chemical environmental conditions. (Engelmann, 1970). Among them, nutrition is probably the most important factor (Colless and Chellapah, 1960; Bellamy and Bracken, 1971). Figure 2 also shows that the number of eggs produced by females which ingested smaller amounts of blood is more closely associated with the regression line, i.e., points in the scatter diagram are closely distributed along the line. However, the numbers of eggs from females which took a large blood meal were irregular. For example, one female which ingested 7.6 mg of blood laid only 94 eggs, while another female which consumed 7.8 mg blood laid 209 eggs (Figure 2).

Engorged females were classified into two categories—"partially" and "fully" engorged based upon their blood meal size. Females which ingested more than 5.18 mg are defined as fully engorged and those that obtained less than 5.18 mg as partially engorged. This critical weight, 5.18 mg, was selected because average unfed *A. nigromaculis* females weighed 3.43 mg (Table 1) and they can ingest blood about 1.51 times their own body weight in a single feeding (Table 3). For fully engorged females, there was no significant correlation between the number of eggs laid and amount of blood ingested ($r=0.474$).

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CHROMOSOMAL TRANSLOCATIONS IN *ANOPHELES ALBIMANUS* WIEDEMANN

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INTRODUCTION

Reciprocal chromosomal translocations are of considerable interest and seem to be quite promising as a practical tool in genetic control of insect pests (Curtis, 1968; Laven, 1969; Rai, 1967; Rai and Asman, 1968; Serebrovoskii, 1940; Wagoner *et al.*, 1969) and in linkage group-chromosome correlation studies (McDonald and Rai, 1970; Sakai *et al.*, 1971; Wagoner, 1967).

Although progress in translocation stud-

ies has been reported in *Culex* and *Aedes* mosquitoes, similar studies are lacking in *Anopheles*. In our laboratory, we have produced some reciprocal translocations in *Anopheles albimanus*, a vector of human malaria in South and Central America. In this paper, the first in a series, we are presenting the methods of induction, screening and maintenance and descriptions of some interesting translocations.

MATERIALS AND METHODS

The stock of *A. albimanus* used was originally collected in Panama in 1970 and since that time has been maintained as a mass culture colony.

X-radiation from a deep therapy X-ray machine was used as the mutagenic agent with a total dose of 4,000 Röentgens at the rate of 200 R per minute. Males 1 to 4 days old were irradiated, then mass mated with virgin females of the same age and a screening procedure, shown schematically in Figure 1, followed.

Salivary gland chromosomes were used to detect any aberration induced. The presence of high quality salivary chromosome complements (Hobbs, 1962; Keppler *et al.*, 1972) made detection and screening possible (Figure 2). The use of salivary gland chromosomes may substitute, in *Anopheles* species, for the visible mutations which are usually used for studies involving structural changes in chromosomes. In our salivary gland chromosome preparation of aberration strains, we could detect the break-points very precisely. For salivary gland chromosome preparations we use early fourth instar larvae grown at 23°±2° C, using the standard method described by French *et al.* (1962).

After a translocation is discovered the stock is increased by mass-mating within sibs or with wild type stock for one generation. Next generation, after allowing mass sib-mating, gravid females are isolated for egg-deposition and individual families of larvae are reared and screened in fourth instar for the same translocation. Families showing translocations are saved and the adults from such families are put together in the stock cage. The stock is thus maintained by heterozygote x heterozygote and heterozygote x normal matings and screening is necessary every generation. Thirty to 40 egg batches are enough to give the required number of families to establish a translocation stock at a minimal level. A generation without selection followed by another with selection cuts down on routine maintenance. This is the method followed to maintain autosome-autosome and X-autosome translocation strains. Maintenance of a Y-autosome translocation stock is no more difficult than maintaining a regular wild type stock. No selection is necessary in such a case because all male progeny are expected to be translocation heterozygotes and such a translocation is passed on only through males.

For larvae we use standard *Anopheles* food (wheat germ, baker's yeast, Kellogg's concentrate 1 part each, mixed and finely powdered). Adults are kept on 10 percent sucrose solution in colony cages (24 x 27 x 30 cm) at 27°±2° C. Females are blood-fed on a guinea pig. For digestion of blood 72–80 hours are allowed and the gravid females are isolated in 2 x 9.5 cm shell vials with water and filter paper lining for egg deposition.

Counting for hatching percentage is done under a dissecting scope after transferring the larvae and eggs to a 9 cm disk of filter paper upon which 1 cm squares have been drawn to facilitate counting.

DESCRIPTIONS OF TRANSLOCATIONS

Following are the descriptions of some interesting translocations which are currently maintained. The break-points are identified by numbers which appear on the

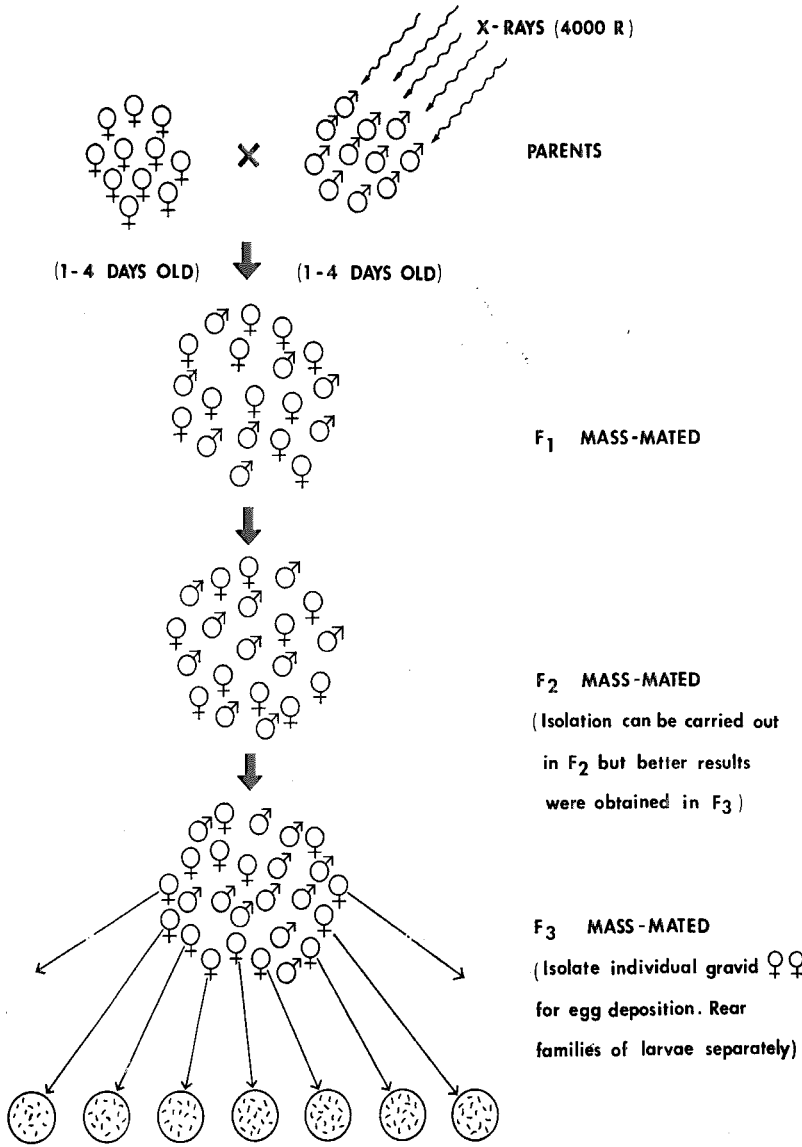

FIG. 1.—Method of screening for translocations.

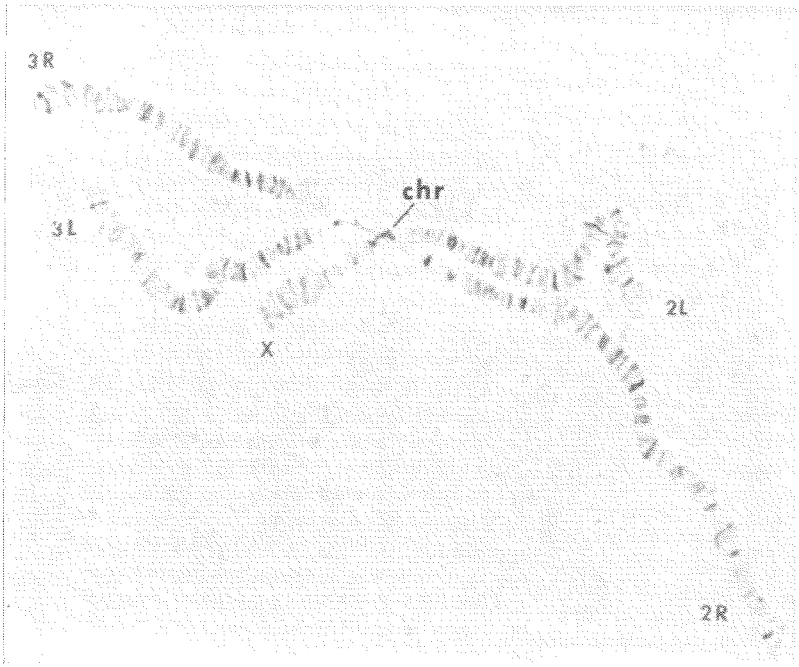

FIG. 2.—Salivary gland chromosome complement, female. A male complement is the same except for the X, which is comparatively thinner. Only one arm of the X-chromosome is visible, the other is heterochromatic. Chr = chromocenter.

map of the salivary gland chromosomes of *Anopheles albimanus* (Keppler *et al.*, 1972). Sterility percentages presented here are preliminary estimates.

AUTOSOME-AUTOSOME TRANSLOCATIONS. *T(2R;3L) 1:* This translocation (Figure 3) involves 2R, the longest arm in the complement and 3L. Break-points: 10B on chromosome 2 and 42A on chromosome 3. This is one of the first translocations produced in our laboratory and has been maintained for over a year. No homozygote has been detected in spite of repeated heterozygote x heterozygote crossings. Sterility in egg-batches from heterozygote x normal and reciprocal crosses: 50.25± 0.72 percent. This translocation is transmitted through both sexes.

T (2R;3R) 1: Figure 4 shows complements heterozygous for this translocation. Break-points involved are 7A on chromosome 2R and 29B on 3R. Like *T (2R;3L) 1,* it is transmitted by both sexes. No homozygotes have been detected as yet. Sterility: 52.89±3.58 percent.

T (2L;3R) 1: This autosome-autosome translocation (Figure 5) involves chromosomes 2 L and 3R. Break-points are 19A on 2L and 33C on 3R. Calculated sterility percentage is 51.93±3.32. Transmitted through both sexes.

X-AUTOSOME TRANSLOCATIONS. *T (X;2L) 1:* Figure 6. X-autosome translocations are transmitted only through females and in the progeny from a heterozygote x normal cross a disruption of sex ratio (2 ♀ ♀ :1 ♂) is observed. This may be due to the inability of hemizygous males to survive. Break-points are 4C on the X-chromosome and 25A on chromosome 2L. Sterility is higher than in autosome-

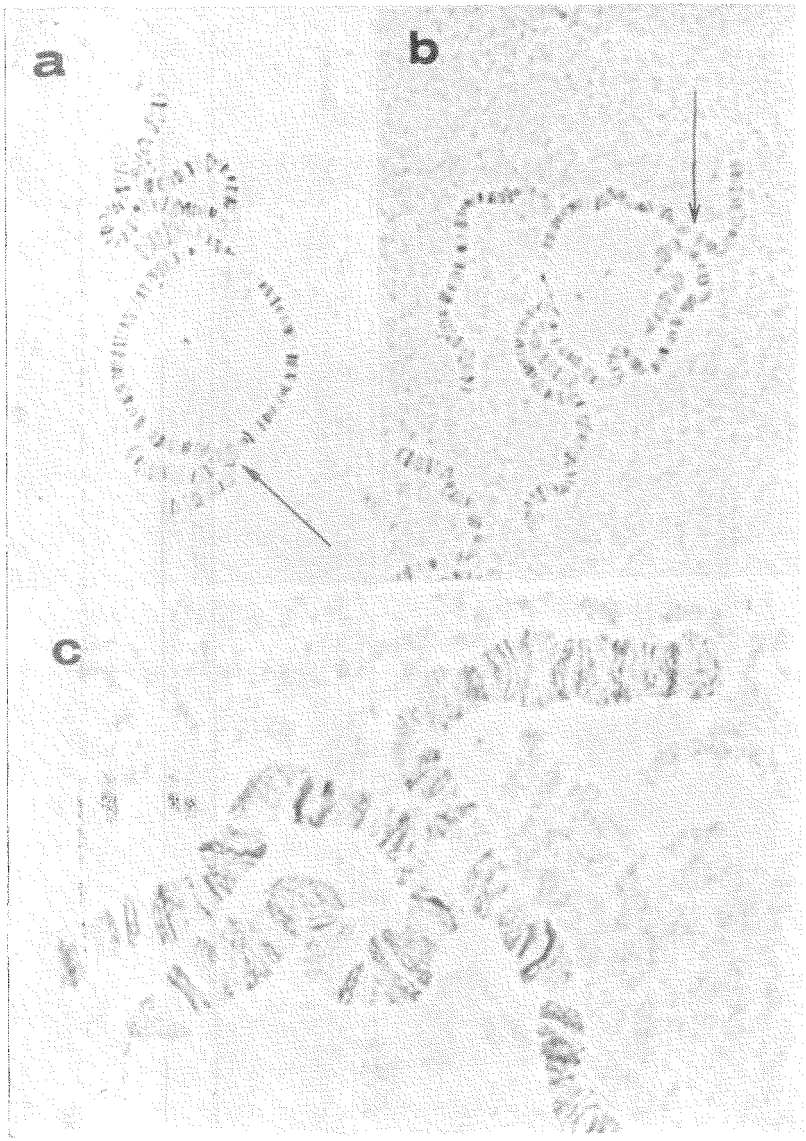

FIG. 3.—a, b. Salivary chromosome complements heterozygous for *T(2R; 3L)1*. Arrows indicate points of interchange. c. Magnification of a part of the complement shown in b, showing characteristic pairing configuration between the chromosomes involved in the interchange.

autosome translocations. Sterility for this particular translocation: 55.77±4.87 percent.

T (X;3R) 1: Figure 7 shows another X-autosome translocation which involves chromosomes X and 3R. Break-points:

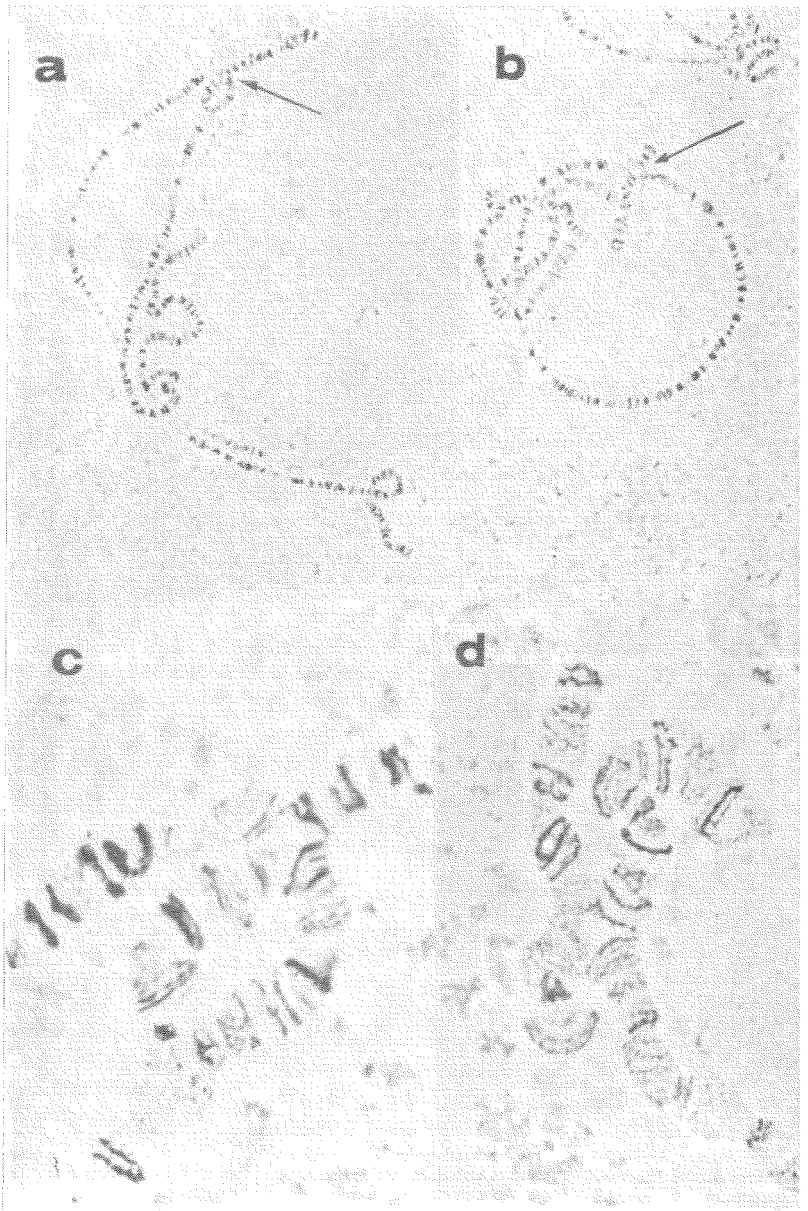

FIG. 4.—a, b. Salivary chromosome complements heterozygous for *T(2R; 3R)1*. Arrows indicate points of interchange. c. Magnification of a part of the complement shown in a. d. Interchange area of *T(2R; 3R)1* in another complement.

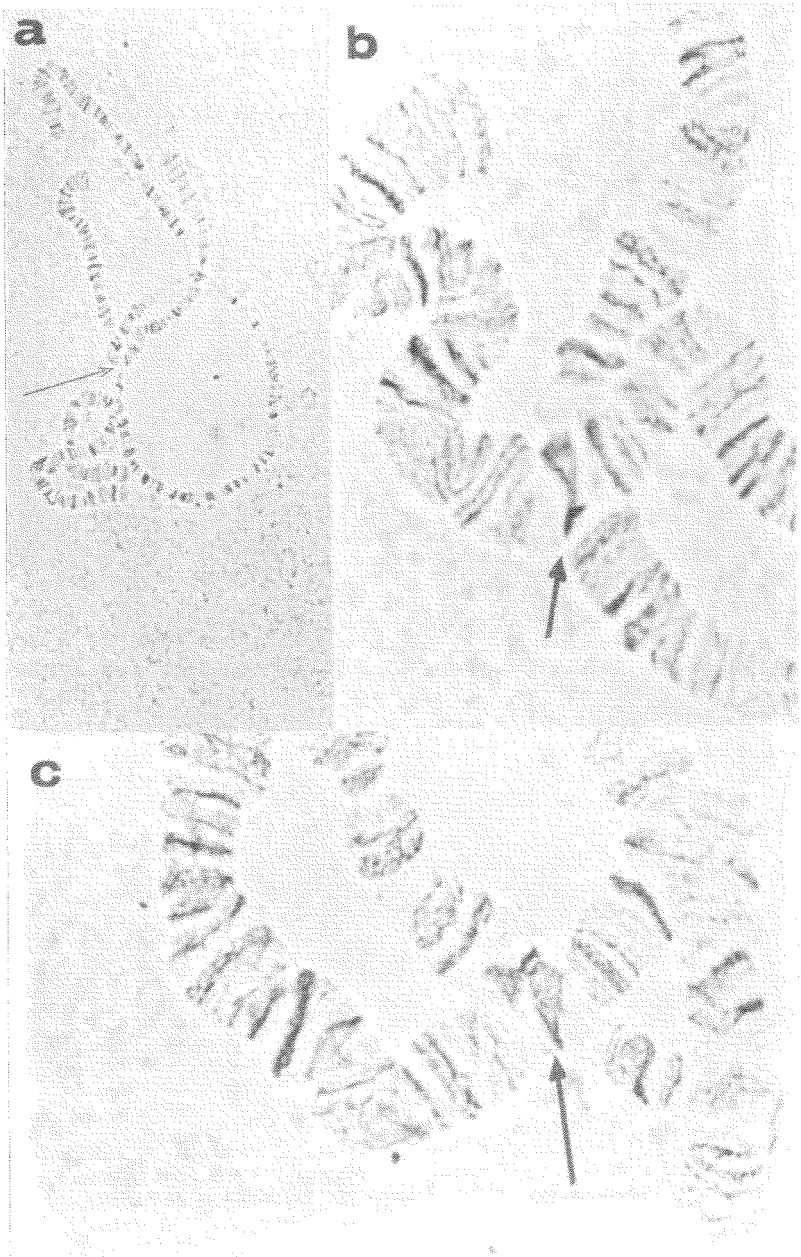

FIG. 5.—Complements heterozygous for *T(2L; 3R)1*. a. Complete complement. Arrow indicates point of interchange. b, c. Magnified portions of complements showing interchange areas.

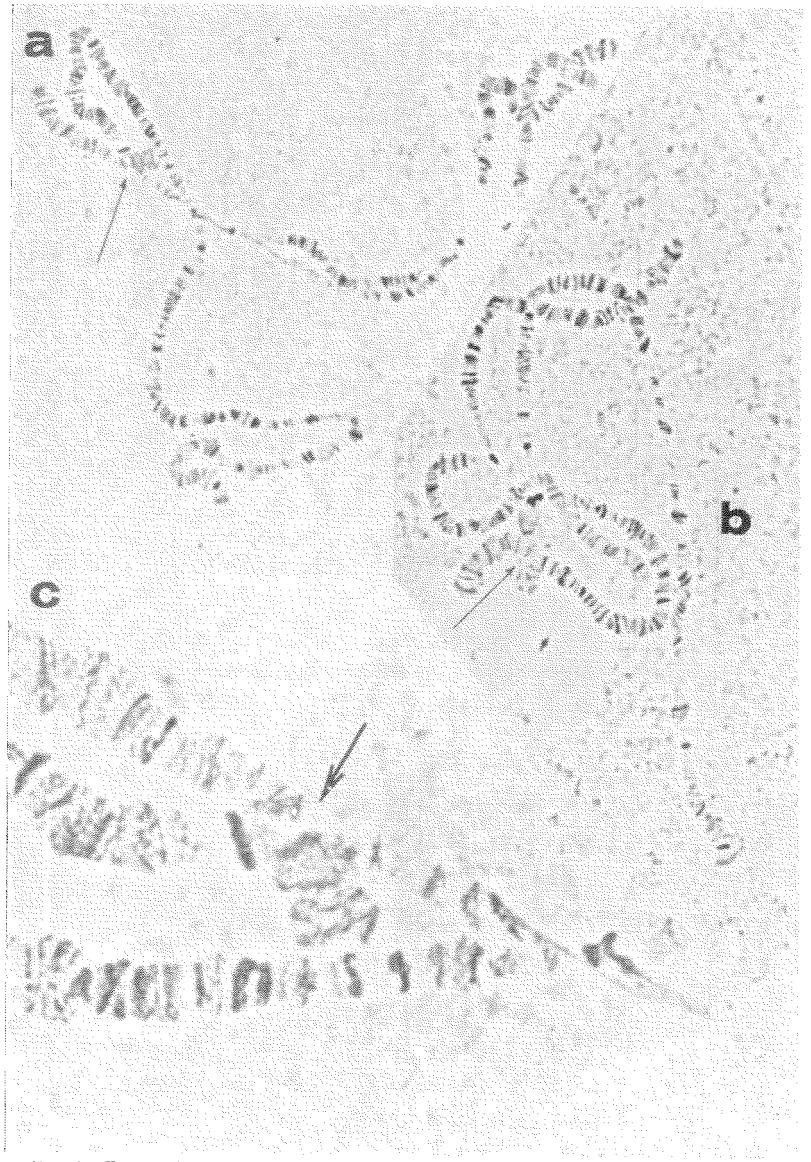

FIG. 6.—*T(X; 2L)1*. a, b. Complements from heterozygotes. Arrows point to interchange areas. c. Magnification of interchange area shown in a.

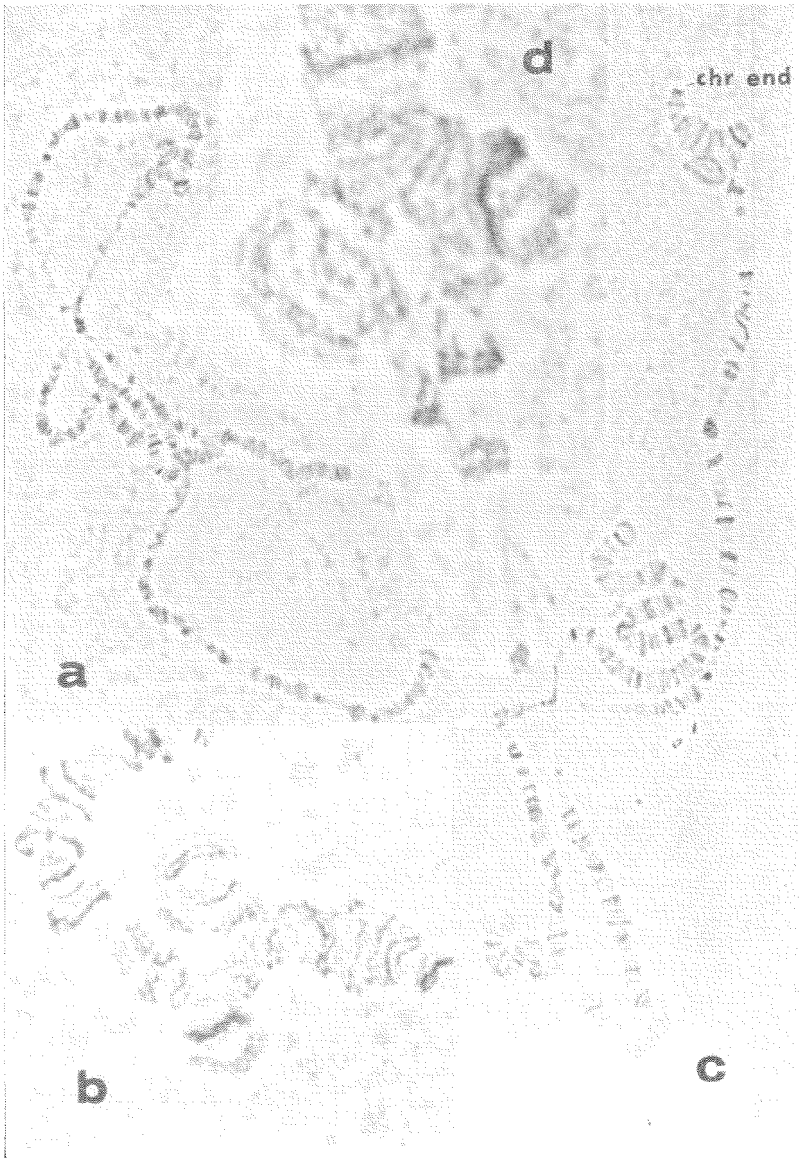

FIG. 7.—*T(X; 3R) 1.* a. A heterozygous complement. b. A portion of a, magnified. c. Another heterozygous complement. The chromocentric end of the X-chromosome often gets detached from the chromocenter during preparation. d. Magnification of interchange area shown in c.

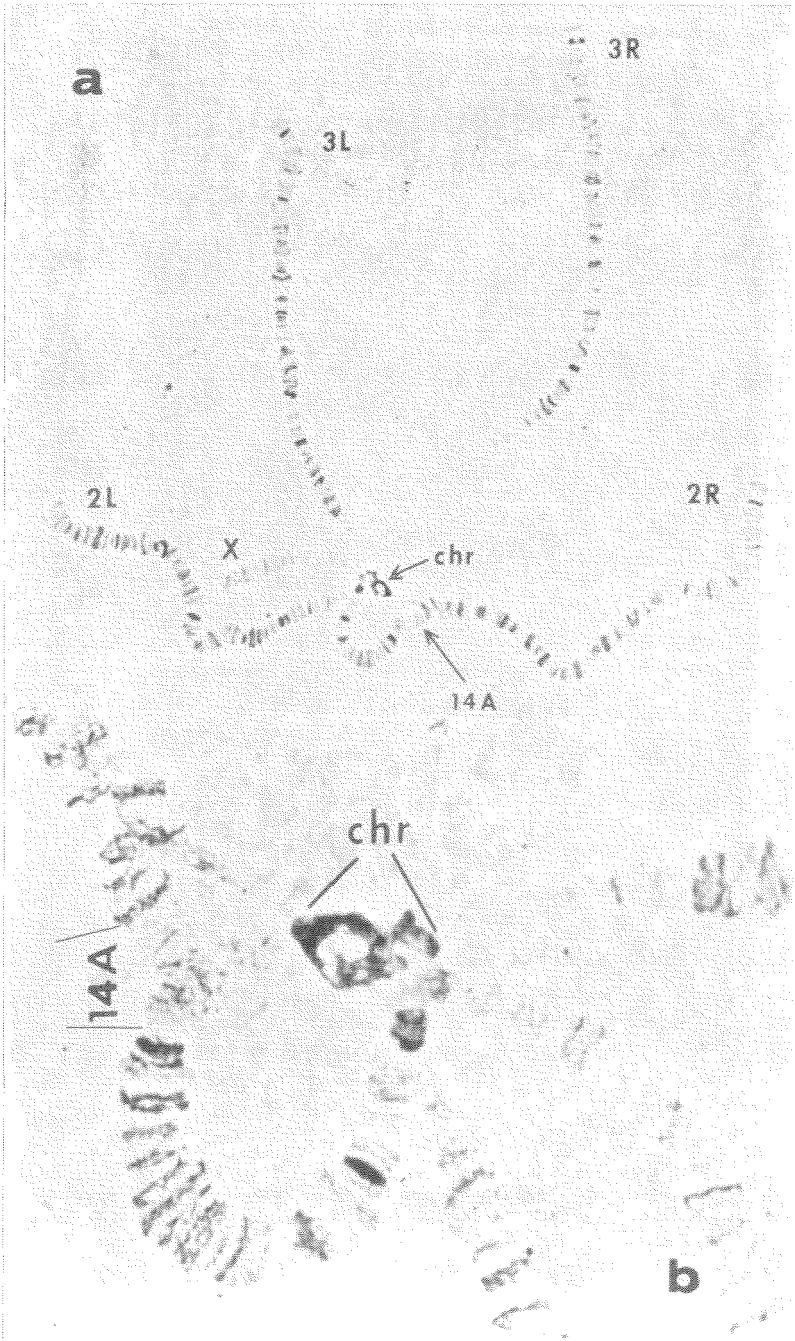

FIG. 8.—*T(Y; 2R) 1.* a. Male. The X-chromosome is comparatively thinner and the chromocenter (chr) rich in heterochromatin. One strand of 2R (Region 14 A) always goes through the chromocenter. b. A portion of a, magnified.

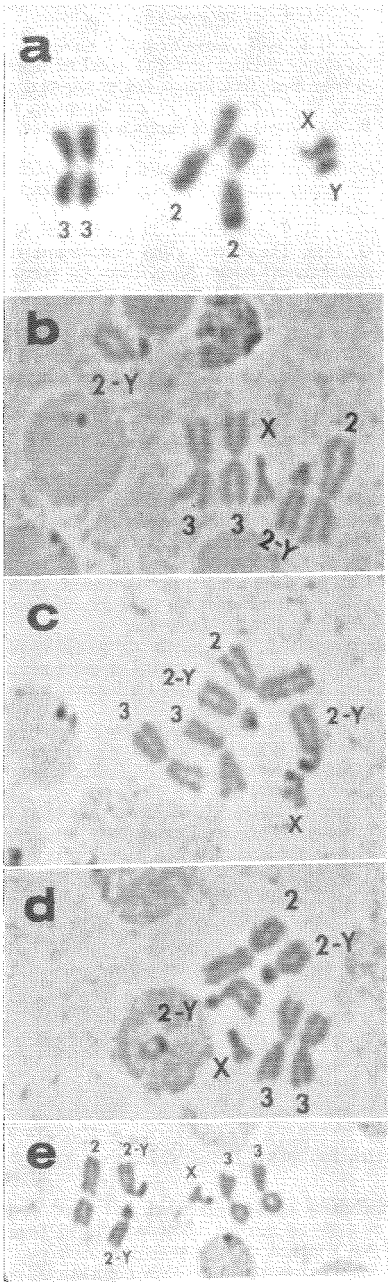

FIG. 9.—Mitotic chromosomes from brain of fourth instar larvae. a. Normal male. b. through e. *T(Y; 2R)1* male.

1B on X and 26B on 3R. Transmitted only through females. Sterility: 58.79± 2.06 percent.

Y-AUTOSOME TRANSLOCATION. *T (Y; 2R) 1:* This is one of the most interesting and promising translocations. Figures 8 and 9 show the heterozygotes in salivary gland and mitotic chromosomes. Breakpoint on 2R is at 14A. This translocation is transmitted only through males and all of the male progeny from normal x heterozygote cross carry this translocation. This particular fact may make this translocation especially suitable for field release study. No screening is needed to maintain this translocation. No crossing over to the X-chromosome has been detected as yet. Sterility: 52.86±2.95 percent.

DISCUSSION

The translocations described above offer interesting experimental possibilities. The Y-autosome translocation particularly calls for promising future studies such as competitiveness of the translocated chromosome in the laboratory as well as in nature, leading to possible evaluation of its potential usefulness in a large scale field release for genetic control of *Anopheles albimanus*. At present, we are carrying out studies to evaluate the competitiveness in population cages.

In addition, these translocations open up the possibility of linkage group-chromosome correlation studies but unfortunately the formal genetics of this species is not well known at the moment. One interesting phenomenon is the presumptive failure of translocation homozygotes to survive. During more than a year we have failed to detect any translocation homozygote. Absence of homozygotes may be considered favorable in a field release since homozygotes which produce balanced gametes are presumably fully fertile. Homozygotes, if obtainable, may possibly replace the original population. The unknown vector capacity of such homozygotes precludes their use.

The translocations described above also

offer an excellent opportunity for further cytological studies on both mitotis and meiosis, as well as genetic studies on position effect when marker genes are available.

Furthermore, these translocation strains may find a use as starting materials in synthesizing new karyotypes.

SUMMARY

Six reciprocal translocations are described along with their methods of induction and maintenance. The possibility of the practical use of one of the translocations *T(Y;2R) 1* in a future genetic control program is considered. Structural aberrations reported in this paper are promising for further studies of linkage group-chromosome correlations, position effects and building artificial karyotypes.

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LABORATORY AND FIELD EVALUATION OF A SONIC SIFTER AS A MOSQUITO EGG EXTRACTOR

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ABSTRACT. A sonic sifter proved to be a simple and dependable device for extracting aedine mosquito eggs from air-dry soil samples. It gave a high recovery rate (91.68 percent) of samples seeded with a known number of *Aedes nigromaculis* (Ludlow) eggs. There was no effect on hatchability of the eggs which had been sifted for 1 to 10 minutes. Samples collected from dense vegetated areas contained the most eggs; samples collected from the bottom of a depression with no vegetation contained the least eggs.