisterility clear evidence for translocations (Figure 1: tested positiv). The remaining 6 F_2 offsprings tested in the same way had first shown a sterility between 20% and 30%. It disappeared in the next generation or could be found in only a few individuals (Figure 1: tested negativ). This phenomenon is not characteristic for translocations, because half of the offspring should have been translocation carriers.

[1] A. S. SEREBROVSKY, Zool. Zh *19*, 618 (1940).
[2] H. LAVEN, Anz. Schädlingsk. *41*, 1 (1968).
[3] C. F. CURTIS, Bull. ent. Res. *57*, 509 (1968).
[4] H. LAVEN, Nature, Lond. *221*, 958 (1969).
[5] H. LAVEN, E. JOST, H. MEYER and R. SELINGER, IAEA-Symp. Vienna (1971), p. 415.
[6] P. T. MCDONALD and K. S. RAI, Science *168*, 1229 (1970).
[7] R. H. BAKER, R. K. SAKAI and A. MIAN, Science *171*, 585 (1971).
[8] H. LAVEN and E. JOST, Experientia *27*, 471 (1971).
[9] H. LAVEN, R. BIENIOK, G. GUILLE, H. MEYER and J. OHMANN, Experientia *27*, 968 (1971).
[10] A. O. TANTAWY, A. A. ABDEL-MALEK and A. W. WAKID, J. econ. Ent. *59*, 1392 (1966).

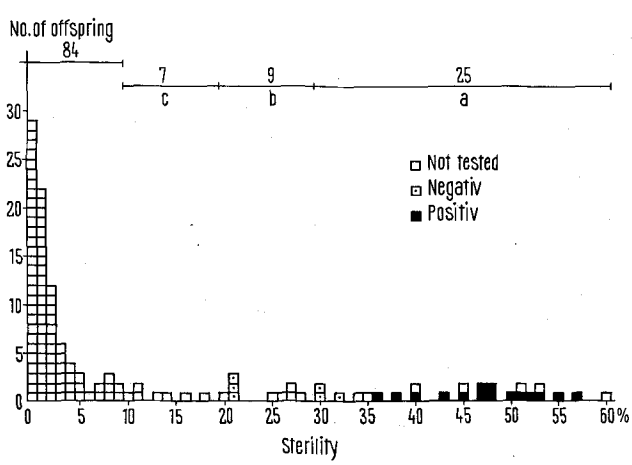

Fig. 1. Degree of sterility in 126 F_2 offsprings of *Culex tritaeniorhynchus* after 3500 R irradiation of the P generation.

From this observations it can be assumed that the majority of single translocations in *Culex tritaeniorhynchus* reduce the offspring to about 50%. This assumption was confirmed by 36 other lines, which were isolated after irradiation with 4000 R, 5000 R and 5500 R. Most of them showe da mean value of about 50%, only 3 lines seem to be of a lower degree of semisterility. Moreover, it is not proven whether the semisterility of these low-sterility lines is due to a translocation or to a pericentric inversion. Cytological investigation for one of these lines is not yet finished but it points to a short pericentric inversion. Therefore it is possible that single translocations in *Culex tritaeniorhynchus* all produce a similar degree of lethality, namely 50 ± 5%. Theoretically this would mean that double translocations should show a lethality of about 75%. Lines of such a degree of semisterility have been found, and it is possible that they contain 2 translocations, since double translocations in *Culex pipiens* reveal a lethality between 75% and 90%.

For 5 of the 9 translocation lines of the TM type, cytological examinations of testes were made. In two lines the change of chromosome segments had occurred between she smallest chromosome and one of the larger chromosomes, in 3 other lines, which did behave genetially in the tame way, the 2 larger chromosomes are involved in the translocation (Figure 3). These observations suggest, in contrast to other investigations[7], that the sex determining factors M and m are located on one of the two larger chromosomes.

Average degree and variability of semisterility in 15 lines of *Culex tritaeniorhynchus*

No. of line	Type of translocation	Mean value (%)	Standard deviation (%)	Value of semisterility Minimum (%)	Maximum (%)
8	TM	53.7	± 5.7	37.3	67.4
14	TM	53.3	± 7.6	41.3	78.1
33	TM	48.1	± 9.6	32.0	66.9
47	TM	54.3	± 7.2	39.4	67.3
69	TM	52.6	± 6.7	37.4	76.2
70	TM	53.2	± 7.0	36.7	69.7
73	TM	51.5	± 5.6	38.4	64.3
79	TM	48.9	± 6.8	34.6	67.1
96	TM	52.9	± 5.6	38.8	67.1
15	Ta	48.5	±10.8	31.6	64.6
17	Ta	44.8	± 8.2	32.3	61.3
24	Ta	49.4	± 6.4	34.2	60.1
44	Ta	48.8	±10.4	30.2	68.9
94	Ta	39.7	±11.9	31.3	62.9
103	Ta	46.6	± 7.6	31.0	65.7

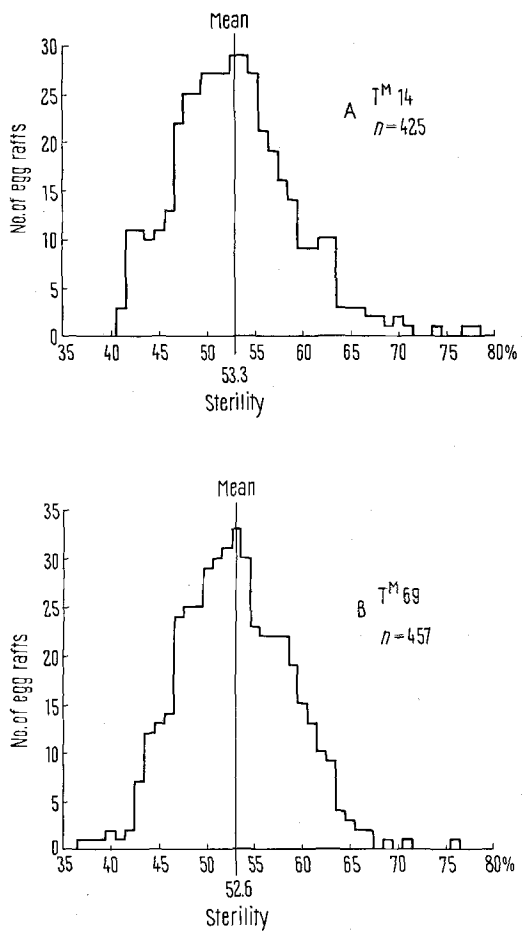

Fig. 2. Variation of sterility percentages within 2 lines of type TM. A) Line TM 14, 425 egg rafts. B) Line TM 69 ,457 egg rafts.

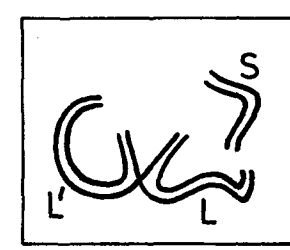

Fig. 3. Prophase chromosomes from testes showing a reciprocal translocation between the 2 larger chromosomes (S = short chromosome; L, L' = larger chromosomes).

The method applied in these experiments needs no marker genes for the isolation of chromosomal aberrations. Based on theoretical considerations this is an advantage for mass production and field experiments since marker genes often reduce the viability of their carriers to a level below that of the wild type.

Zusammenfassung. Mit unterschiedlichen Dosen von Röntgenstrahlen wurden bei der Stechmücke *Culex tritaeniorhynchus* chromosomale Aberrationen (vorwiegend reziproke Translokationen) produziert, die von der zweiten Tochtergeneration an einen konstanten Grad von Semisterilität zeigen. Die Mehrzahl der isolierten Linien zeigte im Durchschnitt eine Letalität von etwa 50%. Die Variationsbreite innerhalb einer Linie betrug ± 10–15%. Durch cytologische Untersuchungen von Prophasechromosomen wurden die geschlechtsbestimmenden Faktoren M und m auf einem der beiden langen Chromosomen lokalisiert.

R. SELINGER

Institut für Genetik, Johannes Gutenberg-Universität, Saarstrasse 21, D-65 Mainz (Germany),
28 September 1971.